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Development Trajectory, Emission Profile, and Policy Actions: Thailand

Qwanruedee
Chotichanathawewong and
Natapol Thongplew

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Qwanruedee Chotichanathawewong is president of the Thailand Environment Institute. Natapol Thongplew is researcher at the Thailand Environment Institute.

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Please contact the author(s) for information about this paper.

Email: qwan@tei.or.th

Asian Development Bank Institute
Kasumigaseki Building 8F
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500
Fax: +81-3-3593-5571
URL: www.adbi.org
E-mail: info@adbi.org

Abstract

In Thailand climate change has been integrated into the formulation of several national plans and policies. Even though Thailand is not obligated to reduce greenhouse gas emissions, it voluntarily takes numerous actions to mitigate emissions. Both the public and private sector have been actively involved in reducing greenhouse gas emissions, with a series of measures and actions implemented in each sector.

The development of renewable energy and the promotion of energy conservation and efficiency are the primary means to mitigate greenhouse gas emissions in Thailand. With the establishment of the Energy Conservation Program in 1995, a viable movement for energy conservation and efficiency and renewable energy had begun. Over the years, progress in renewable energy and energy efficiency has been made. Recently, the 15-Year Renewable Energy Development Plan and the 20-Year Energy Conservation Plan comprised several innovative measures and incentive mechanisms to further advance the development of energy efficiency and renewable energy. Regardless of government policies and measures, the private sector has also taken part in greenhouse gas emissions mitigation by implementing a number of activities to reduce carbon sources (e.g., improved production processes and resource efficiency) and to create carbon sinks (e.g., reforestation and mangrove plantations).

Thailand has made significant progresses toward green and low-carbon development; however, there is a need to further address the issue. The country has to focus on the implementation of no-regret policies to ensure the decoupling of economic growth, while starting to look further at implementing least-cost policies. There should be short-term policies to immediately address a rapid increase of greenhouse gas emissions and long-term policies to address fundamental changes towards a green and low-carbon society.

JEL Classification: Q54, Q58

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1. INTRODUCTION

1.1 Current Economic Development and Future Emission Profiles

Thailand is a developing country in Southeast Asia, which has shifted from having an agriculture-based economy to an industry-driven economy. Since 1960, there has been rapid economic growth in Thailand, with significant expansion of the industry sector. The contribution to gross domestic product (GDP) of the industry sector increased from 22.6% during the 1960s to 43.9% in 2005 (Akrasanee 2006).

The national economy is predicted to continue to grow at a slower rate up to 2030. The National Institute of Development Administration projected that Thailand's GDP would increase by 3%–5% per year from 2010 to 2030 (based on electricity demand) (Table 1.1).

Table 1.1: Thailand Gross Domestic Product Projection

Year	Low Scenario	Base Scenario	High Scenario
2010	3.41	3.41	3.41
2011	3.88	4.02	4.28
2012	3.84	4.24	4.78
2013	3.50	4.06	4.24
2014	4.32	4.78	5.12
2015	3.97	4.46	4.83
2016	3.82	4.28	4.61
2017	3.85	4.28	4.60
2018	3.68	4.10	4.43
2019	3.75	4.15	4.49
2020	3.87	4.24	4.58
2021	3.82	4.18	4.53
2022	3.63	4.01	4.37
2023	3.60	3.95	4.31
2024	3.58	3.92	4.28
2025	3.58	3.92	4.28
2026	3.58	3.92	4.28
2027	3.58	3.92	4.28
2028	3.58	3.92	4.28
2029	3.58	3.92	4.28
2030	3.58	3.92	4.28

Notes: Figures in the table represent GDP growth. GDP projection for each year is projected under three scenarios (low scenario, base scenario, and high scenario). Each scenario reflects the possibility of economic growth, e.g., the low scenario refers to low economic growth and high scenario refers to high economic growth.

Source: National Institute of Development Administration 2010

Based on the GDP projection (GDP data from 2031 to 2050 are assumed to be the same as GDP in 2030, and sector GDP data are assumed based on expert opinions) and other key data for each sector, greenhouse gas emission projection until 2050 was carried out by the Joint Graduate School for Energy and Management (JGSEE) for the Thailand Greenhouse Gas Management Organization (TGO). The study projected greenhouse gas emissions for three scenarios: business as usual, power development plan 2010, and climate plan scenario.

1.1.1 Business-as-Usual Scenario

Under the business as usual (BAU) scenario, greenhouse gas emission from all economic activities were estimated without any implementation of greenhouse gas emission reduction activities. Key factors used to determine the greenhouse gas emissions projection under the

BAU scenario are GDP and electricity generation sources. The electricity generation source ratio is assumed to remain the same until 2050, with natural gas at 71% and coal at 20%. Other assumptions and factors for the BAU scenario are in Table 1.2.

Table 1.2: Key Assumptions and Factors for the Business as Usual Scenario

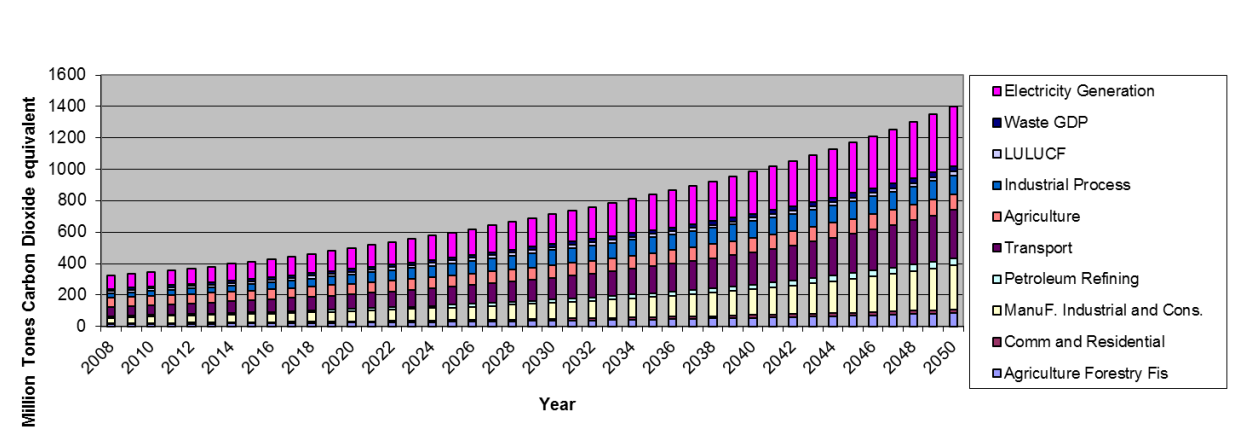
Sector	Assumptions and Factors
Energy sector: Transport	Economic growth, population, crude oil price, economic crisis, GDP growth 3.7%
Energy sector: Energy use in industry	Economic growth, population, crude oil price, coal price, electricity price, economic crisis, GDP growth 3.7%
Energy sector: Residence	Economic growth, population, crude oil price, economic crisis, GDP growth 3.7%
Industry sector: Cement industry	Economic growth, clinker production is not more than 50 million tons, GDP growth 4%
Industry sector: Iron industry	Upstream iron production, middle and downstream iron production, GDP growth 4%
Agriculture sector: Livestock	Economic growth, population, meat price, raw milk price, cow price, buffalo price, poultry price, GDP growth 3% (equivalent to 4% of national GDP)
Agriculture sector: Rice	Irrigated area, area of seasonal rice, fertilizer use
Agriculture sector: Agricultural land	Irrigated area, area of double-crop rice fields, GDP growth3% (equivalent to 4% of national GDP)
Agriculture sector: Open burning	Irrigated area, area of double-crop rice fields
Land use change and forestry sector	Forest statistics, population
Waste sector	Economic growth, population, GDP growth 4%

GDP = gross domestic product

Source: Joint Graduate School for Energy and Management 2010

With such factors, Thailand's greenhouse gas emissions under the BAU scenario are estimated to be 498.7 million tons of carbon dioxide equivalent (MtCO2eq) in 2020, 715.2 MtCO2eq in 2030, 985.7 MtCO2eq in 2040, and 1,398.7 MtCO2eq in 2050. Details of greenhouse gas emission projections for the BAU scenario are in Annex 1 and Figure 1.1.

Figure 1.1: Greenhouse Gas Emission Projections under the Business as Usual Scenario



Agriculture Forestry Fis = agriculture, forestry, and fishery; Comm and Residential = commercial and residential; LULUCF = land use change and forestry; ManuF. Industrial and Cons. = manufacturing, industrial processes, and construction

Source: Joint Graduate School for Energy and Management 2010

1.1.2 Power Development Plan 2010 Scenario

The power development plan (PDP) 2010 scenario takes the PDP 2010 into consideration for projecting greenhouse gas emissions.[1] As a result, it is only the power sector that shows any change from the BAU scenario. To extend this scenario to 2050, the ratio of energy sources for electricity generation from 2031 to 2050 is assumed to be the same as the ratio in 2030.

Under the PDP 2010, the power sector will undergo changes in terms of primary energy sources—decreased use of natural gas and lignite and increased use of coal (Table 1.3).

Table 1.3: Key Assumptions and Factors in the Power Development Plan 2010 Scenario

Sector	Assumptions and Factors
Power sector: PDP 2010	In 2020, natural gas at 55% and coal at 12% (including lignite at 7.3%) In 2030, natural gas at 40% and coal at 21% (including lignite at 3%) From 2031 to 2050, the ratio remains the same as at 2030

PDP = power development plan.

Source: Joint Graduate School for Energy and Management 2010

In the PDP 2010 scenario, it is estimated that the amount of greenhouse gas emissions from electricity generation per kilowatt-hour (kWh) of electricity will reduce from 0.482 kilograms (kg) of carbon dioxide (CO2) per kWh in 2010 to 0.368 kg CO2/kWh in 2030 (Table 1.4).

Table 1.4: Estimated Carbon Dioxide Emissions under the Power Development Plan 2010, 2010–2030

Year	Estimated CO_2 Emissions (kg CO_2/kWh)
2010	0.482
2011	0.471
2012	0.470
2013	0.462
2014	0.468
2015	0.448
2016	0.423
2017	0.408
2018	0.398
2019	0.401
2020	0.387
2021	0.374
2022	0.373
2023	0.381
2024	0.361
2025	0.341
2026	0.357
2027	0.354
2028	0.363
2029	0.367
2030	0.368

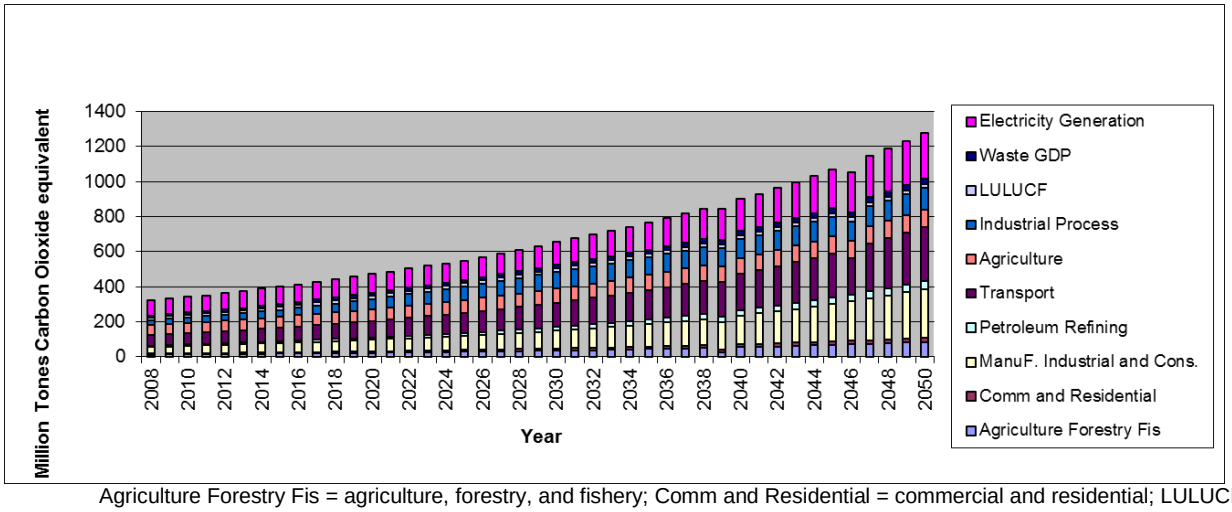
kg CO_2/kWh = kilograms of carbon dioxide per kilowatt-hour

Source: Electricity Generating Authority of Thailand 2010

[1] The PDP 2010 is a long-term national electricity generation and development plan, which will be effective from 2010 to 2030.

With such expected changes in the power sector, greenhouse gas emissions from the power sector are projected to increase due to the increasing electricity demand. However, greenhouse gas emissions per kWh of electricity are projected to decrease. As a result, national greenhouse gas emissions under the PDP 2010 scenario are estimated to be lower than in the BAU scenario, with 472.9 $MtCO_2eq$ in 2020, 654.4 $MtCO_2eq$ in 2030, 899.5 $MtCO_2eq$ in 2040, and 1,276.5 $MtCO_2eq$ in 2050. Details of greenhouse gas emissions projected under the PDP 2010 scenario are in Annex 1 and Figure 1.2.

Figure 1.2: Greenhouse Gas Emission Projections under the Power Development Plan 2010 Scenario



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Source: Joint Graduate School for Energy and Management 2010

1.1.3 Climate Plan Scenario

The climate plan scenario takes possible measures for greenhouse gas emissions mitigation into account in predicting the future greenhouse gas emissions profile. Mitigation measures include activities in electricity generation, industry (industrial process and manufacturing industries), transport, commercial and residential sector, agriculture sector, land use change and forestry sector, and waste sector (Table 1.5).

Table 1.5: Key Assumptions and Factors in the Climate Plan Scenario

Sector	Mitigation Measure	Assumptions and Factors
Energy Sector: Electricity generation	Minimizing loss for electricity transfer and distribution systems	For 2004–2008, the loss was in the range of 6.1%–6.7%. Assumed that the loss will be 4% in 2050.
	Renewable energy promotion	After accomplishment of the 15-Year Renewable Energy Development Plan in 2022, there will be control for electricity generation from renewable energy at not less than 5% of the total electricity generation and the ratio of renewable energy will be 6% (from 2010 to 2030). There are additional measures to support renewable energy in terms of plant factor for biomass and biogas. The utilization of renewable energy for electricity will be intensified—biomass (4,400 MW), biogas (144 MW), solar (3,000 MW), municipal waste (395 MW), and hydropower (644 MW). These measures will be implemented from 2020, which will result in 9% of renewable energy electricity generation in 2030.
	Increasing efficiency of power plants	Currently, the efficiency of electricity generation is 40% for natural gas and 35% for coal. These efficiencies will be improved to 65% for natural gas and 50% for coal.
	Fuel switching (to low carbon)	It is assumed that 50% of new coal-fired power plants (planned to begin construction in 2019) will be replaced with natural gas fired power plants.
	Carbon capture and storage	It is assumed that in 2030 carbon capture and storage will be used in 50% of new coal power plants.
Energy sector: Energy use in industry	Increasing efficiency of boilers	During 2008–2017, old boilers will be replaced with high-efficiency boilers—new rotary burners and super boilers—which can save energy by 16%.
	Increasing efficiency of furnaces	Developing new furnaces to be more efficient by preheating fuel and adding soot in the flame. This will increase efficiency by 20%.
Energy sector: Transport	Promoting eco-cars	Supporting the use of eco-cars that have fuel consumption rates of 5 liters per 100 kilometers (km) and release pollution emissions of less than 120 milligrams per km (Euro 4 standard). It is assumed that all new personal cars with engines smaller than 1,600 cubic centimeter (cc) capacity in the market in 2030 will be eco-cars.
	Promoting hybrid cars	Hybrid cars can increase fuel efficiency by about 20%. It is assumed that all new cars with engines larger than 2,000 cc (using gasoline) in the market will be hybrid cars.
	Promoting ethanol	After accomplishment of the 15-Year Renewable Energy Development Plan, it is assumed that all fuel will contain 20% ethanol (gasohol E20).
	Promoting biodiesel	After implementation of the 15-Year Renewable Energy Development Plan, it is assumed that in 2023 all diesel fuel will contain 5% biodiesel (biodiesel B5)
Energy sector: Building and residential	Promoting high-efficiency stoves	High-efficiency liquid petroleum gas (LPG) stoves—such as swirl flow, infrared flow, and radical flow—are promoted to replace all normal stoves. It is assumed that replacement is undertaken during 2006–2030 with the replacement rate at 20% every 5 years.
	Promoting high-efficiency wood stoves	High-efficiency wood stoves that consume less charcoal are promoted to replace all normal wood stoves. It is

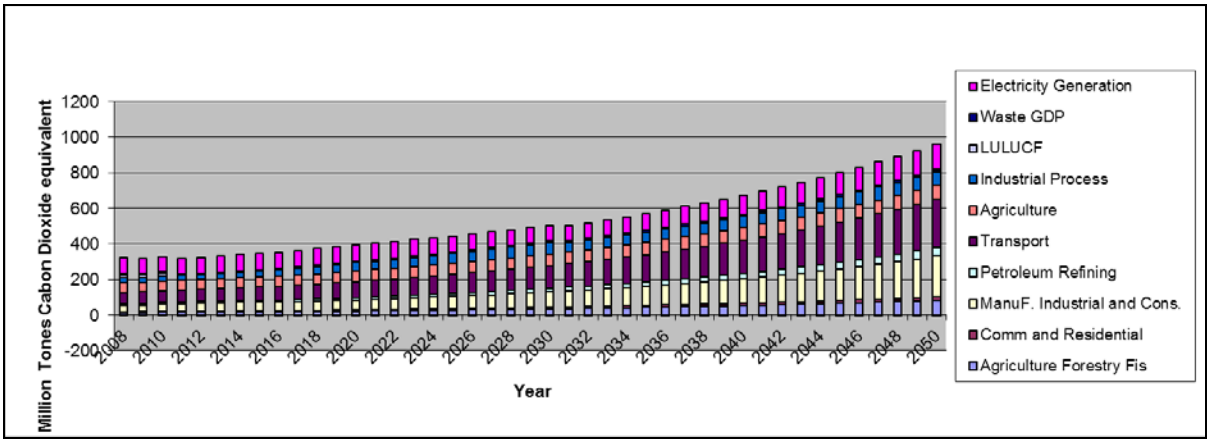
Sector	Mitigation Measure	Assumptions and Factors
		assumed that replacement is undertaken during 2006–2030 with the replacement rate at 20% every 5 years. This replacement can reduce energy consumption by about 14.8 thousand tons of oil equivalent..
	Demand-side management (DSM)	DSM will be implemented in three categories: rescaling the current criteria of existing appliances, introducing new criteria for new appliances (studies already exist), and introducing new criteria for new electrical appliances (conducting new studies).
Industrial processes	Clinker substitution	Using substitution materials—such as fly ash, ground blast furnace slag, and natural pozzolan—for calcium carbonate. The substitution will start in 2012 with 100% substitution during 2031–2050 (as prescribed in the plan of World Business Council for Sustainable Development/International Energy Agency 2009).
	Promoting high-efficiency technology for iron industry	New technology—integrated blast furnace basic oxygen furnace—will be used in 2015. In 2025 this will be a "best available technology" measure.
	Carbon capture and storage (CCS)	CCS will begin to be used in the cement industry in 2020–2030 (about 21% of cement plants). All cement facilities will use CCS during 2031–2050 (as prescribed in the plan of WBCSD/IEA 2009).
Agriculture sector	Waste management for biogas production	Intensifying the implementation plan of the Ministry of Energy on biogas production by encouraging small farms to produce biogas. During 2014–2019, it is assumed that 2.6 million pigs, 800,000 dairy cows, and 850,000 cows will be included in biogas production.
	Increasing efficiency of feed conversion through feed formula changes (for cows and dairy cows)	Increase the efficiency of feed conversion by improving food formula by increasing dairy efficiency from 60% to 70% in 2015.
	Methane reduction from paddy fields: Water management	Encourage water management in paddy fields (release water from paddy field in the middle of the growing season). This can reduce methane generation from paddy fields by 30%–40%. It is assumed that this water management will take place in 2011 and will be implemented in 70% of irrigated paddy fields in 2050.
	Methane reduction from paddy fields: Use of low-carbon fertilizer	Use ammonium nitrate (inhibitor of methanogenesis) as a fertilizer. It can reduce methane generation from paddy field by 9%–15%. It is assumed that this will begin in 2011.
	Methane reduction from paddy fields: Both water management and the use of low-carbon fertilizer	Combination of water management and low-carbon fertilizer used. This will begin in 2011 and implementation will cover 80% of irrigated paddy fields in 2050.
	Fertilizer reduction: Site-specific nutrient management	Analyze soils before using fertilizers by using site-specific nutrient management. It is assumed that this implementation will reduce fertilizer use by 34% in 2050.
	Slow-dissolving fertilizer (nitrification inhibitor)	The use of nitrification inhibitor can reduce the release of nitrous oxide by 30%. It is assumed that 20% of the nitrogen fertilizer used in 2050 in the country will be nitrification inhibitor.
	Reducing open burning of agricultural waste	Manage agricultural residues for sugar cane and paddy plantations. It is assumed that in 2050, 211,200 square kilometers (km^2) of in-season rice fields, 211,200 km^2 of double-crop rice fields, and 64–128 km^2 of sugar cane plantation fields will not employ open burning.
Land use change and forestry sector	Forest conservation	Maintain same forest area as in 2005.
	Afforestation and reforestation	Have 40% of forest area in the country in 2020.

Sector	Mitigation Measure	Assumptions and Factors
Waste sector	Waste reduction and recycling	Maintain the waste generation rate at 1 kilogram per person per day (from 2038). Have recycling rate at 30% during 2011–2050.
	Using technologies	Use technology for making organic fertilizer and anaerobic decomposition, methane (from landfills) utilization, and for semi-aerobic landfills.

Source: Joint Graduate School for Energy and Management 2010

With a series of measures in many sectors, greenhouse gas emissions for each sector are estimated to decrease. As a result, national greenhouse gas emissions under the climate plan scenario are estimated to be lower than in the BAU scenario and PDP 2010 scenario, at 391.5MtCO_2eq in 2020, 497.1MtCO_2eq in 2030, 669.2MtCO_2eq in 2040, and 955.7 MtCO_2eq in 2050. The details of greenhouse gas emission projections for the climate plan scenario are in Annex 1 and Figure 1.3.

Figure 1.3: Greenhouse Gas Emission Projection under the Climate Plan Scenario



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Source: Joint Graduate School for Energy and Management 2010

1.1.4 Greenhouse Gas Emissions Reduction

GDP projections for Thailand for the next 40 years suggest that there will be moderate economic growth. Increasing economic activity is likely to increase the consumption of energy and increase greenhouse gas emissions, which are projected to continue increasing under all three scenarios.

Table 1.6 compares greenhouse gas emissions under the BAU, PDP 2010, and climate plan scenarios. In short, if Thailand can implement greenhouse gas emission reduction measures as listed in the climate plan scenario, the level of greenhouse gas emissions will be approximately 956 MtCO_2eq in 2050. This is a reduction of 30% from the BAU scenario.

Table 1.6: Greenhouse Gas Emissions and Percent Reduction for Projection Scenarios

Scenario	2020		2030		2040		2050	
	Greenhouse Gas Emission ($MtCO_2eq$)	Percent reduction from BAU	Greenhouse Gas Emission ($MtCO_2eq$)	Percent reduction from BAU	Greenhouse Gas Emission ($MtCO_2eq$)	Percent reduction from BAU	Greenhouse Gas Emission ($MtCO_2eq$)	Percent reduction from BAU
BAU	498.7		715.2		985.7		1,398.6	
PDP 2010	472.9	5.2	654.4	8.5	899.5	8.7	1,276.4	8.7
Climate Plan	391.5	21.5	497.1	30.5	669.2	32.1	955.7	31.7

BAU = business as usual, $MtCO_2eq$ = million tons of carbon dioxide equivalent, PDP = power development plan.

Source: Joint Graduate School for Energy and Management 2010

1.2 Basic Indicators of Low-Carbon Green Development

In Thailand there are no specific low-carbon green development indicators. However, the indicators are defined under the broad development indicators—the sustainable development indicators. These indicators are formulated by the Office of National Economic and Social Development Board (NESDB) and Thailand Environment Institute (TEI), and economic, social, and environmental dimensions were taken into account. Table 1.7 summarizes the 39 indicators.

Table 1.7: Thailand's Sustainable Development Indicators

Objectives	Indicator
Economic Dimension	
Quality	1. Total factor productivity of each sector
	2. Ratio of energy consumption to GDP
	3. Renewable energy utilization
	4. Waste reutilization and recycling
	5. Organizations having environmental management system and products having green label
Stability	6. Unemployment rate
	7. Current account per GDP
	8. Short-term external debt per national reserve
	9. Public debt per GDP
Equality	10. Gini coefficient
	11. Poverty incidence
	12. Gap between the highest and the lowest income quintile
Social Dimension	
Human development and adjustment to a knowledge-based society	1. Average year of education
	2. Test score from four major subjects
	3. Percent of investment in research and development per GDP
Quality of life and life security	4. Life expectancy at birth
	5. Percent of people with major illnesses
	6. Percent of people with access to tap water
	7. Percent of losses (life and assets) from fires and floods
	8. Ratio of crime and drug cases to total population
Community development and cultural immunity	9. A number of activities for supporting, conserving, and disseminating arts and culture
Equity and participation	10. Human rights violations by the government
	11. Ratio of female to male members in local government
	12. Corruption
	13. Ratio of communities having community development plans to total communities
Environmental Dimension	
Conservation	1. Percent of forest area
	2. Percent of mangrove compared to the past
	3. Economic marine animals being captured per hour
	4. Marine fauna (in the protected areas) for endangered species
	5. Ratio of usable surface water quantity to the total quantity of surface water, and ratio of groundwater used to total groundwater quantity
Good environmental quality	6. Ratio of water resources meeting minimum acceptable quality standards to total water resources
	7. Infertile land
	8. Air quality in main cities exceeding the standards
	9. Ratio of treated hazardous waste
	10. Chemicals used in agriculture
	11. Proportion of green areas in cities
Participation and resource allocation	12. A number of networks for conserving natural resources and environment
	13. Quantity of greenhouse gas emissions
	14. Quantity of ozone-depleting substances

GDP = gross domestic product

Source: National Economic and Social Development Board and Thailand Environment Institute 2006.

From the set of indicators, key issues for achieving green and low-carbon development are included, such as energy consumption, renewable energy, research and development, forest conservation, resource efficiency, and greenhouse gas emissions.

1.3 Insights for Policy Analysis: Key Sectors and the Challenges Facing the Country in 2050

1.3.1 Energy and Power Sector

With the rising demand for electricity to drive economic growth in the future, dependence on natural gas and coal-fired power plants will not sustainably enhance energy security or reduce the vulnerability of the economy. Therefore, energy efficiency and renewable energy are important considerations when addressing energy security and economic growth, as well as climate change in Thailand (Nakawiroa, Bhattacharyyaa, and Limmeechokchaib 2008).

The current direction for key greenhouse gas emissions reduction policies in Thailand have been laid down until 2030. With the 15-Year Renewable Energy Development Plan, the 20-Year Energy Conservation Plan, and the Power Development Plan 2010 (PDP 2010), the country's direction can be summarized as follows: renewable energy and energy efficiency will be further promoted with both traditional and innovative measures to increase energy security and safeguard the environment. Public–private partnership will be emphasized and the role of the private sector in promoting renewable energy and energy efficiency will be more prominent. Additionally, massive cuts in greenhouse gas emissions are expected.

Even though the development of renewable energy and progress on energy efficiency is expected, it is unavoidable that fossil fuels will remain the primary source of energy supply and Thailand will still rely on imported energy. Based on the current policies and plans, the challenges for Thailand to foster green and low-carbon development are renewable energy utilization and the PDP 2010.

1.3.1.1 Renewable Energy Utilization

Although the 15-Year Renewable Energy Development Plan (described in section 2) is formulated based upon the domestic potentials in the country, there are challenges for the country to meet the renewable energy utilization targets. Based on the implementation result in 2010, the gaps between the utilization target and actual utilization can be clearly observed, especially for wind, hydropower, biomass, and municipal waste (Table 1.8).

Table 1.8: Renewable Energy Utilization, 2010

Renewable Energy Source		Utilization	Target	Difference
Wind (MW)		5.61	45.00	(39.39)
Solar	Electricity (MW)	48.57	48.00	0.57
	Heat (ktoe)	2.14	2.80	(0.66)
Hydropower (MW)		58.85	142.00	(83.15)
Biomass	Electricity (MW)	1,650.00	2,454.00	(804.00)
	Heat (ktoe)	3,136.00	3,130.00	(6.00)
Biogas	Electricity (MW)	103.40	55.00	48.40
	Heat (ktoe)	311.00	320.00	(9.00)
Municipal waste	Electricity (MW)	13.13	58.00	(44.87)
	Heat (ktoe)	1.09	7.00	(5.91)
Ethanol (million liters/day)		1.23	2.11	(0.88)
Biodiesel (million liters/day)		1.72	1.35	0.37

ktoe = thousand tons of oil equivalent, MW = megawatt.

Source: Department of Alternative Energy Development and Efficiency 2011a.

There are several challenges for increasing renewable energy utilization, one of the key ones being the lack of financial incentive. Financial incentives for some energy sources are still insufficient to overcome the financial barrier faced when developing renewable energy projects,

such as wind and solar projects. There are other specific challenges for each energy source (Table 1.9).

Table 1.9: Challenges for Renewable Energy Utilization in Thailand

Energy Source	Key Challenges
Wind	Land acquisition for installing windmills (most suitable areas are mostly conservation forest)
Hydropower	Slow implementation for construction (by government agencies and state-owned enterprises)
Biomass	Diversifying the biomass (suitable technologies for utilizing agricultural residuals other than rice husks and bagasse)
Municipal waste	Conflicts between local communities and investors, and acceptance from local communities

Source: Authors

1.3.1.2 Power Development Plan 2010

The key concern for electricity generation in Thailand is the high dependency on natural gas and imported energy. The PDP 2010 is trying to address these issues by diversifying energy sources through the introduction of nuclear power and coal. However, the suitability and public acceptance of nuclear power and coal are issues that need to be addressed.

Nuclear Power

Before the nuclear accident in Fukushima (Japan) in 2010, most Thai people agreed with nuclear power, although they did not want the nuclear power plants to be located in their communities and provinces. Since the Fukushima accident, the public and media are very much aware of the dangers of nuclear power, and the problems that may occur in Thailand if nuclear power plants are constructed. Furthermore, there are concerns and questions regarding the readiness of, and the need for, Thailand to have nuclear power plants. There are also strong antinuclear movements, especially in the potential locations for the nuclear power plants. The public is urging the government not to ever build nuclear power plants in Thailand. Currently, the government has ceased the process of considering nuclear power plants, but nuclear power is still in the PDP 2010.

Coal-Fired Power

Coal-fired power plants are also not welcomed by most Thai people, and serious questions surround the health and environmental impacts of coal, especially air pollution. There are anti-coal movements in several areas, especially potential construction areas. The government has provided information about coal being environmentally friendly when used in clean coal technologies; however, the public still does not agree with coal-fired power plants.

With a solution being required for achieving energy security, the government together with the public and other stakeholders should agree on a future national power plan, including nuclear power and coal power.

1.3.2 Industry Sector

The industry sector has been involved in greenhouse gas emissions reduction through energy efficiency and conservation activities. There are a range of measures and programs provided by the government to support energy conservation and efficiency in industry, and progress has been made. However, implementation is limited to large and medium-sized enterprises. As there are millions of small enterprises in Thailand, the challenge remains for related agencies to

promote and provide support for small enterprises to improve their performance on energy efficiency and conservation.

Energy efficiency technologies are the other main obstacle to achieving a low-carbon industry sector. Such technologies are still expensive and technology deployment remains difficult for a number of industries. It is essential for the relevant agencies to consider how to bring down the cost of energy efficiency technologies so that deployment can occur on a wide scale.

The other strategy for promoting greenhouse gas emissions reduction in the industry sector is to promote greenhouse gas emissions reduction by using on-site renewable energy generation technologies. There are several viable renewable technology options that can be installed at factory sites to generate energy. However, promotion of and support for on-site renewable energy generation technologies in industry are not yet realized in the policy. Thus, it is necessary for policy makers to consider the possibilities that on-site renewable energy generation technologies offer the industry sector.

1.3.3 Agriculture Sector

Greenhouse gas emission reduction policies in agriculture involve farmers' practices, such as controlling water in rice fields and changing crop cultivation practices. Changing traditional practices can be a challenge because farmers are used to traditional practices.

1.3.4 Waste Sector

Policies on waste in Thailand are in line with the "3Rs" concept.[2] There are a number of programs and activities to promote the implementation of 3Rs, especially in Bangkok and other big cities; however, waste management remains a problem. The key challenges for the waste sector pertaining to greenhouse gas emissions reduction are to reduce or maintain the waste generation rate and increase the recycling rate.

Waste generation involves both product provision systems (ways that products are produced and provided for consumers) and consumption behaviors. In Thailand, the consumption level, especially in cities, is growing due to many factors, including changing lifestyles; people generally consume more than they used to. Additionally, there are increasing numbers of disposable products and packaging. As a result, reducing or maintaining the waste generation rate is a challenging task.

Waste recycling rate in Thailand is still low (23% of household waste was recycled in 2008 [PCD 2009]). Possible explanations for low recycling rates are that people do not separate wastes, infrastructure for waste separation is not in place, the waste collection system does not corresponded to recycling practices, and there are limited recycling technologies. These are the key challenges for increasing the waste recycling rate.

[2] 3Rs concept refers to reuse, reduce, and recycle.

2. CURRENT PLEDGES AND POLICY ACTIONS

2.1 Policies and Plans

In Thailand, primary actions and pledges concerning greenhouse gas emissions reduction are associated with renewable energy and energy efficiency. The plan to promote renewable energy and energy efficiency became tangible with the establishment of the Energy Conservation (ENCON) Program in 1995. Progress toward renewable energy and energy efficiency is driven by the 15-Year Renewable Energy Development Plan (REDP) and 20-Year Energy Conservation Plan.

2.1.1 Energy Conservation Program

The ENCON Program is the master plan that lays down the framework for developing renewable energy and improving energy efficiency in Thailand. Since the establishment of the ENCON program in 1995, implementation can be divided into three phases: phase 1 1995–1999, phase 2 2000–2004, and phase 3 2005–2011 (Table 2.1).

Table 2.1: Results of Energy Conservation Program, 1995–2007

	Result	
Implementation	**Energy saving** (ktoe/year)	**Cost saving** (B million)
Energy conservation and efficiency (industrial, commercial, residential, building)	1,117	29,220
Energy conservation and efficiency (transport)	437	13,443
Renewable energy utilization (including NGV)	3,586	53,126

ktoe = thousand tons of oil equivalent

Source: Energy Policy and Planning Office 2008

After more than 10 years of implementation, the program was revised during phase 3. The revised phase 3 is characterized as a rolling plan, which is subject to revision every year due to the changing factors. In general, the program has three implementation programs: the Renewable Energy Development Program, the Energy Efficiency Improvement Program, and the Strategic Management Program (Table 2.2).

Table 2.2: Energy Conservation Program, Phase 3

Renewable Energy Development Program	Energy Efficiency Improvement Program	Strategic Management Program
Focus: ethanol, biodiesel, solar, wind, hydropower, biomass, biogas, waste heat, municipal waste	Focus: transport, industry, residential, commercial, and building	Focus: management and planning
Implementation: • Research and development • Development and demonstration • Human resource development • Public relations • Management	Implementation: • Research and development • Development and demonstration • Human resource development • Public relations • Management	Implementation: • Policy study • Administrative and management works • Others
Target: 12.2% of alternative energy share (9.2% of renewable energy and 3.0% of NGV) in 2011	Target: To reduce energy consumption by 10.8% (4.4% for industry, 4.7 for transport, and 1.7% for commercial, residential, building)	

Source: Energy Policy and Planning Office 2008

2.1.2 The 15-Year Renewable Energy Development Plan (2008–2022)

The importance of renewable energy development and utilization is recognized in Thailand, and there is a comprehensive policy to promote renewable energy, especially in power and fuel production. Based on domestic resources and potentials, the Government of Thailand formulated the 15-Year Renewable Energy Development Plan (REDP) to (i) strengthen the security of energy provision; (ii) promote the use of energy for an integrated green community; (iii) support the alternative energy technology industry; and (iv) research, develop, and promote high-efficiency alternative energy technologies (Ministry of Energy 2009). Solar, wind, hydropower, biomass, biogas, municipal waste, ethanol, biodiesel, and hydrogen are renewable energy sources that are set to be developed under the REDP. It is expected that, when the REDP is successfully implemented, there will be greenhouse gas reductions of around 42MtCO_2eq in 2022 (Ministry of Energy 2009) (Table 2.3).

Table 2.3: The 15-Year Renewable Energy Development Plan

Energy	Potential	Existing	2006–2011		2012–2016		2017–2022	
Electricity	**MW**	**MW**	**MW**	**ktoe**	**MW**	**ktoe**	**MW**	**ktoe**
Solar	50,000	32	55	6	95	11	500	56
Wind	1,600	1	115	13	375	42	800	89
Hydropower	700	56	165	43	281	73	324	85
Biomass	4,400	1,610	2,800	1,463	3,220	1,682	3,700	1,933
Biogas	190	46	60	27	90	40	120	54
Municipal waste	400	5	78	35	130	58	160	72
Hydrogen			0	0	0	0	3.5	1
Total		1,750	3,273	1,587	4,191	1,907	5,608	2,290
Heat	**ktoe**	**ktoe**		**ktoe**		**ktoe**		**ktoe**
Solar	154	1		5		18		38
Biomass	7,400	2,781		3,660		5,000		6,760
Biogas	600	224		470		540		600
Municipal waste		1		15		24		35
Total		3,007		4,150		5,582		7,433
Biofuel	**Million liters/day**	**Million liters/day**	**Million liters/day**	**ktoe**	**Million liters/day**	**ktoe**	**Million liters/day**	**ktoe**
Ethanol	3.00	1.24	3.00	805	6.20	1,686	9.00	2,447
Biodiesel	4.20	1.56	3.00	950	3.64	1,145	4.50	1,415
Hydrogen			0	0	0	0	0.1 m kg	124.00
Total			6.00	1,755	9.84	2,831	13.50	3,986
Final Energy Consumption (ktoe)		66,248		70,300		81,500		97,300
Final Renewable Energy Consumption (ktoe)		4,237		7,492		10,319		13,709
Percent of Renewable Energy (%)		**6.4**		**10.6**		**12.7**		**14.1**
NGV (mmscfd)		108.1	393	3,469	596	5,260	690	6,090
(ktoe)				10,961		15,579		19,799
Percent of Alternative Energy (%)				**15.6**		**19.1**		**20.3**

ktoe = thousand tons of oil equivalent, Mmscfd = million standard cubic feet per day, MW = megawatt. Source: Ministry of Energy 2009

There are three key strategies in implementing the plan: supporting the production and utilization of renewable energy, supporting research and development into renewable energy, and raising awareness and knowledge dissemination (Table 2.4).

Table 2.4: Implementing the 15-Year Renewable Energy Development Plan

Strategy	Measures
Supporting the production and utilization of renewable energy	• Having fair incentive measures for renewable energy development • Having public participation for developing and utilizing renewable energy • Revising adder costs, providing fiscal and financial incentives, supporting the investment through ESCO, supporting renewable energy projects for the CDM, and announcing registrations for facilitating the development of renewable energy • Establishing standards for renewable energy, supporting renewable energy industry, and creating knowledge transfer
Supporting research and development into renewable energy	• Allotting the budget for and collaborating on upstream and downstream developments in researching and demonstrating renewable energy technologies, and extending the research and knowledge sharing • Studying energy management alternatives at both macro and micro scales
Raising awareness and knowledge dissemination	• Raising awareness among all stakeholders of the importance of renewable energy • Disseminating the policy and plan on renewable energy to the public • Establishing renewable energy network for knowledge sharing, arranging workshops and seminars • Establishing academic curriculum on renewable energy for students

Source: Ministry of Energy 2009

2.1.3 The 20-Year Energy Conservation Plan (2011–2030)

In 2011, the Government of Thailand launched a comprehensive plan—the 20-Year Energy Conservation Plan—on energy efficiency focusing on the transport, industry, commercial, and residential sectors (Ministry of Energy 2009). The plan is intended to be a long-term plan for energy conservation and energy efficiency (the previous approach on energy conservation and efficiency was only short term). Under the plan, it is expected that greenhouse gas emissions will be reduced by about 49 $MtCO_2eq$ by 2030 (Ministry of Energy 2009).

The target of the plan (Table 2.5) is to reduce energy intensity by 8% in 2015, by 15% in 2020, and by 25% in 2030 (the reduction of energy intensity is about 1.5% annually) compared with the base year (2005), and to reduce final energy consumption at 20% in 2030.

Table 2.5: Target for Energy Conservation under the 20-Year Energy Conservation Plan

Sector	Technical Potential			Target (ktoe)	Ratio (%)
	Heat (ktoe)	Electricity (GWh)	Total (ktoe)		
Transport	16,250	0	16,250	13,400	44.7
Industry	10,950	33,500	13,790	11,300	37.7
Commercial and residential					
Large building	410	27,420	2,740	2,300	7.6
Small building and residential house	1,690	23,220	3,670	3,000	10.0
Total	**29,300**	**84,140**	**36,450**	**30,000**	**100.0**

GWh = gigawatt hour, ktoe = thousand tons of oil equivalent

Source: Ministry of Energy 2011a

To achieve the target, the plan includes a number of policy measures for promoting energy efficiency—energy standards and regulations, capacity building, energy efficiency networking, awareness raising, and financial incentives (Table 2.6).

Table 2.6: Implementing the 20-Year Energy Conservation Plan

Strategy	Measure
Using regulations and standards	• Enforcing law and regulation • Using mandatory □abelling • Minimum energy performance standards • Energy efficiency resources standards
Promoting and supporting energy conservation	• Voluntary agreement (for energy conservation) • Measures to support the use of energy □abelling for products, buildings, and vehicles • Measures to support mass transportation and high-efficiency logistics systems • Measures to support investment in energy conservation through DSM bidding (for large business) and standard offer program (for SMEs) • Support ESCOs through ESCO Fund
Raising awareness and changing behaviors	• Supporting the concepts of a low-carbon society and low-carbon economy • Setting energy prices to reflect the true costs and use taxes as a tool to support energy conservation
Supporting the development of technologies and innovations	• Measures to support research and development for increasing energy efficiency of technologies and for reducing the cost of technologies • Measures to support the demonstration of high and advanced technologies and to support the deployment of technologies
Building capacity for human resources and institutes	• Measures to support ESCOs to be in charge of managing and implementing energy conservation • Measures to support capacity building for government and private agencies and institutes to be in charge of planning, controlling, and supporting the implementation of energy conservation

ESCOs = energy service companies, SMEs = small and medium-sized enterprises.

Source: Ministry of Energy 2011a

2.2 Current Pledges and Implications of Sector Policies

With the realization of the importance of energy security and climate change in Thailand, there has been investment in greenhouse gas emissions mitigation investments in several sectors. In general, most pledges and actions for reducing greenhouse gas emissions that have been given and taken are considered to be "no-regret"[3] policies and actions. Most of these implementation approaches are related to energy efficiency, renewable energy (based on local resources and potentials), forest conservation, and afforestation and reforestation. Additionally, least-cost policy options are being implemented in the energy sector. However, most sectors do not have clear greenhouse gas reduction targets (in terms of $MtCO_2eq$); most targets are set based on the policies, plans, and actions themselves, which are usually implemented in more than one sector. The details of pledges and actions for each sector are described in sections 2.2.1–2.2.7.

[3] No-regret policies and actions can be referred to as policies and actions that create economic benefits (or at least no economic losses) and result in reduction of greenhouse gases.

2.2.1 Energy and Power Sector

2.2.1.1 Alternative and Renewable Energy

Since the beginning of the ENCON Program in Thailand, the government has adopted numerous policies and measures to ensure renewable energy is developed and utilized. In the last few years, the 15-Year Renewable Energy Development Plan (REDP) was introduced to strengthen the development of renewable energy. Table 2.7 details the types of policy approaches and measures being implemented in Thailand under the ENCON program and REDP.

Table 2.7: Policy Measures for Renewable Energy in Thailand

Policy Measure	Implementation
General policy	Yes
Promotion target	Yes
Fiscal and financial incentive	Tax incentives, Revolving Fund, ESCO Fund, grant, and adder costs[a]
Grid access assurance	Yes
Power purchase assurance	Yes
Pricing assurance	Yes

[a] The measures are described in chapter 3.

Source: Author's summary

Based on recent information, progress on renewable energy development in Thailand has been made, especially in biogas and biofuels (Table 2.8).

Table 2.8: Renewable Energy Utilization, 2010

Renewable Energy Source		Utilization
Wind (MW)		5.61
Solar	Electricity (MW)	48.57
	Heat (ktoe)	2.14
Hydropower (MW)		58.85
Biomass	Electricity (MW)	1,650.00
	Heat (ktoe)	3136.00
Biogas	Electricity (MW)	103.40
	Heat (ktoe)	311.00
Municipal waste	Electricity (MW)	13.13
	Heat (ktoe)	1.09
Ethanol (million liters/day)		1.23
Biodiesel (million liters/day)		1.72

ktoe = thousand tons of oil equivalent, MW = megawatt

Source: Department of Alternative Energy Development and Efficiency 2011a

2.2.1.2 Research and Development into New Technologies

Research and development into new environmental and energy technologies, especially for renewable energy, are being carried out by several organizations, with second- and third-generation technologies under development. Advanced energy efficiency technologies are also undergoing research and development.

2.2.1.3 Implications of Energy Sector Policies

The launch of renewable energy promotion policies and measures has had implications for the power and fuel production industry. One of the key implications is the substantial growth of the sector, especially small and very small power producers (SPPs and VSPPs). Policy measures allowed small producers to join the energy production sector (financially) and attracted investors to renewable energy projects. The growth of the energy production sector is a reflection of the increasing number of renewable energy projects in Thailand, especially in biomass, biogas and biofuel.

Another key implication is on national energy security. Introducing renewable energy promotion policies and measures has increased the energy security of the nation. Developing and utilizing renewable energy increases energy availability, enhances energy diversity, augments the availability of clean energy technologies, improves the role of the private sector in power production, reduces dependency on imported energy, and reduces greenhouse gas emissions from power production.

However, there are some concerns regarding development and utilization of renewable energy—such as competition for resource utilization, forest intrusion, and the "food versus fuel" issue. Moreover, some current incentives may not be sufficient to attract investment in some renewable energy sources, such as wind power.

2.2.2 Industry Sector

2.2.2.1 Greenhouse Gas Reduction through Energy Conservation and Efficiency

Thailand began to take serious action on energy conservation and efficiency in the early 1990s. One of the notable programs to promote energy conservation and efficiency in the industry sector is the national Energy Conservation (ENCON) Program It comprises a number of compulsory, voluntary, and complementary measures and activities (Table 2.9). Energy conservation and efficiency measures in the industry sector are summarized in Table 2.9.

Table 2.9: Energy Efficiency Instruments Implemented in the Industry Sector

Policy Measure	Implementation
Equipment/appliance labeling	Yes
Building codes (factory)	Yes
Energy audits	Yes
Fiscal and financial incentive	Revolving Fund, ESCO Fund, tax incentives, subsidy, and DSM biding[a]
Private sector participation	Yes
Awards	Yes
Campaign programs	Yes

[a] = Described in Chapter 3

Source: Author's summary

2.2.2.2 Other Actions for Energy Efficiency

In addition, other government and nongovernment agencies have promoted energy efficiency in the industry sector. Energy efficiency can be targeted at both technology and human improvements. One of the comprehensive approaches to promoting energy efficiency is total

energy management (TEM),[4] which takes into account both technological improvements and employee training for energy efficiency and conservation.

Greenhouse Gas Reduction Through Labeling Schemes

The **Carbon Reduction Label** is a label that shows reduced greenhouse gas emissions of the product or service (for the same manufacturer compared with base year [2002]) in terms of carbon dioxide (CO_2) equivalent. It has been established through cooperation between the Thailand Greenhouse Gas Management Organization (TGO) and the Thailand Environment Institute (TEI). The aims are to encourage manufacturers and consumers to be a part of greenhouse gas emission reduction. During the initial stage (up until November 2011), the scope of evaluation for greenhouse gas reduction has been limited solely to the production stage. The implementation and implementation results of the Carbon Reduction Label are in Box.1.

In addition to the Carbon Reduction Label, there are other labeling schemes related to greenhouse gas emission reductions, including Carbon Footprint, CoolMode, Green Label, and Energy Efficiency Label (non-electrical). **Carbon Footprint** is a label showing greenhouse gas emissions from each production unit for the product life cycle (cradle to grave), i.e., the calculation of greenhouse gas emissions emitted from raw material extraction, transportation, production, utilization, and waste management of product. The aims of the Carbon Footprint label are to increase the attention of the industry sector on greenhouse gas emissions and to increase the competitiveness of Thai industries in the world market. As of September 2011, there were 233 products from 68 companies certified with Carbon Footprint (TGO 2011c).

CoolMode is a label initiative for clothing showing the reduction of greenhouse gas emissions as a result of reduced electricity consumption. The label will be issued to textile manufacturers who make materials that are comfortable to wear and breathable, allowing for decreased energy consumption due to reduced need for air conditioning. Furthermore, the fabric should be easy to clean to reduce water consumption. The aims are to encourage the textile industry to develop CoolMode fabrics for selling in the domestic and export market and to give consumers more options to reduce greenhouse gas emissions. As of September 2011, 18 types of fabric from six companies were certified with CoolMode (TGO 2011a).

Green Label is a Type I eco-label, which awards specific products that have reduced environmental impacts from a life-cycle perspective than other products with the same function. An initiative of the Thailand Business Council for Sustainable Development (TBCSD), the Green Label was launched in 1994 by the Thailand Environment Institute (TEI) in association with the Ministry of Industry. From the initial period to June 2011, there were certification criteria for 48 products, and 506 products from 25 product categories and 75 producers were registered (TEI 2011).

The **Energy Efficiency Label** was initiated by the Department of Alternative Energy Development and Efficiency (DEDE) to address high energy consumption (non-electrical) machines, equipment, and materials. The label covers household gas stoves, variable speed drives, insulators, and energy-saving glass. As of 2009, the Energy Efficiency Label program had issued 577,850 labels for gas stoves, which generated fuel savings equal to 21 thousand tons of oil equivalent (ktoe) and reduced greenhouse gas emissions of 0.118 $MtCO_2eq$/year (Sajjakulnukit 2011).

[4] Details of the TEM approach can be found in the TEM handbook: available at http://www.asiaeec-col.eccj.or.jp/cooperation/1-1-1/01.pdf

2.2.2.3 Implications of Industry Sector Policies

Implemented alternative and renewable energy and energy conservation and efficiency measures have a number of positive implications for sector policy and the economy. The first is awareness of energy and environmental issues in the industry sector. Because burgeoning industrial development in Thailand brought environmental and high-energy consumption problems along with economic growth, the Government of Thailand introduced environmental regulations as well as energy conservation and efficiency measures (both compulsory and voluntary). This led the industry sector to incorporate environmental rationalities as well as energy conservation and efficiency principles into corporate principles and practices. However, the implementation of these principles varies by industry and company.

The second implication is the utilization of wastes and unused materials for energy production. Renewable energy incentive schemes made it possible to utilize wastes and unused materials to generate power and electricity. This brings financial and environmental benefits to both the company and the environment.

The third implication is the competitiveness of the industry sector and growth of the national economy. The implementation of energy conservation and efficiency measures is related to technical and behavioral changes, which manifested as lower energy consumption (lower energy costs). As a result, the competitiveness of Thai industries has increased, allowing them to compete globally. This is especially true for export-oriented industries such as the electrical and electronics industry and the food processing industry. Increased competitiveness also contributes to national economic growth in terms of revenue from exports.

The fourth implication is the environmental and climate change awareness of consumers. Since the emergence of the Green Label (in 1992) and now with the current initiatives on carbon labeling (Carbon Reduction Label, Carbon Footprint, and CoolMode), awareness of consumers on environmental issues, especially climate change, has significantly increased. This is reflected in the survey, Thai People with Global Warming, conducted in Bangkok and other large cities in Thailand including in Chiang Mai province, Khonkaen province, and Songkhla province by Assumption University. The survey shows that more than 97% of the population were aware of global warming, more than 82% perceived that global warming posed a threat to the national economy, and more than 67% were concerned that global warming would pose a threat to their working conditions (Assumption University, cited in Chotichanathawewong and Thongplew 2009). One reason that climate change and global warming have become well known is because of the labeling schemes.

Box 1: Case Study: Carbon Reduction Label

Implementation:

- Aims to encourage manufacturers and consumers to mitigate greenhouse gas emissions through everyday purchasing
- 151 products from 37 manufacturers obtained Carbon Reduction Label (as of September 2011) (Vongvanich 2011)
- Certified products include food and beverages, personal products, packaging, equipment, and construction materials

Key results and implications:

- Greenhouse gas emission reduction from this program is estimated at 4.47 $MtCO_2eq$ (as of September 2011) (Vongvanich 2011)
- Climate change awareness is increasing among manufactures and consumers, and greenhouse gas mitigation actions have been taken

2.2.3 Commercial and Residential Sector

2.2.3.1 Greenhouse Gas Reduction through Energy Conservation and Efficiency

The Government of Thailand has implemented a number of measures on energy conservation and efficiency in the commercial and residential sector (under the ENCON Program). Several policy measures for promoting energy efficiency (Table 2.10) are being implemented under demand-side management and other policies—energy standards and regulations, capacity building, energy efficiency networking, awareness raising, and financial incentives.

In the commercial sector, implemented activities promote the use of energy efficient equipment and energy conservation. Most fiscal and financial measures for promoting energy efficiency in the commercial sector are the same as those in the industry sector—Revolving Fund, ESCO Fund, tax incentives, and subsidy.

In the residential sector, implemented measures are mostly campaigns promoting energy efficient appliances and creating awareness on energy saving. It is estimated that the demand-side management program can reduce the demand for electricity by 120 MW/year (du Pont 2005). One of the ongoing energy efficiency activities implemented under the demand-side management program is the Energy Efficiency Label (Energy Label No. 5). The program is targeted at reducing the use of high energy consumption appliances and products through energy efficiency certification. The Energy Label No. 5 program is regarded as successful (du Pont 1998; Singh and Mulholland 2000).

Table 2.10: Energy Efficiency Instruments Implemented in the Commercial and Residential Sector

Policy Measure	Commercial/ Residential	Implementation
Equipment/appliance labeling	Commercial	Yes
	Residential	Yes
Building codes	Commercial	Yes
	Residential	No
Energy Audits	Commercial	Voluntary
	Residential	
Fiscal and financial incentives	Commercial	Revolving Fund (ENCON Fund), ESCO Fund, Tax incentives, and Subsidy*
	Residential	No
Energy efficiency networking	Commercial	Yes
	Residential	No
Awards	Commercial	Yes
	Residential	Yes**
Campaign programs	Commercial	Yes
	Residential	Yes

* Described in Chapter 3.

**Energy conservation award for homes

Source: Author's summary

2.2.3.2 Implications of Commercial and Residential Sector Policies

The implication of energy conservation and efficiency measures for the commercial and residential sector is increasing concern in Thai society on energy efficiency. Further, appliance producers can continue to manufacture more efficient products.[5]

2.2.4 Building Sector

2.2.4.1 Greenhouse Gas Reduction through Energy Conservation and Efficiency

Most of the energy conservation and energy efficiency measures for the building sector are implemented in combination with the commercial and residential sector (under the ENCON Program). The measures for buildings are building codes and regulations, capacity building, energy efficiency networking, awareness raising, and financial incentives.

One discrete policy measure exists for the building sector, whereby energy management is implemented for designated buildings and factories and building energy codes are implemented for new buildings.

2.2.4.2 Carbon Reduction Certification for Building

Carbon Reduction Certification for Building is a voluntary initiative of the Thailand Environment Institute (TEI) and the Thailand Business Council for Sustainable Development (TBCSD) introduced in 2010. Its aim is to encourage nonresidential building owners to reduce greenhouse gas emissions through reduced of electricity consumption, fossil fuel consumption,

[5] Energy Label No. 5 is discussed further in section 3.

and waste generation. This certification scheme allows building owners to declare their intention to reduce greenhouse gas emissions and communicate this to the public. This scheme also creates a commitment by and incentives for building owners to continue to improve their greenhouse gas emissions reduction strategies and actions for the building. As of September 2011, eight buildings from five companies had been awarded with the Carbon Reduction Certification for Building, resulting in greenhouse gas emission reductions of around 16,000 tons CO_2eq/year (compared with base year in 2002) (Thailand Environment Institute 2011b).

2.2.4.3 Implications of Building Sector Policies

It is clear that policy measures and voluntary activities in energy conservation and efficiency in the building sector have resulted in increasing awareness on energy efficiency and climate change. As a result of enforced standards, codes, awards, and labeling schemes, the building sector, and especially designated buildings, have adopted the concept of energy conservation and efficiency and implemented energy conservation and efficiency measures in order to comply with regulations. Some proactive organizations take further actions in order to be seen as leaders in energy efficiency by applying for the international green building certification – Leadership in Energy and Environmental Design (LEED).

2.2.5 Transport Sector

2.2.5.1 Greenhouse Gas Reduction through Alternative and Renewable Energy

In the transport sector, use of biofuels (gasohol and biodiesel) is promoted on both the demand and supply sides. Demand-side measures are the mandatory and voluntary uses of gasohol and biodiesel for vehicles. One mandatory measure applies to diesel fuel, whereby diesel for vehicles is diesel B3 (3% biodiesel). Additionally, price incentives for consumers are implemented in some high-percentage biofuels (E10, E20, E85, and B5).

On the supply side, measures are implemented under the REDP, which are described in the sections of background information (Section 2.1.2) and pledges and policy actions of energy and power sector (Section 2.2.1) (fiscal and other incentive measures are implemented for ethanol and biodiesel producers).

The government also gives strong support to the use of compressed natural gas (CNG) in the transport sector, including public transport (buses and taxis) by subsidizing the retail price. Within the last few years, the demand for CNG for vehicles has substantially increased due to the high price of gasoline and the subsidized price of CNG. The number of fuelling stations has increased to serve the demand for CNG.

2.2.5.2 Greenhouse Gas Reduction through Energy Efficiency and Public Transport

Other energy efficiency transport sector policies are “eco cars”, public transport, and park-and-ride scheme policies. The eco car policy provides incentives for car manufacturers to produce cars that have small engines, are energy efficient, and have low fuel consumption and high emission standards. The extension of mass public transport, especially in Bangkok, is another government policy—BTS skytrain, MRT system, and Bus Rapid Transit are new public transport systems in the Bangkok metropolitan area. The BTS Skytrain is a mass public transport system with extended coverage in Bangkok and vicinity. The MRT system (also known as Bangkok Metro) is an underground mass rapid transit system, which also has an extension plan. Bus Rapid Transit carries commuters between suburbs and the city. The park-and-ride scheme provides parking areas for commuters in outer areas so they can then travel to the city using skytrains and underground trains.

2.2.5.3 Implications of Transport Sector Policies

Introducing biofuels, natural gas, and eco car policies has a number of implications for the transport sector. Car manufacturers have adapted to changes in government policy by introducing new cars to the market, such as eco cars (high fuel efficiency and low emissions) and cars that use biofuels.

Another implication is the change in fuel use for vehicles. Because of the higher cost of gasoline, many car users, including personal car users, have modified their cars for CNG use. The switch from gasoline to CNG has occurred mostly in areas where there are natural gas fuelling stations available, especially in big cities such as Bangkok.

The other implication is the use of public transportation among people in Bangkok and surrounded areas. BTS skytrain and MRT system have become the main choice of commuters traveling from suburbs to the city and commuting within the city.

2.2.6 Agriculture Sector

Recently, the Government of Thailand implemented an agricultural plan on climate change (including both greenhouse gas mitigation and adaptation), which focuses on research and development for new plants (high yield and resistance, and low maintenance and inputs), plantations, production of agricultural products, agricultural technologies, and logistics. However, implementation is still in the early stages.

2.2.7 Other Pledges and Actions

2.2.7.1 Greenhouse Gas Reduction Through Forest Conservation and Afforestation and Reforestation

The aim of the key national forest policy is to have at least 40% of the country's area as forest, which is to be utilized for two primary purposes. The first purpose is for conservation (conserving soil, water, plants, and wild animals), including for study, research, and recreation (25% of the national area) (Royal Forest Department 2011b). The second purpose is for forest to be used economic purposes (15% of the national area).

The forest area in Thailand decreased to 25% in the late 1990s. Since then, forest areas have continuously increased as a result of forest conservation, afforestation, and reforestation activities. In 2008, national forest coverage is about 33.5%. Thus, the activities on forest conservation, afforestation, and reforestation will be continued in order to increase the forest areas.

Table 2.11: Forest Areas in Thailand

Year	Forest Area (km^2)	Percentage of forest to total area
1973	221,707.00	43.21
1976	198,417.00	38.67
1978	175,224.00	34.15
1982	156,600.00	30.52
1985	150,866.00	29.40
1988	143,803.00	28.03
1989	143,417.00	27.95
1991	136,698.00	26.64
1993	133,554.00	26.03
1995	131,485.00	25.62
1998	129,722.00	25.28
2000	170,110.78	33.15
2004	167,590.98	32.66
2005	161,001.30	31.38
2006	158,652.59	30.92
2008	171,585.65	33.44

km^2 = square kilometer.

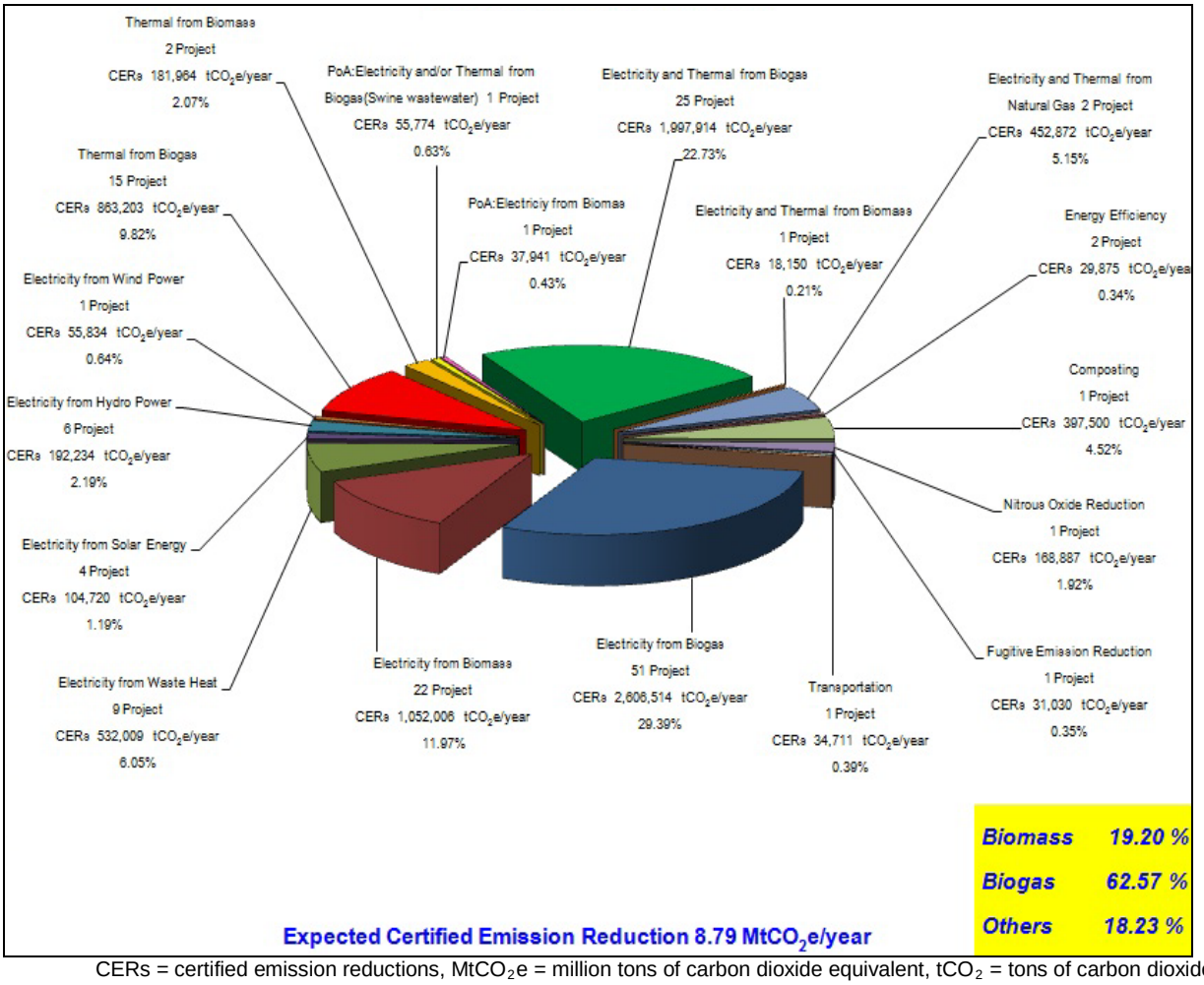
Source: Royal Forest Department 2011

2.2.7.2 Greenhouse Gas Reduction through the Clean Development Mechanism

Thailand as a developing country is listed as a non-Annex I Party, and thus does not have an obligation to mitigate greenhouse gas emissions under the Kyoto Protocol. However, Thailand participated in greenhouse gas emissions reduction under the Kyoto Protocol through the Clean Development Mechanism (CDM). In Thailand, the CDM has played a significant role in greenhouse gas mitigation because it has helped make greenhouse gas emissions reduction more feasible.

As of 1 October 2010, the Thailand Greenhouse Gas Management Organization had issued 146 letters of approval for CDM projects. From these projects, it is estimated that the total greenhouse gas emissions reduction will be 8.79 million tons of CO_2 equivalent ($MtCO_2eq$) per year, of which CDM biogas project activities account for 62% and biomass project activities 19% (Thailand Greenhouse Gas Management Organization 2011b) (Figure 2.1).

Figure 2.1: Clean Development Mechanism Projects in Thailand Receiving Letters of Approval

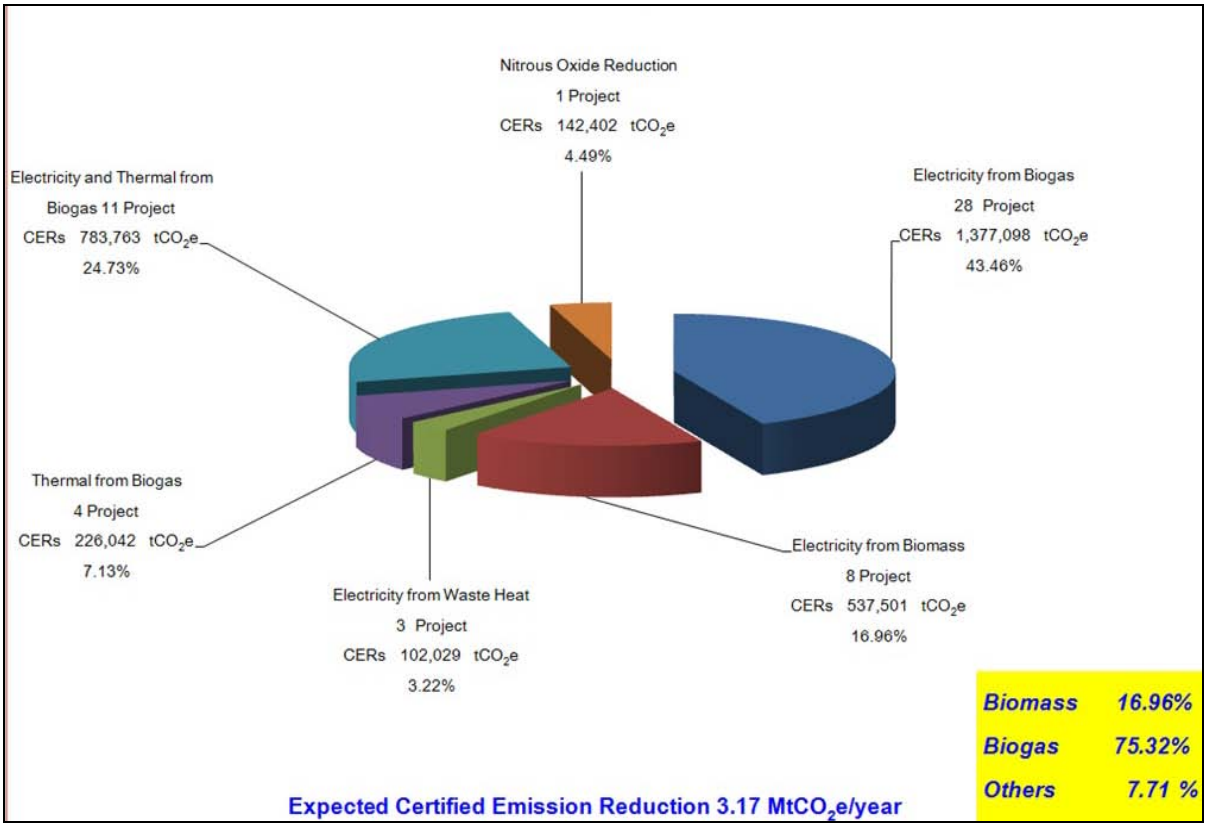


CERs = certified emission reductions, $MtCO_2e$ = million tons of carbon dioxide equivalent, tCO_2 = tons of carbon dioxide.

Source: Thailand Greenhouse Gas Management Organization 2011b.

Of the CDM projects receiving letters of approval, 55 are registered by the CDM executive board. The total greenhouse gas emissions reduction of registered CDM projects is estimated at 3.17 $MtCO_2eq$ per year (Thailand Greenhouse Gas Management Organization 2011b).

Figure 2.2: Clean Development Mechanism Projects in Thailand Registered by the Clean Development Mechanism Executive Board



CERs = certified emission reductions, $MtCO_2e$ = million tons of carbon dioxide equivalent, tCO_2 = tons of carbon dioxide.
Source: Thailand Greenhouse Gas Management Organization 2011b.

2.2.7.3 Thailand Business Council for Sustainable Development

The Thailand Business Council for Sustainable Development (TBCSD) is a group of more than 30 leading companies in Thailand working toward sustainable development. As individual companies, members have strived for environmental improvements and sustainable development. Several actions have been taken to improve environmental performance, including the mitigation of greenhouse gas emissions. Based on the last computation for greenhouse gas emission reduction mitigated through actions on carbon sinks and sourced from TBCSD members, greenhouse gas reductions were 10.47 $MtCO_2eq$ for 2008–2010 (Thailand Business Council for Sustainable Development 2011).

2.2.7.4 Private Fragmented Efforts for Reducing Greenhouse Gas Emissions

Greenhouse gas emissions reduction is a recent initiative in the private sector. Several enterprises and companies have implemented activities to reduce greenhouse gas emissions by creating carbon sinks and reducing carbon emissions. One of the most implemented activities is creating carbon sinks through afforestation and reforestation. To reduce carbon emissions, a number of manufacturing companies implemented internal environmental improvement activities—such as 3Rs, changing fuels, and eco-efficiency—to improve their environmental performance and reduce emissions.

Box 2: A Case Study on the Private Sector Participation in GHG Emissions Reduction

Siam Cement Group (SCG):

Policies and implementation for GHG emission reduction

- Production processes (Siam Cement Group 2011)
- Reduce GHG emissions per unit of production by 10% in 2022 (3-27% reduction for Scope 1 and 3-6% reduction for Scope 2 in 2010)
- Utilize renewable energy (utilized 14% in 2010)
- Supply chain (Siam Cement Group 2011)
- Green procurement (purchasing volume is 1,352 million Baht in 2010)
- Greening the supply chain (assisted 34 suppliers to meet the green procurement guideline in 2010)
- Green products and services (under self-declared eco-label: SCG eco value) (Siam Cement Group 2011)
- Develop SCG eco value products (39 products and services with more than 270 items use eco value products)

Driving factors

- Comprehensive business philosophy and codes of conduct: Sustainable development and environmental concerns are integrated into its business philosophy and codes of conduct
- Strategic CSR and proactive approach: Sustainable committee and other working committees concerning environmental responsibility were formed in order to carry out, monitor and improve the implementation.

2.2.8 Summary of Sector Pledges and Actions

Sector pledges and actions for mitigating greenhouse gas emissions have been made in many sectors in Thailand (Table 2.12). These aim to not only reduce greenhouse gas emissions through renewable energy and efficiency but also create greenhouse gas sinks through forest conservation, afforestation, and reforestation. Several implementation approaches have been used to achieve greenhouse gas emission reductions, including mandatory measures, voluntary measures, incentive provisioning, capacity building, and raising awareness.

Table 2.12: Summary of Sector Pledges and Actions

Sector	Pledges and Actions	Greenhouse Gas Reduction
Energy and power	Renewable Energy Development Plan	42 $MtCO_2eq$ in 2022 (shared target among energy and power sector and transport sector)
Industrial	National Energy Conservation Program (ENCON)	…
	20-Year Energy Conservation Plan (recently introduced in 2011)	49 $MtCO_2eq$ in 2030 (shared target among transport, industry and commercial, residential, and building sectors)
	Labeling schemes: Carbon Reduction Label, Carbon Footprint, CoolMode, Green Label, Energy Efficiency Label (non-electrical)	Carbon Reduction Label has a total reduction of 4.47 $MtCO_2eq$ (2007–2011) Energy Efficiency Label (non-electrical) has reductions of 0.118 $MtCO_2eq$/year (as of 2009)
Commercial and residential	ENCON (only demand side management measures)	…
	Energy Efficiency Label (Energy Label No.5)	12.6–17.4 $MtCO_2eq$ (1993–2004) and additional 14.7–27.6 $MtCO_2eq$ until 2010
	20-Year Energy Conservation Plan (recently introduced)	49 $MtCO_2eq$ in 2030 (shared target among transport, industry and commercial, residential, and building sectors)
Building	Energy standard of buildings, building codes, label, and awards	…
	Carbon Reduction Certification for Building	16,000 tons CO_2eq
	20-Year Energy Conservation Plan (recently introduced in 2011)	49 $MtCO_2eq$ in 2030 (shared target among transport, industry and commercial, residential, and building sectors)
Transport	Renewable Energy Development Plan (REDP) through renewable energy (gasohol and biodiesel) and alternative energy (compressed natural gas)	42 $MtCO_2eq$ in 2022 (shared target among energy and power sector and transport sector)
	Eco Cars	…
	Public transport system and Park-and-Ride	…
	20-Year Energy Conservation Plan (recently introduced in 2011)	49 $MtCO_2eq$ in 2030 (shared target among transport, industry and commercial, residential, and building sectors)

Sector	Pledges and Actions	Greenhouse Gas Reduction
Agriculture	Agricultural plan on climate change	…
Other	National forest policy: forest conservation and reforestation	…
	Clean Development Mechanism (CDM)	8.29 $MtCO_2eq$ per year
	Fragmented actions on carbon sinks and sources by Thailand Business Council for Sustainable Development	10.47 $MtCO_2eq$ (2008–2010)
	Fragmented actions on carbon sinks and sources by other parties in the private sector	…

$MtCO_2eq$ = million tons of carbon dioxide equivalent

Source: Authors' summary

2.3 Review and Analysis of Current Subnational Pledges and Actions

2.3.1 Bangkok Metropolitan Area

The Bangkok Metropolitan Administration (BMA) has committed to greenhouse gas mitigation actions. Based on the Action Plan on Global Warming Mitigation 2007–2012, the BMA will reduce greenhouse gas emissions by (i) expanding the mass transit rail system, (ii) promoting the use of renewable energy, (iii) improving building electricity consumption efficiency, (iv) improving solid-waste management and wastewater treatment efficiency, and (v) expanding park areas (BMA 2007).

It is expected that, by the end of 2012, greenhouse gas emission will be mitigated by 15% (9.75 $MtCO_2eq$) compared with the business-as-usual scenario in 2012 (BMA 2007). Details of greenhouse gas emission mitigation for Bangkok is summarized in Table 2.13.

Table 2.13: Bangkok's Action Plan on Global Warming Mitigation, 2007–2012

		Future Greenhouse Gas Emissions (2012)	
	Greenhouse Gas Emissions in 2007 ($MtCO_2eq$)	Business-as-Usual Scenario ($MtCO_2eq$)	BMA Action Plan Implementation ($MtCO_2eq$)
Sector	**2007**	**2012**	
Transportation	21.18	25.30	19.77
Biofuels energy (reduced greenhouse gas)			(0.61)
Electricity	14.86	16	13.75
Waste/Waste water	1.13	1.13	0.95
Waste recycle			(0.28)
Others (estimate 15% of total greenhouse gas emission from other sectors)	5.58	6.36	6.36
Green area	(0.10)	(0.10)	(1.00)
Total	**42.65**	**48.69**	**38.94**

BMA = Bangkok Metropolitan Administration, $MtCO_2eq$ = millions of tons of carbon dioxide equivalent..

Source: Bangkok Metropolitan Administration 2007.

Implication of BMA policy and action. Other implications stem from implementation of the Action Plan on Global Warming Mitigation, the key one being improved environmental quality and livelihood of people in the Bangkok metropolitan area. Several activities directly contribute to this improvement, such as improved public transport and traffic systems, the promotion of biofuel consumption, and enhancement of green areas.

2.3.2 Other Areas

There are other areas pursuing greenhouse gas emissions reduction at the local level through a variety of approaches. The key examples of greenhouse gas emission reduction initiatives being implemented are described in the following sections.

2.3.2.1 Four Low-Carbon Cities

A cooperation initiative between the Thailand Greenhouse Gas Management Organization and local municipalities aims to develop low-carbon city models in four participating cities—Muangklang Municipality, Phuket City, Sikhiu City, and Amphawa Municipality. One of the main outcomes of the project is a handbook for reducing greenhouse gas emissions at the municipality level. This handbook can then be used to create low-carbon cities in other municipalities.

2.3.2.2 Phalaui Island

Phalaui Island is a small island in SuratThanni province, with a population of less than 500. The Department of Alternative Energy Development and Efficiency (DEDE) of the Ministry of Energy is implementing a number of green energy measures and technologies in order to develop the island into a demonstration green community, with effective energy management and green energy technologies. Solar power and wind power are utilized to generate electricity. The project also supports the utilization and/or reutilization of biomass, biogas, and biofuel. Additionally, the use of high-energy-efficiency light bulbs, electrical motors, efficient stoves, and solar-powered drying beds (for producing dried food) is encouraged to improve the livelihood of people, energy use, and the island's environment. Project completion is expected in 2015, and reductions of approximately 250 tons of CO_2eq/year are forecasted (Ministry of Energy 2011b).

2.3.2.3 Samui Island

On Samui Island there are several "green island" and greenhouse gas emission reduction initiatives being separately implemented. These are initiated by government agencies, private partnership, and nongovernment organization–private sector collaboration. Green island approaches include energy efficiency, waste management, and natural resource protection. Because there are several fragmented initiatives being implemented by many stakeholders, and a lack of willingness to cooperate, it is difficult to have much impact on reducing greenhouse gas emissions.

2.3.3 Summary of Subnational Pledges and Actions

Subnational pledges and actions for mitigating greenhouse gas emissions can be found in several areas in Thailand, including big cities, small cities, and tourist destinations (Table 2.14). These pledges and actions are initiated and implemented by government agencies, nongovernment agencies, and the private sector, with the aims of reducing greenhouse gas emissions and creating carbon sinks. This will be achieved by using renewable energy technology, energy efficiency, extending public transport, and afforestation and reforestation.

Table 2.14: Summary of Subnational Pledges and Actions

Area	Pledges and Actions	Greenhouse Gas Reduction
Bangkok	Expanding the mass transit rail system Promoting the use of renewable energy Improving building electricity consumption efficiency Improving solid-waste management and wastewater treatment efficiency Expanding park area	9.75 $MtCO_2eq$ in 2012
1. Muangklang Municipality, Rayong 2. Phuket City, Phuket 3. Sikhiu City, Nakorn Rachasima 4. Amphawa Municipality, Samut Songkhram	Reduced Carbon Footprint for Low-Carbon City	Cannot determine
Phalaui Island	Green island (green energy management and technologies)	250 tons CO_2eq/year
Samui Island	Green island	Cannot determine

$MtCO_2eq$ = millions of tons of carbon dioxide equivalent.

Source: Authors' summary

2.4 Decoupling Economic Growth and Low-Carbon Emissions

There is great potential for Thailand to decouple economic development and low-carbon emissions in Thailand. Renewable energy and energy efficiency are the key potentials. Based upon the evaluation of the ENCON program, the investments for renewable energy and energy efficiency in Thailand provide significant benefits for the country. Financial benefits created by energy saving are greater than financial investment on renewable energy and energy efficiency projects (EPPO Undated). The financial benefits originate from energy saving and reduction of imported energy. Currently, Thailand has high energy intensity, at 16.2 ktoe/billion baht in 2005, and also has high energy elasticity at 0.98 (average for the last 20 years) (Ministry of Energy 2011a). Based on the cost–benefit estimation for the spending budget and financial benefits from energy saving, financial benefits are greater than the spending budget. Thus, if Thailand is able to increase energy efficiency (reduce energy elasticity and energy intensity), this will create a decoupling scenario.

A number of potential energy efficiency and renewable energy technologies in many sectors have potential for the decoupling of economic development and low-carbon emissions. In the industry sector, efficient furnaces, boilers, arc furnaces, chillers, air compressors, and motors have negative abatement costs. In the commercial and residential sector, efficient LPG stoves, compact fluorescent lamps, and air conditioners (Energy Label No.5) have negative abatement costs. In the energy and power sector, biomass and biomass technologies have negative abatement costs (Limmeechokchai et al. 2009).

In Thailand, the main obstacles to promoting decoupling for economic development and low-carbon emissions relate to technologies and behavioral changes.[6]

2.5 Government Strategies for Private Sector Inclusion

The Government of Thailand directed the policies, strategies, and measures to include the private sector in mitigating greenhouse gas emissions. Private involvement in greenhouse gas emissions reduction is witnessed in the improvement of energy efficiency and the development of renewable energy. The Revolving Fund, ESCO Fund, and SPP and VSPP programs are the key milestones for private sector inclusion for greenhouse gas emissions reduction because the energy and power sector has never before had such deep participation from the private sector. Commercial banks, energy service companies, and investors (in renewable energy and energy efficiency) are included in implementation mechanisms for greenhouse gas mitigation.

It should be noted that voluntary implementation of greenhouse gas emissions reduction can be effective. For example, the Energy Efficiency Label and CDM are voluntary measures that involve the private sector and are effective in mitigating greenhouse gas emissions. It is also noted that financial incentives may play a crucial role in the effectiveness and success of the measures implemented in the private sector.

The other thing to note is that the private sector is very effective in implementing renewable energy and energy efficiency projects. As soon as there are windows of opportunity, the private sector will initiate renewable energy and energy efficiency works to reduce greenhouse gas emissions.

2.6 Major Strengths and Weakness of Current Policy Actions and Strategies

The following are the strengths and weaknesses of current key policies and plans pertaining to renewable energy, energy efficiency, and greenhouse gas emissions reduction.

2.6.1 Overview of Strengths

2.6.1.1 Comprehensive Plans and Actions for Addressing Renewable Energy and Energy Efficiency

Several factors have been taken into account in formulating renewable energy and energy efficiency plans. Several studies were conducted to assess availability of potentials and resources. These results were incorporated into the formulation of renewable energy and energy efficiency plans.

One of the fundamental factors that can promote the decoupling of economic development and greenhouse gas emissions reduction is the utilization of local and abandoned resources. It is evident that renewable energy and energy efficiency plans acknowledged the availability of local and abandoned resources, such as using agricultural biomass for producing energy, using oil palm and sugar cane for producing biofuels, and using municipal wastes and animal wastes for generating biogas.

[6] These obstacles are elaborated upon in Section 2.6.2.

2.6.1.2 Innovative Measures

The Government of Thailand has adopted a number of innovative measures to promote the development and utilization of renewable energy and energy efficiency. These include financial incentives, fiscal incentives, direct subsidies, and barrier removal for the deployment of environmentally friendly technologies. Some measures can eliminate financial barriers and reduce other concerns for investors and entrepreneurs with regard to the promotion of renewable energy and energy efficiency.

2.6.1.3 Public–Private Partnership

The government policies and strategies allow the private sector to take charge in implementing renewable energy and energy efficiency measures. For renewable energy, SPPs and VSPPs, where private investors can invest in the power generation industry and supply electricity to the Electricity Generating Authority of Thailand (EGAT), are clear examples of public–private partnership. In the case of energy conservation and efficiency, the Revolving Fund and ESCO Fund, where investors and commercial banks participate in developing renewable energy and energy efficiency projects, are explicit forms of public–private partnership. With such an active private sector role, the development of renewable energy and energy efficiency will be further advanced.

2.6.2 Overview of Weaknesses

2.6.2.1 Lack of Financial Incentives

Even though a number of incentives are provided for renewable energy and energy efficiency projects, they may not overcome the financial investment of some projects, where the investment cost is very high. Wind energy and solar energy are examples of renewable energy projects where this applies.

2.6.2.2 Need for Resource Management

A conflict over resource use is a concern for promoting renewable energy. Local resources and abandoned materials can become valuable when there are increasing demands for such resources. Additionally, some resources can be utilized for many purposes; e.g., rice husks are a common agricultural residue in Thailand, and they can be used for electricity generation for the cement industry and for agricultural activities. Such a situation can create a conflict for the resources. As a result, it is essential for concerned parties to plan and manage resource utilization.

2.6.2.3 Lack of Cooperation and Aggregation of Fragmented Efforts

From time to time, mitigation actions and projects have been implemented in one geographic area by several groups. Some of these activities and program have the same goal and objective, but they are implemented by different groups. In this situation, there may be overlap of the work and conflicts among the implementation groups. For effective implementation in reducing greenhouse gas emissions, there should be cooperation among all groups carrying out the activities. This can be achieved by drafting a clear plan and targets with the involvement of all stakeholders.

2.6.2.4 Low Civil Society Involvement

It is noticeable that greenhouse gas reduction policies and actions concerning civil society are mostly awareness rising and promotional campaigns. These measures and actions do not

create a commitment to reducing greenhouse gas emission from civil society. As a result, it is difficult to set a clear target for greenhouse gas emissions reduction and to actually reduce greenhouse gas emissions. Thus, it may be useful to consider the policies and measures to promote greenhouse gas reductions among civil society by involving people at a deeper level. Providing incentives (such as providing financial incentives for reducing electricity consumption) and facilitating environmentally friendly behaviors (placing recycling points close to communities) are some examples of deeper engagement with civil society.

2.6.2.5 Inconsistent Policy Implementation

Several well-planned policies and programs are implemented and provide many benefits. However, sometimes these policies and programs are interrupted during implementation by political issues. Low political stability is one cause of inconsistent policy implementation in Thailand. For example, a policy of the former government may be altered, modified, or discontinued by the new government.

2.6.3 Weaknesses at Sector and Subnational Levels

2.6.3.1 Energy and Power Sector

Low Level of Research and Development

The level of R&D in new renewable energy technologies in Thailand is still low. This is a major obstacle to promoting renewable energy in the country; most technologies have to be transferred from other countries. The cost for such technologies, such as solar, is also high, causing problems for deployment. Additionally, some imported technologies, such as for biomass and biogas, may not be completely suitable to Thailand (they may not give high efficiency).

Insufficient Incentive to Invest in Small and Very Small Power Producers

Currently, SPP and VSPP programs provide a number of incentives for investment in renewable energy, including the adder costs. However, technologies for some types of renewable energy have relatively high investment costs compared to the benefits. As a result, private entrepreneurs have little interest in investing in such projects, leaving only government agencies to make the investments.

Low Local Community Engagement and Incentives

When establishing renewable energy power plants it is important to have the agreement of local people in the area to proceed with the project. A common method used to gain access to the area is public hearing (during the environmental impact assessment process), but these may not be sufficient for local people to agree to build the project. Thus, it may be useful to increase the engagement (such as forming a committee for the project) and to provide incentives (such as free electricity) for local communities.

2.6.3.2 Building Sector

Low Awareness of Green Building

Green building awareness is still low in Thailand. Most entrepreneurs of designated buildings only concern themselves with energy efficiency and energy management in buildings, and do not pay attention to other aspects of green buildings, such as building maintenance. Furthermore, entrepreneurs of nondesignated buildings are barely concerned about energy efficiency and energy management.

No Green Building Concept for Small Buildings and Condominiums

The green building concept for new large buildings and new homes has developed and been modified over the years to suit Thailand's climate. Experience gained from applying the green building concept to large buildings can be used when constructing new large buildings, but the green building concept and guidelines for small buildings and residential complexes have yet to be developed. Thus, it is difficult for entrepreneurs to apply green building concepts to small buildings.

2.6.3.3 Transport Sector

Low Price Difference between Gasoline and Gasohol

A change in fuel price in Thailand in mid-August 2011 due to a policy change (tax being collected for the Oil Fund) saw the price gap between gasoline 91 and gasohol 91 reduced from B7.80 per liter to B3.03 per liter (PTT 2011). This change may affect biofuel consumption. With the smaller price difference, people may turn to gasoline instead of gasohol.

Priority for Transport Policy

Private vehicle ownership is driven by economic growth. If there is high economic growth in coming years, there will be more private vehicles on the road (more motorcycles and higher shift from owning motorcycles to private cars), which will continue to cause traffic problems and air pollution, and consume fuel. Thus, it is essential for the government to prioritize its public and nonmotorized transport policies (Pongthanaisawan and Sorapipatana 2010).

2.6.3.4 Agriculture Sector

Lack of Local Climate Change Information

There is insufficient climate change data to be utilized for agricultural planning. As a result, agriculture planning with regard to the changing environment and climate cannot be done, especially for suitable plantation area, type of crops or plants, agricultural product storage, and water movement and reservoirs. Additionally, without the ability to project future climate change scenarios for agriculture, technology transfer for agriculture cannot properly be initiated.

Lack of Clear Agricultural Planning Concerning Food versus Fuel

Because fertile land is limited, it is important to have an agricultural plan in terms of what crops to plant, where to plant them, and how large the plantation area for each crop or plant should be. The concern about land availability is intensified by the production of biofuel. Most biofuel technologies being used in Thailand are first-generation technologies, which require the use of food crops and plants (e.g., oil palm and sugar cane). Currently, the planning issues concerning food versus fuel have not yet been clearly addressed.

2.6.3.5 Waste Sector

Lack of Understanding between Government Agencies and Local Communities on Municipal Waste Reutilization

In addition to the issue of waste management (recycling rate and waste generation rate), reutilization of municipal waste remains a problem. One obstacle is that there is a lack of understanding of waste reutilization between local government and local communities. Currently, local people are concerned by the potential impacts of waste reutilization projects; as a result, they do not want to have such projects near their communities. Without clearly ensuring the impacts issues are addressed and ensuring that local people understand the purposes and benefits of the development, municipal waste reutilization projects cannot be established. It

should be noted that good governance and transparent public participation are required during project initiation.

2.6.3.6 Low-Carbon City

Lack of Stakeholder Involvement in Low-Carbon City Models

Most of the implementation for low-carbon cities in Thailand involves only a few stakeholders in the city. This type of implementation can be easily achieved; however, the magnitude of success for reducing greenhouse gas emissions may not be high, and these low-carbon activities may be unsustainable because they lack cooperation and involvement of all stakeholders.

2.7 Major Challenges in Technology Resource Mobilization and Private and Public Finance

2.7.1 Technology and Resource Mobilization

2.7.1.1 Low Level of Research and Development

In Thailand, the level of research and development for new clean and green technologies in renewable energy, energy efficiency, and other areas concerning climate change is low. Most clean and green technologies, especially sophisticated technologies, are deployed in the country through technology transfer. Deploying clean and green technologies from other countries has high costs and, as a result, the deployment rate is low. This is because small and medium-sized enterprises have financial difficulty in deploying such technologies.

The Clean Development Mechanism (CDM) is an effective mechanism that can reduce the barriers to deploying clean and green technologies. However, the technologies that can be facilitated through the CDM are limited, as only technologies of a certain type and scale can be transferred through the CDM.

2.7.1.2 Mobilization of Clean and Green Technologies for Commercial Purposes

Some research and development activities for clean and green technologies are being domestically undertaken on a pilot scale. These technologies have the potential to alleviate environmental problems and mitigate greenhouse gas emissions. However, some fail to be adopted commercially because manufacturers do not see the market potential (do not create the supply) and government agencies do not promote and support the emergence of technologies (do not create the demand).

2.7.2 Private and Public Finance

2.7.2.1 Public Finance

Public finance is the primary financial source for supporting green and low-carbon development in Thailand. The Energy Conservation Promotion Fund (ENCON Fund) is the key public finance support for government agencies, state enterprises, nongovernment organizations, individuals, and businesses in implementing energy conservation, energy efficiency, renewable energy development, energy-related technology development, human resource development and training, and public awareness campaigns.

The ENCON Fund was established in 1992 with an initial budget of B1.5 billion. The primary sources of revenue for the fund are petroleum taxes, bank interest, and irregular government

and private budgets. Since the establishment of the fund, the budget has been allotted to facilitate the implementation of programs and activities under the ENCON program, such as energy conservation and efficiency, renewable energy development, technology demonstration, research and development for technologies, and raising awareness.

Under the ENCON program, during 2005–2007 energy conservation and efficiency activities to improve the efficiency of energy consumption in the industry, building, commercial and residential, transport, and government office sectors created energy savings of about 1,554 ktoe/year, and renewable energy promotion activities created renewable energy substitution of crude oil of about 3,586 ktoe/year. These activities created savings of about B95.79 billion (EPPO 2008).

Since the establishment of the ENCON Fund, the actual spending budget of the ENCON program for developing renewable energy and improving energy efficiency has been lower than the estimated budget. This is because the implemented renewable energy and energy efficiency activities have also been less than estimated. As a result, the key challenge regarding public funding is to fully utilize the budget of the ENCON program to improve the implementation of renewable energy and energy efficiency activities.

The budget of the ENCON Fund to execute such energy- and environment-related activities was estimated at B19.21 billion (approximately equivalent to $620 million) during 2007–2011 (ENCON Fund 2011).

2.7.2.2 Private Finance

The role of the private sector in supporting the development of green and low-carbon initiatives is perceived from the emergence of private finance. Currently, the Revolving Fund and ESCO Fund are public–private partnerships for promoting energy efficiency and renewable energy in Thailand.

Revolving Fund

As part of the government's initiate to involve the private sector in terms of finance, the public–private partnership between the Department of Alternative Energy Development and Efficiency (DEDE) and private financial institutions was established in 2003 with the Revolving Fund for promoting energy conservation and efficiency, and renewable energy. The fund provides loans with a maximum fixed interest rate of 4% over 7 year with a grace period of not more than 12 months. The maximum lending amount is B50 million. In general, the ratio for financial contribution for the lending amount is 1:1 between the government agency and the bank (Sutabutr 2010).

The Revolving Fund is an effective program in terms of creating private finance for investing in energy efficiency and renewable energy projects, creating energy and fuel savings, and generating financial savings. In the first phase of the Revolving Fund, participation of financial institutes was limited to six banks. In the second and third phases, participation increased to 11 participating financial institutions (Asawutmangkul 2010).

Additionally, the budget of the Revolving Fund has been continuously allocated from the ENCON Fund. The cumulative budget being allotted to the Revolving Fund is currently more than B7 billion (DEDE 2011b), and the ratio of private finance in the fund program has increased steadily over the years (Table 2.15).

Table 2.15: Financial Details of Revolving Fund

Details	Period						Total
	Energy Conser-vation 1	Energy Conser-vation 2	Energy Conser-vation 3 Renew-able energy 1	Energy Conservation 3 (Addition-al)	Energy Conser-vation 4	Energy Conser-vation 5	
	30/1/2003 to 29/1/2006	17/3/2006 to 6/3/2009	2/8/2007 to 1/8/2010	2/8/2007 to 1/8/2010	2/9/2009 to 1/9/2012	1/6/2010 to 31/5/2013	
Approved project	78	85	81	23	11	2	280
Investment cost (B million)	3,427	3,536	3,812	2,576	1,272	20	14,643
Budget size of the fund (B million)	2,000	2,000	2,000	942.5	400	500	7,842.5
Approved budget for energy efficiency and renewable energy projects (million Baht)	1,902	1,805	1,988	865	383	20	6,963
Banks' lending amount (B million)	1,525	1,731	1,824	1,711	889	0	7,680
Electricity saving (million kilowatt-hours /yr)	251	232	301	219	103	2	1,108
Fuel saving (million liter/yr)	81	88	36	21	5	0.2	231.2
Total financial saving (B million/yr)	1,394	1,415	1,092	751	302	7	4,961
Reduction of imported crude oil (thousand tons of oil equivalent/yr)	97.60	102.45	59.27	38.74	13.21	0.37	311.64

Note: The data are as of October 2011

Source: Department of Alternative Energy Development and Efficiency 2011b.

It can clearly be seen that there are interesting benefits from the Revolving Fund in terms of energy and fuel savings, and financial savings. As of September 2010, it is estimated that the Revolving Fund, with total investment B14.64 billion (both government and private finances), can reduce the import of crude oil by 311.6 ktoe per year and can generate financial savings of B4.97 billion per year (DEDE 2011b).

Interestingly, the Revolving Fund program can prompt financial institutions to create lending programs for energy efficiency and renewable energy projects (interest rates are negotiable). It is estimated that the lending amount from financial institutions is about B70 billion (Sutabutr 2010).

ESCO Fund

The ESCO Fund is a government co-investment scheme to support ESCOs and other investors in investing in clean energy, renewable energy, energy efficiency, and building retrofit projects. The support is categorized into equity investment, venture capital investment, carbon credit trading, equipment leasing, technical assistance, and credit guarantee. The fund was established in 2008 with an initial budget of B500 million from the ENCON Fund. The Energy for Environment Foundation and the Energy Conservation Foundation of Thailand are fund managers.

During the implementation period of 2009–2010, B527.08 million was invested in 39 energy efficiency and renewable energy projects, with total investment of B5.11 billion. These energy efficiency and renewable energy projects can create energy savings of 20.61 ktoe/year and financial savings of B721.36 million per year (DEDE 2011c).

In short, it can be seen that the public and private financial mechanism to promote energy efficiency and renewable energy begins to work when there is deeper participation from financial institutions (more institutions and larger lending amounts) and environmental and financial benefits from the programs. However, challenges for private finance for green and low-carbon development remains, one of the key ones being creating green finance for other environmental improvements. Currently, low-interest loans for green and low-carbon improvements (other than energy efficiency and renewable energy) are offered by only one financial institution, Krungthai Bank, which received financial support from the Environmental Fund of the Office of Natural Resources and Environmental Policy and Planning. The challenge, therefore, is for concerned agencies and financial institutions to create green soft loans for entrepreneurs, especially small and medium-sized enterprises, for investing in environmental improvement programs.

3. ACHIEVING LOW-CARBON GREEN ASIA 2050

3.1 The Role of Lifestyle Choices, National Innovation Systems and Technology Transfer, and Market-Based Instruments in Achieving Voluntary Targets, and the Costs Involved

In the past several years, numerous initiatives and activities have been implemented to mitigate greenhouse gas emissions in Thailand. Because Thailand is a non-Annex I party to the Kyoto Protocol, all mitigation actions are taken voluntarily, with the aim of being part of the global action in reducing the level of greenhouse gas emissions and alleviating the impacts of climate change.

While there is no clear voluntary greenhouse gas emissions reduction target in Thailand, it has been recognized that it is crucial for all nations to undertake greenhouse gas mitigation. As a result, the Government of Thailand and other sectors have initiated a number of initiatives and actions to mitigate greenhouse gas emissions. However, emissions reduction in regards to green lifestyle, national systems and technology transfer, and market-based instruments is still in the initial stage of development.

3.1.1 Green Consumer and Lifestyle—Emerging Yet?

When discussing green consumers and lifestyle choices, there are many consumption practices involved—food consumption, travel mode choices, and leisure practices (Spaargaren 2003). All of these practices contribute to greenhouse gas emissions to varying degrees. Within each practice, there are choices for consumers, and each choice has different greenhouse gas emission implications. For example, a person going to the office by personal car may cause higher greenhouse gas emissions than someone taking public transport. In general, it is well understood that green products and services have less environmental impacts (they may cause less greenhouse gas emissions).

In Thailand, green consumers and lifestyles are the key challenges for reaching sustainable development. Green products and services have been increasing in recent years, but the green market in Thailand is still limited because there are few green consumers who consider

environmental factors when making purchases (Pollution Control Department [PCD] 2006). Thai consumers are price-sensitive consumers, and the prices of green products are higher than those of non-green products.

Despite a low number of green consumers, there are signs of increasing awareness in terms of food consumption. Organic food is becoming a viable green movement in Thailand. This green movement is active in engaging both green producers and green consumers, and in providing information to consumers.[7] Additionally, retail shops selling organic products and healthy products in Thailand are increasing. The government, as the largest consumer in the nation, has enforced a green procurement policy with the hope of increasing the demand for green products and services (PCD 2006). All government agencies are obligated to comply with the green procurement policy.

The emergence of green food consumers and demand for green products and services created by the government forecasts a promising future for an increase in green consumers and green consumption in Thailand. However, there may be a need for the government and private sector to further implement measures to create green demands from consumers. This could be addressed by using both short-term and long-term measures, e.g., providing incentives for purchasing green products and services (short term) or providing education and raising awareness (long term).

3.1.1 National Innovation Systems and Technology Transfer

3.1.1.1 National Innovation System

Energy Efficiency Label (Energy Label No.5)

Energy Label No.5 is an interesting innovation to promote energy efficiency in the residential sector in Thailand. As a demand-side management (DSM) program, Energy Label No.5, which was started in 1991, is the key program undertaken by the Electricity Generating Authority of Thailand (EGAT). This label program is free and voluntary—appliance producers do not need to pay to participate in the program. The program's key objectives are to (i) encourage producers to manufacture and/or import energy efficient products, (ii) provide energy efficient products to end users, (iii) educate people about energy and energy efficiency, and (iv) efficiently utilize energy in the country.

The program uses a label (efficiency scale range from No.1 to No.5, with No.5 being the highest efficiency level) to communicate to consumers about energy efficiency, energy consumption, and electricity cost information of appliances (the details of the label for each appliance may differ from one to another, but the key message to consumers is the same—energy efficiency of the appliance). The program began labeling a few high-energy-use home appliances—refrigerators and air conditioners—by running commercial campaigns promoting the label to the public and providing details of financial benefits that consumers could get from using certified products. As a consequence of the promotion and campaign, the label is highly recognized among Thai people, and end-users tend to select products that have high efficiency. With an active demand-side movement, producers have improved the energy efficiency of products to gain the trust of end-users and increase sales (Na Phuket and Prijyanonda 2000). The program is successful and EGAT has expanded the program to cover a broad range of home appliances. Additionally, EGAT periodically rescales the certification criteria of Energy Label No.5 for each product, and appliance producers keep pace with the tightening energy efficiency criteria, resulting in increased appliance efficiency.

[7] An example of a green network is Thaigreenmarket. http://www.thaigreenmarket.com/

As a result of this dynamic between EGAT, appliance producers, and end-users, the successful program has generated multiple benefits, the key ones being the level of energy efficiency of products, energy and financial savings, and reduced greenhouse gas emissions. Energy savings are a result of the use of high-energy-efficient products nationwide. This reduces electricity demand and the need to construct new power plants. With reduced energy demand, greenhouse gas emissions from energy production and consumption are simultaneously reduced by the label program. Box 3 shows the implementation and key implementation results of the label program.

Box 3: Case Study: Energy Efficiency Label (Energy Label No.5)

Implementation:

- The label is part of a demand-side management program to reduce energy consumption of high energy consumption products.
- Certification began with a few products and expanded to a wider range of products covering refrigerators, air conditioners, compact fluorescent lamps, ballasts, electric fans, rice cookers, electric lamps, electric water boilers, televisions, and monitors.
- The program is very effective as it is promoted through TV campaigns that inform about the savings that can be realized when using energy efficient appliances. This creates high recognition among end users. Consequently, people tend to purchase certified (high efficiency) appliances, with the result that producers improve the energy efficiency of products.

Key results and implications:

- The World Bank estimated that the use of energy efficiency lighting, refrigerators, and air conditioners (Energy Efficient Label) as a result of the program has reduced greenhouse gas emissions by 12.6–17.4 $MtCO_2eq$ during 1993–2004 and additional 14.7–27.6 $MtCO_2eq$ during 2005–2010 (World Bank 2006).
- As of February 2007, energy savings from certified refrigerators and air conditioners (highest efficiency label) are estimated at 1,000 megawatts.
- As of February 2007, greenhouse gas emission reductions created by certified refrigerators and air conditioners (highest efficiency label) are estimated at 4 $MtCO_2eq$.

Product	Number of issued labels	Energy saving		Greenhouse Gas Emissions Reduction (Tons of CO_2eq)
		GWh	MW	
Air Conditioners	18,272,449	2,416.0	254.2	1,763,799
Refrigerators	5,995,192	3,278.5	743.4	2,195,029

Source: EGAT 2009a, 2009b

- People recognize the label and consider the label when purchasing electrical appliances.
- Manufacturers can continuously improve energy efficiency of products to meet with the tightening criteria of the label, which are rescaled approximately every 5 years.

$MtCO_2eq$ = million tons of carbon dioxide equivalent

Small Power Producer and Very Small Power Producer Program

The SPP and VSPP program is an innovative system to stimulate the utilization of renewable energy in Thailand. Reform of the power sector started in 1992 with the introduction of the Purchase Power from Small Power Producers (SPP) Regulation. The regulation allows private companies to be a part of the national power supply. The Independent Power Producers (IPPs) program (for large power producers) is a beginning point that brings private investment to power generation activity, which can be viewed as a starting point of the SPP and VSPP program.

Initially, the SPP and VSPP program was ineffective and underwent several changes to policy, financial and investment systems, institutional conditions, and economic situation. Only recently has the SPP and VSPP program provided significant contributions to the development of renewable energy, enhancement of energy security, and structure of the power sector.

The fundamental concept of the SPP and VSPP program is to provide more practical and more investor-friendly regulations by modifying criteria for qualifying as a facility, calculation of the avoided cost, and interconnection requirements. The details of the current SPP and VSPP program are as follows:

1. Cogeneration facilities are applicable to the SPP and VSPP program. The power that can be sold from the facility is 10–90 MW for SPPs and not more than 10 MW for VSPPs.
2. SPP cogeneration facilities can have a long-term contract for selling power to the grid.
3. The feed-in tariff for SPPs and VSPPs using renewable energy is increased. An adder is provided over the normal tariff rate for SPPs and VSPPs that use renewable energy with the duration of 7–10 years (from the commercial operation date). Table 3.1 shows the adder provided to SPPs and VSPPs.
4. Soft loans and investment subsidy for selected types of renewable energy covers biogas from pig farms, tapioca starch factories, palm oil factories, rubber factories, ethanol factories, other agro-industry factories, municipal waste, and micro-hydro.
5. There is budget from the government for technical assistance and pilot projects using new and unfamiliar technologies.
6. The program encourages private investment from ESCOs and the ESCO Venture Capital Fund.
7. It is an approved policy for carbon credit trading via the Clean Development Mechanism (CDM).

Table 3.1: Adder Provided to Normal Tariff for Small Power Producers and Very Small Power Producers Using Renewable Energy

Fuel/Technology	Adder (B/kWh)	Additional Adder* (B/kWh)	Adder (B/kWh) for 3 southern provinces	Period (years)
Biomass				
≤ 1 MW	0.50	1.00	1.00	7
> 1 MW	0.30	1.00	1.00	7
Biogas				
≤ 1 MW	0.50	1.00	1.00	7
> 1 MW	0.30	1.00	1.00	7
Municipal waste				
Composite/Landfill	2.50	1.00	1.00	7
Thermal process	3.50	1.00	1.00	7
Wind				
≤ 50 kW	4.50	1.50	1.50	10
> 50 kW	3.50	1.50	1.50	10
Hydro				
50–200 kW	0.80	1.00	1.00	7
< 50 kW	1.50	1.00	1.00	7
Solar	8.00	1.50	1.50	10

kWh = kilowatt-hour, MW = megawatt.

Note: * = Additional adder is designated for producers who have projects in areas where there is electricity production from diesel.

Source: Energy Policy and Planning Office 2009.

The responses of power producers to the new SPP and VSPP policy is clearly positive. The numbers of renewable energy projects, generation capacity, diversification of energy sources, and proposed power for selling to the grid have increased markedly. The impact of the new policy on VSPPs is particularly high.

Box 4: Case Study: Small Power Producer and Very Small Power Producer Program (Renewable Energy)

Implementation:

- Encouraging private sector to participate in renewable energy development.
- Providing several incentives for eligible projects (e.g., biomass, biogas, municipal waste, wind, hydropower, and solar).
- Incentives include feed-in tariff, subsidy, technical assistance, and soft loans.

Key result of implementation and implication:

- The emergence of renewable energy utilization projects in Thailand.
    - As of June 2011 there were 57 renewable energy small power producer projects (proposed, under consideration, or operational), which can sell 2,201.62 megawatts (MW) of power to the grid (EPPO 2011).
    - As of June 2011, there were 1,330 renewable energy VSPP projects (proposed, under consideration, or operational) with can sell approximately 5,708.59 MW of power to the grid (EPPO 2011).
- Reform of the power sector in Thailand is seen in terms of private sector participation and resources for power generation.

Key successful factors:

- Financial incentive, especially adder

  In the past, incentives for SPPs and VSPPs were not sufficient to attract investors, which resulted in limited applications for SPP and VSPP projects (especially VSPP). For the current SPP and VSPP program, lucrative and long-term financial incentives are provided and have been the key factor in overcoming the financial constraint on investing in renewable energy projects. Adder is the incentive that most catches investor attention, especially for VSPP investors. Furthermore, other financial incentives, including the Clean Development Mechanism, also contribute to financial feasibility, resulting in the rapid establishment of numerous SPP and VSPP projects.

- SPP and VSPP reclassification

  Before the current SPP and VSPP program came into force, the allowance for selling power from SPP and VSPP projects could not exceed 90 MW for SPPs and 1 MW for VSPPs. Consequently, there were few VSPP projects as the allowance was too small to gain any financial return. The new policy has increased the VSPP limit to up to 10 MW, resulting in the emergence of more VSPP projects.

- Technical assistance and other assistance to reduce technological risks

  SPP and VSPP projects are directly associated with small and medium-sized enterprises (SMEs); most of the entrepreneurs participating in SPP and VSPP projects are from SMEs. SMEs lack technical knowledge and experience, especially in the energy business, and this causes technological difficulties for investors. Providing technical assistance and advice, and other assistance, throughout project implementation can help enhance investor confidence, resulting in reduced technological risks.

3.1.1.2 Technologies and Technology Transfer

Through several government organizations and research institutes, Thailand has invested in research and development activities pertaining to greenhouse gas mitigation, especially research and development for second- and third-generation renewable energy and new

technologies for energy efficiency. However, technological research and development has not yet led to such technologies being used on a commercial scale; further development is required. Furthermore, it is essential to commercialize such technologies so that they can be used for mitigating greenhouse gas emissions.

Current policies in Thailand are conducive to the transfer of environmentally sound technologies, and a number of barriers have been eliminated by reducing import duties, reducing corporate taxes, and providing subsidies. Additionally, the implementation of CDM projects has a significant level of technology transfer and has brought advanced environmentally sound technologies to the country. The higher level of technology transfer may result from approval criteria of CDM projects, tariffs on imported equipment (lower or exempt), and other factors (Seres 2008).

3.1.2 Market-Based Instruments for Pollution Control and Environmental Improvement

3.1.2.1 Economic Instruments

Although there has been enforcement of environmental regulations (command and control approach) in Thailand since the early 1990s, there has still been environmental degradation, especially water quality (PCD 2009). The "polluter pays" principle is seen as a way to effectively solve environmental problems. The government has developed the Act on Economic Instruments for Environmental Management as an economic instrument for solving environmental pollution problems and improving environmental quality; however, as of October 2011 the act had not been introduced.

Based on the current structure of economic instruments in Thailand, the draft Act on Economic Instruments for Environmental Management will serve as an overall framework for all economic instruments used for environmental protection and improvement. Under the act (based on the most current draft), there are five proposed decrees covering five areas of environmental management—water pollution, air pollution, electronic wastes and used products, CO_2 emissions from vehicles, and tourism. The proposed economic instruments for these five areas are pollution taxes, service charges, product taxes and fees, performance bonds, tradable permits, and environmental subsidies. Currently, the draft act and decrees are under consideration for approval of the Cabinet and the Council of State (some decrees are approved by the Cabinet and under review of the Council of State).

It can be expected that, if economic instruments (under the decrees) are successfully introduced, there will be significant environmental management and remediation impacts, including reduced greenhouse gas emissions. The act also aims to introduce the allocation of greenhouse gas caps. Additionally, the revenues collected from pollution taxes will be used to improve environmental management and pollution treatment, which will contribute to the mitigation of greenhouse gas emissions.

3.1.2.2 Carbon Trading Scheme

In addition to the upcoming economic instruments for environmental protection and remediation, other market-based instruments are under consideration in Thailand. The Thailand Greenhouse Gas Management Organization (TGO) has an initiative to establish the Thailand Voluntary Emission Trading Scheme (TVETS) and Thailand Voluntary Emission Reduction (T-VER) scheme in order to intensify voluntary greenhouse gas emissions reduction efforts as a non-Annex I party. The establishment of these schemes is still at an early stage.

If the TVETS and T-VER schemes are established and functioning, it should be possible to obtain systematic and comprehensive data on voluntary greenhouse gas emissions reduction, and witness significant greenhouse gas emissions reduction in several sectors in the country through renewable energy utilization; energy saving and efficiency;; and afforestation, reforestation, and/or forest conservation activities.

3.2 Positioning National Actions within the Current Global Climate Regime and Regional Cooperation Framework

Sufficiency Economy Philosophy

The Sufficiency Economy Philosophy was bestowed on Thai people by His Majesty King Bhumibol Adulyadej. In 1999, the formal interpretation of the Sufficiency Economy Philosophy was made by the Sufficiency Economy Working Group and was approved by the king. In accordance with the formal definition, Sufficiency Economy has four key elements:

> Sufficiency Economy is an approach to life and conduct which is applicable at every level from the individual through the family and community to the management and development of the nation.
>
> It stresses a middle path, especially in developing the economy to keep up with the world in the era of globalization.
>
> Sufficiency has three components: moderation, reasonableness, and the need for built-in resilience against the risks which arise from internal or external change.
>
> In addition, the application of theories in planning and implementation requires great care and good judgment at every step. At the same time, all members of the nation – especially public officials, academics, and business people – need to develop their commitment to the importance of knowledge, integrity, and honesty, and to conduct their lives with perseverance, tolerance, wisdom, and insight, so that the country has the strength and balance to respond to the rapid and widespread changes in economy, society, environment, and culture in the world. (Wibulswasdi, Piboolsavut, and Pootrakool 2010: 1)

Since the 8th National Economic and Social Development Plan (1997–2002), the Sufficiency Economy Philosophy has been adopted as a guiding principle for national development. The key elements of the philosophy have also been integrated into the 11th National Economic and Social Development Plan (2012–2016).

From the national position and policy regarding the Sufficiency Economy Philosophy, it can be seen that Thailand is pursuing a balanced development path, taking economic, societal, environmental, and cultural factors at the local, national, regional, and global levels into account. This can be clearly interpreted as an indication that Thailand is seriously considering global environmental changes as a key factor in determining national development. Thus, the national position of Thailand is in line with the current global climate regime and regional cooperation on climate change.

Such a position ensures that multiple and co-benefit policies and actions for mitigating greenhouse gas emissions will be considered for implementation. Additionally, no-regret and least-cost policies and actions on greenhouse gas emissions reduction, which do not have significant negative impacts on the economy and society, can be expected.

3.3 Trade and Investment Links with Other Asian Economies

Thailand promotes international trade and investment for environmental goods and services. In terms of trade and investment in environmental goods, the Board of Investment and other government agencies provide extensive incentive packages to promote investment in renewable energy and energy efficiency and environmentally friendly trade of goods and services. For investment in renewable energy and energy efficiency, there are both nontax and tax incentives, such as corporate income tax exemption, and import tax exemption for technologies.

For trade and investment in environmental services, Thailand made commitments under the General Agreement on Trade in Services (GATS) on environmental services. The current status of environmental service is seen as "no restriction" (liberalized) for market access and national treatment under cross-border supply and consumption abroad, and as "partial restriction" (partially liberalized) for market access and national treatment under commercial presence[8] (Yoko and Okuda 2000).

3.4 Major Constraints on Regional Cooperation, and Solutions

3.4.1 Global Regimes

Thailand is in the process of drafting nationally appropriate mitigation actions (NAMAs) and a measurement, reporting, and verification (MRV) system. Significant progress has been made in developing NAMAs because some assistance has been received. Japan, via the Institute for Global Environment Research and Pacific Consultant, in cooperation with Thailand's Greenhouse Gas Management Organization (TGO) conducted a feasibility study of NAMAs for waste management (Ministry of the Environment of Japan and Global Environment Centre Foundation 2011). The development of NAMAs is nearing completion, and it is likely that the first of them will soon be submitted to the United Nations Framework Convention on Climate Change). Drafting of the domestic MRV system is also being undertaken by the TGO and other related agencies, and significant progress has been made.

For reducing emissions from deforestation and degradation, and the role of conservation, sustainable management of forest, and enhancement of forest carbon stocks in developing countries (REDD+), Thailand supports REDD+ because it is in line with the national policy for protecting and conserving forests and reducing greenhouse gas emissions (Srethasirote, 2011). Further progress and Thailand's position on REDD+ is still being discussed and developed.

3.4.2 Trade and Investment in Green and Low-Carbon Products and Services

With the introduction of several incentives and regulations, Thailand has facilitated trade and investment in green and low-carbon products and services.

However, there are some concerns regarding the promotion of trade and investment because utilization in the domestic market is still limited. The use of green and low-carbon products and services is associated with financial costs and benefits, and applicability of the products and services to the local context. The cheaper the products and services, the more they will be utilized. Thus, financial incentives from the government and other agencies to promote the use of green and low-carbon products are essential. Financial incentives should be enough to overcome the financial barriers and to provide reasonable benefits. Furthermore, it is important to consider the local contexts for adopting green and low-carbon products and services.

[8] Commercial presence refers to service suppliers that establish, operate, or expand a commercial presence—such as an agency, branch, subsidiary, or joint venture—in another country.

Acceptance of such products and services by people in the countries and local communities has to be gained before applying products and services. Thus, it is necessary to utilize acceptable products and services and/or create understanding with the local people.

3.4.3 Institutional and Governance System

In Association of Southeast Asian Nation (ASEAN) countries, the institutional and governance challenge relates to the extent of cooperation and integration on climate change and green economy among member countries; thus far it is not greatly in evidence—the impact of climate change is clearly not a priority issue. As a result, international cooperation and assistance is rarely provided to the region. Furthermore, standard baseline data at the regional level concerning climate change and greenhouse gas emission reduction efforts and calculations are scattered.

3.4.4 Greater Mekong Subregion Cooperation

The Greater Mekong Subregion (GMS) comprises six member countries—five Association of Southeast Asian Nations (ASEAN) countries (Cambodia, the Lao People's Democratic Republic [Lao PDR], Myanmar, Thailand, and Viet Nam) and the People's Republic of China. One of the key areas of GMS cooperation is energy. The cooperation and initiatives in the energy sector under the GMS are emphasized in cross-border electrical power trading and transmission networks (Zhai 2010).

Under the GMS, Thailand has bilateral cooperation on power trade and development with Cambodia and the Lao PDR. Thailand exports 115 kilovolts of electrical power to Cambodia (Zhai 2010).

3.4.4.1 Cooperation between Thailand and the Lao People's Democratic Republic on Power Development and Purchasing

As Thailand has to rely on imported energy and power, it has cooperated with the Lao PDR as there is great potential to purchase power, especially hydropower, from the Lao PDR. As of 2010, Thailand had power purchase agreements with the Lao PDR on six projects, five of which were hydropower projects (2,082.6 MW) (Royal Thai Embassy Vientiane 2011) and the other a lignite project (1,473 MW) (EGAT 2011). Thailand has also signed a tariff memorandum of understanding for purchasing power from other projects in the Lao PDR. It should be noted that the development of hydropower plants in the Lao PDR is assisted by the Asia Development Bank (ADB).

The use of renewable resources in the Lao PDR to generate electricity to sell to Thailand can be conceptualized as a regional energy hub. The purchase of power from the Lao PDR not only enhances energy security for Thailand (in terms of adequate energy supply and affordability) but also contributes to the reduction of greenhouse gas emissions of the energy and power sector. The reduction of greenhouse gases originates from the nature of the power project itself, because most power projects developed in the Lao PDR use hydropower. There are also other advantages for the Lao PDR, such as generating income, poverty reduction, improving quality of life, and creating energy security. However, local environmental impacts from the project construction remain a concern for local people and nongovernment organizations because environmental impact assessment was not comprehensive.

3.4.4.2 The Future of Greater Mekong Subregion Cooperation in the Energy sector

With technical assistance from ADB, the formulation of a regional strategy for the energy sector in the GMS is solidified. Recently, cooperation in the energy sector was expanded by integrating

environmental and social aspects into the planning and implementation of energy cooperation. Under a plan to implement the GMS Energy Strategy, energy security, renewable energy, and environmentally sound energy practices are included for cooperation (Greater Mekong Subregion Economic Cooperation Program 2009). Deeper cooperation with the integration of environmental concerns, especially climate change, is expected to create green and low-carbon development for the region and for member countries, resulting in economic growth, energy security, and reduced environmental impacts.

A MARKAL-based integrated energy system model study conducted by Watcharejyothin and Shrestha found that unrestricted energy resource development and trade within the GMS would provide economic and environmental benefits for member countries (except for Myanmar). Furthermore, unrestricted energy resource development with reduced CO_2 emissions of 5% for each member country would enhance energy security, reduce energy imports, lessen the dependency on fossil fuels, and increase the trading volume of power within the region (Watcharejyothin and Shrestha 2009).

3.5 Major Policy Reforms in Thailand

In Thailand, progress on renewable energy and energy efficiency can be observed through the development and implementation of renewable energy and energy efficiency plans. The 15-Year Renewable Energy Development Plan (REDP) and Energy Efficiency Improvement (under the ENCON Program) are the key initiatives. These two plans consist of a number of measures, including reform measures to promote renewable energy and energy efficiency in Thailand.

3.5.1 The 15-Year Renewable Energy Development Plan

The 15-Year Renewable Energy Development Plan (REDP) consists of several policies creating incentives for renewable energy production and utilization:

- **Tax incentives from the Board of Investment:** Tax exemptions cover import machinery duties and corporate tax for new investment (8 year income tax holiday and a further 5 years with 50% reduced taxation).
- **Revolving Fund:** The Revolving Fund provides fixed low-interest loans at less than 4% with a maximum lending amount of B50 million and a loan period of 7 years. Eligible investment costs are equipment and installation, consultation, civil works, piping, or necessary components for the project, as well as other associated costs, such as removal of existing equipment, transportation, and taxes.
- **ESCO Fund:** This is a government co-investment scheme for encouraging private investment in renewable energy projects. The fund provides financial investment and other benefits including equipment leasing, carbon credit trading, technical assistance, and a credit guarantee facility. The investment term is 3–7 years with a mutually agreed exit clause.
- **Investment grant:** Grants are given to develop small renewable energy projects (biogas, municipality waste, solar hot water). The grant is provided for design, consultants, and partial investment, with a maximum amount of B50 million.
- **Adder cost:** Adder is provided over the normal tariff rate for SPPs and VSPPs using renewable energy, with the duration of 7–10 years from the commercial operation date.
- **Other assistance:** Technical assistance (such as energy maps), technology catalogues, and favorable regulations applicable for CDM projects are arranged.

3.5.2 Energy Efficiency Improvement

The Government of Thailand adopted five reform measures to promote energy conservation and energy efficiency: ENCON Fund, ESCO Fund, tax incentives, direct subsidy, and DSM biding.

- **Revolving Fund:** (For details see point 3.5.1.)
- **ESCO Fund:** (For details see point 3.5.1.)
- **Tax incentives:** There are few incentive schemes to promote the use of and investment in energy efficiency projects.
  - Tax incentive for energy efficiency products provides 25% tax credit from purchasing 19 energy efficiency products (mostly certified with Energy Label No.5). This program will be continued until December 2012.
  - Others:
    - Board of Investment tax incentive: Exemptions of corporate income tax and import duties with the maximum of 8 years for energy efficiency equipment manufacturers and ESCOs and 50% tax reduction in years 9–13.
    - Performance-based tax incentive: Energy saving value can be claimed for income tax reduction (maximum tax privilege that can be claimed is B2 million).
- **Subsidy:** A subsidy is provided for energy efficiency investments. The subsidy is applicable for standard technologies (approved technologies), high technologies (demonstrated energy efficiency technologies), and individual projects (other measures and technologies). The program provides a 20% direct subsidiary (of B50,000–B3 million) to facilities that have payback periods of not more than 7 years.
- **DSM biding:** The program provides financial support for investment in higher energy efficiency machines and equipment. Proposals that have lower weighted subsidy will be the first to be subsidized. Subsidy is granted based on actual energy saving (the subsidy amount = annual energy saving x the subsidy rate). The subsidy rate for electricity is B1/kWh, for heat from liquid and gas fuels it is B75 per million British thermal units (BTUs), and for heat from solid fuels it is B15/million BTUs.

3.5.3 Key Lessons

The success of the Revolving Fund, ESCO Fund, and adder costs (limited to some types of renewable energy) has been noticeable. At the end of 2008, the Revolving Fund supported over 240 energy efficiency and renewable energy projects ($500 million of total investment), generating energy savings of around $120 million per year (Asawutmangkul 2010); the ESCO Fund approved 17 projects ($125 million of total investment) generating energy savings of around $14 million per year (Asawutmangkul 2010); and adder costs for SPPs and VSPPs could generate investment for some sources of renewable energy.

Based on these implementation results, it is clear that the private sector is ready to invest in energy efficiency and renewable energy projects. However, without some positive conditions—such as adequate financial and technical support to overcome investment barriers, financial gains generated from the investment, and favorable conditions and regulations—the investment might not eventuate. Table 3.2 provides a summary of policy lessons learned in Thailand.

Table 3.2: Policy Lessons Learned in Thailand

Policy	What worked	Issue to be strengthened
Energy efficiency (Under ENCON)		
Energy efficiency in the power sector	…	Energy saving and loss
Energy efficiency in the industry sector	Energy audits Revolving Fund ESCO Fund	Increasing the role of energy service companies for energy efficiency Deploying more efficient technologies in key industries Enhancing energy efficiency for SMEs
Energy efficiency in the household sector	Energy Label No.5 (demand-side management program)	Continuing to rescale the efficiency level
Renewable energy (under ENCON, SPP and VSPP, and REDP)		
Renewable energy development targeting the power sector (utilize solar, hydropower, wind, biogas, biomass)	Promoting energy production as co-benefits Adder for increasing financial feasibility of some SPP and VSPP projects Revolving Fund for renewable energy investment ESCO Fund for renewable energy investment Promoting CDM for project development	Providing more financial incentives, especially investment subsidy for some renewable energy resources, such as wind and solar Extending period for adder for some renewable energy, such as wind and solar Developing laws and regulations concerning project development
Renewable energy development in the industry sector (utilize wastes and other materials and resources)	Promoting energy production as co-benefits Adder for increasing financial feasibility of some SPP and VSPP projects, such as biomass and biogas Revolving Fund for renewable energy investment ESCO Fund for renewable energy investment Promoting CDM for project development (limited to large companies)	Addressing the cost for CDM project development Expanding renewable energy development (covering more industries and medium-sized enterprises)
Renewable energy development in the agriculture sector (utilize agricultural wastes)	Promoting energy production as co-benefits Adder for increasing financial feasibility of some projects, such as biomass and biogas	Resource management for biomass Addressing the cost for CDM project development

Policy	What worked	Issue to be strengthened
	Promoting programmatic CDM for project development	
Renewable energy development in the waste sector (utilize municipal waste)	Promoting energy production as co-benefits Adder for increasing financial feasibility Promoting CDM for project development	Understanding between stakeholders for developing energy from municipal waste
Transport		
Rail public transport policy in Bangkok metropolitan area	BTS skytrain and MRT subway	Extending the coverage of the system in Bangkok and vicinity
Biofuel promotion policy	Mandatory use of biodiesel (B3)	Consistency of policy implementation regarding the price of fuels for creating incentives to use biofuels
Waste management		
Waste reduction and recycling policy	Informal sector for recycling	Increasing awareness and action of people for waste reduction and recycling Providing facilities and points for collecting recyclable wastes Health and environmental impacts among informal recyclers
Residential and commercial building		
Green and energy efficiency building and home	Building codes, awards, and certifications concerning energy efficiency	Developing green building and home models for Thai climate Promoting the green and energy efficiency building concepts for small and medium-sized buildings Promoting the use of energy efficient materials for small and medium-sized buildings, and homes
Industry		
Environmentally friendly labeling policy	Reduced greenhouse gas emissions in the manufacturing sector	Raising awareness in the public sector about green purchasing
Forestry		
Forest conservation and reforestation policy	Protecting forest areas and increasing the forest areas	Illegal logging and human intrusion (for agricultural purposes and settlement) in some areas still found

BTS = Bangkok Mass Transit System, CDM = Clean Development Mechanism, MRT = Metropolitan Rapid Transit, SPP and VSPP = small and very small power producers

Source: Authors' analysis.

3.6 Summary of Recommendations

3.6.1 Policy Reform Challenges for Green and Low-Carbon Development

3.6.1.1 Energy Sector Reform

Thailand has started energy sector reform. The private sector can participate in power generation activities, and renewable energy is used for generating electricity. However, the levels of private participation and renewable energy utilization can be increased to improve energy security, maintain economic growth, and minimize greenhouse gas emissions.

The key challenge to deeper reform in the energy sector is inducing the private sector to invest in renewable energy development. Many incentives are being offered to the private sector, but they are not enough to attract investment in solar and wind projects. Thus, it is important to develop suitable incentive options to make investment in renewable energy attractive to the private sector.

3.6.1.2 Economic Reform

Economic reform is a challenging issue in Thailand. In general, environmental costs are not generally integrated into products and services because of the lack of environmental taxes. Environmental and carbon taxes are not yet effective (the [Draft] Act on Economic Instruments for Environmental Management is awaiting implementation), and the economic reform needed to integrate environmental costs into economic and pricing systems has yet to occur.

However, when the (Draft) Act on Economic Instruments for Environmental Management comes into effect, reform in the Thai economy should be clearly seen. However, this reform is expected to bring challenges in terms of associated costs, as the taxes will eventually affect the cost of products and services. With the increasing costs come key challenges for the domestic and international market. In the domestic market, the higher costs of products and services will affect low-income earners; the government must address this issue. In the international market, increasing costs will affect the ability to compete with other exporting countries. This issue is crucial because Thailand is a production hub for many products, such as electronics and appliances, agricultural and food products, and textiles. The government and industry will need to find solutions on international markets.

3.6.1.3 Institutional Reform and Governance

In recent years Thailand has undertaken institutional and governance reform by decentralizing power from the central government to local governments, and having more public participation in many areas, including health and environmental impacts. However, institutional and governance concerning green and low-carbon development for Thailand persists remains problematic in terms of capacity of local governments.

Most environmental responsibilities of the central government are assigned to local governments, which manage local environmental issues. However, most local governments lack the capacity and resources to manage certain environmental issues. Thus, the challenge for Thailand is to increase the capacity of, and supply sufficient resources to, local governments so that they can implement and achieve green and low-carbon development in their areas.

3.6.1.4 Regional Cooperation

In ASEAN, cooperation among member countries is expected to increase in the years to come (through the effectiveness of the ASEAN Economic Community [AEC]). The AEC primarily

focuses on the economic integration of member countries by eliminating tariffs, addressing the movement of professionals and capital, and facilitating customs clearance procedures. However, environmental concerns are not yet part of AEC cooperation. Thus, the challenge for regional cooperation around green and low-carbon issues is to bring environmental consideration into the AEC system, which may not be possible in the initial stages of the AEC.

3.6.2 Recommendations

Climate change has been recognized as a threat to the nation and has been integrated into the formulation of several national plans and policies. Both the public and private sectors have been actively involved in reducing greenhouse gas emissions, and a series of measures and actions have been implemented in each sector to achieve this.

Developing renewable energy and promoting energy conservation and efficiency are the primary ways to mitigate greenhouse gas emissions. Green consumption and production, as well as green lifestyle, have also been addressed but are yet to mature. The other area that has not clearly emerged yet is stakeholder involvement and engagement for tackling climate change. Even though Thailand has made significant progress toward green and low-carbon development, more needs to be done. Overall, Thailand has to focus on implementing no-regret policies to ensure the decoupling of the economy and the environment, while starting to looking further at implementing least-cost policies. Short-term policies should immediately address the issue of rapidly increasing greenhouse gas emissions, and long-term policies should address fundamental changes towards a green and low-carbon society.

In the short term, Thailand needs to increase the implementation of its current promising policies on renewable energy, energy efficiency, and other green policies, such as SPPs and VSPPs, Revolving Fund, and ESCO Fund. Additionally, incentives policies should be introduced using economic instruments through the market system. Policies regarding greenhouse gas emission reduction should allow the participation of the private sector, because the private sector has the abilities and is efficient in making environmental advancements. At the same time, the bodies of knowledge concerning new issues, such as green building and homes, need to be developed.

It is essential for Thailand to emphasize technology transfer regarding green and clean technologies, and regional and bilateral cooperation for developing technologies, so that the technologies can be deployed quickly and at low cost. Nevertheless, R&D into green and clean technologies, especially commercialized energy efficiency and renewable energy technologies, should be prioritized as it is still low in Thailand. The focus of policies on technologies should concentrate not only on R&D but also on generating the demand for such technologies.

For agricultural activities, policies around greenhouse gas emission reduction have not yet taken shape. The key consideration is changing current agricultural practices to be environmentally friendly by changing farmer behavior and introducing new technologies and materials.

New policy initiatives concerning greenhouse gas emissions reduction, such as green buildings and homes, and green islands and cities, should be further developed, and suitable concepts and models should be developed to fit the Thai context. The basic information and knowledge on climate change should be developed and utilized to advance new policy initiatives.

For long-term policies, the foundation of the society needs to be addressed, especially in the public sector. Fundamental changes are needed in terms of environmental awareness and behavior, and these issues should be addressed by integrating both environmental knowledge and awareness into the educational system and facilitating environmentally friendly behavior.

It is important to find innovative solutions to overcome the challenges being faced in each sector (Table 3.3).

Table 3.3: Sector Challenges and Solutions

Sector	Challenge	Solution
Energy and power sector	Achieving 15-Year Renewable Energy Plan	Revise renewable energy incentives
		Remove other barriers to renewable energy utilization for each specific source of energy
		Improve renewable resource management and utilization
	Finalizing the direction of power development through the Power Development Plan	Address the issue of nuclear power and clean coal with public participation for arriving at mutual agreement for the direction of national power development
	Developing new technologies for renewable energy	Research and develop into new renewable technologies (also considering the food versus energy issue)
		Cooperation among developing countries for commercial R&D on technologies to reduce cost and to develop new generation of technologies
Industry sector	Intensifying the utilization of renewable energy	Consider the utilization of on-site renewable energy generation technologies
	Implementation of greenhouse gas emissions reduction is still limited to large and medium-sized enterprises	Integrate environment rationalities into the industry and manufacturing sectors, especially for small enterprises
		Encourage large companies to implement greening the supply chain with their small suppliers
	High cost of technologies	Support the local production of energy efficiency and renewable energy technologies
	Further development of renewable energy and energy efficiency in the industry sector	Consider the tax system and implement new positive economic instruments, such as • carbon taxes (reducing taxes) for products or activities utilizing renewable energy • financial incentives for enterprises that invest in renewable energy or reduce energy consumption; waive annual registration fees
	Development of new technologies for renewable energy and energy efficiency	Research and development into new renewable and energy efficiency technologies, especially for commercial-scale technologies

Sector	Challenge	Solution
Commercial and residential sector	Further development of renewable energy and energy efficiency in the commercial and residential sector	Consider the tax system and implement new positive economic instruments, such as • reduced electricity cost for buildings and houses that can continuously reduce electricity consumption • providing incentives or reducing taxes for using and/or producing renewable energy
	Research and development into renewable energy and energy efficiency in the commercial and residential sector	Research and development into eco design building and housing in tropical climate context
Building sector	Implementing green building concept in Thailand's climate (for new buildings)	Develop the green building concept and guidelines, especially for small buildings and residential complexes
	Intensifying the implementation of energy efficiency in buildings	Consider the utilization of new energy efficiency technologies
	Research and development for renewable energy and energy efficiency in the building sector	Promote research and development and the use of small-scale renewable technologies in commercial operations, such as using small wind turbines in high-rise buildings
Transport sector	Promoting eco cars (small cars with high energy efficiency, high emission standards, and cheaper price) would increase the number of cars on the road; total emissions from cars may significantly increase	Promote ecological cars (fuel efficient and low emissions) and hybrid cars (be aware of battery waste)
		Promote public transport in big cities by improving the public transport system, especially expanding the rail system
	Creating demand for biofuel consumption	Provide suitable price difference for biofuels
Agriculture sector	Changing traditional practices of farmers	Provide incentive system, such as a price premium for agricultural products that are cultivated and harvested using climate-friendly practices
Others	Waste utilization	Promote and give incentives for investing in projects at the local government level, utilizing co-benefit concept, such as solid-waste management and wastewater

Source: Authors.

In addition to sector challenges, there are other large-scale and fundamental challenges for Thailand regarding green and low-carbon development (Table 3.4).

Table 3.4: Supporting Mechanisms for Green and Low-Carbon Development

Issue	Solution
Low-carbon city	Solidify implementation of low-carbon cities by developing a practical plan or guideline or tools for the cities to follow to be a low-carbon city introducing the low-carbon city concept as both reducing greenhouse gas emissions and increasing carbon capture and storage identifying cities and islands to be low-carbon cities through reducing greenhouse gas emissions and/or increasing carbon capture and storage, depending on local context of each city giving priority to tourist destinations
	Involve and cooperate with all stakeholders for the execution for the low-carbon city initiative
Education	Educate and provide practical experience on energy and environment at very young age, beginning at the elementary school level
	Increase the environmental awareness for people through media; both the government and business sector should take action
Public participation in greenhouse gas reduction	Address the issue of environmental awareness versus actual action by facilitating environmentally friendly behaviors, such as improving the public transport system and lowering the costs of public transport, and installing recycling garbage bins in communities
Business and consumer participation in greenhouse gas reduction	Enhance the role of the business sector and consumers in increasing green consumption and green behaviors by considering the implementation of new tax systems and positive economic instruments, such as receiving points for buying green and low-carbon products, which can then be used as a discount or other purpose
	Enhance the role of business in increasing green consumption and green behaviors through voluntary initiatives, such as providing low-interest loans for environmentally friendly buildings and projects which are well designed

Source: Authors.

REFERENCES

Akrasanee, N. 2006. *Thailand's FTAs: Lessons in Trade and Investment Strategy*. Presentation at Asia Pacific Economic Cooperation (APEC) Official Symposium on Impact of Regional Economic Integration in East Asia on APEC Trade Liberalization. Tokyo.

Asawutmangkul, A. 2010. *Energy Efficiency, Standard and Labelling Policies in Thailand*. Presentation on 6 May 2010. http://www.unep.org/climatechange/mitigation/sean-cc/Portals/141/doc_resources/TrainingEEtechnologies/EE%20S-L%20policies%20Thailand_Asawautmangkul.pdf (accessed 2 June 2011)

Bangkok Metropolitan Administration. 2007. *Action Plan on Global Warming Mitigation 2007–2012*. Bangkok.

Chotichanathawewong, Q. and Thongplew, N. 2009. Thai People Have High Awareness on Global Warming and Climate Change. In *2008 Top News on the Environment in Asia* 98–9. Kanagawa, Japan: Institute for Global Environmental Strategies.

Department of Alternative Energy Development and Efficiency. 2011a. Summary of the Implementation on Energy Efficiency and Renewable Energy 2010. Bangkok.

———. 2011b. Knowledge management: Revolving Fund Project. http://www2.dede.go.th/km_berc/menu3.html (accessed 19 October 2011)

———. 2011c. Knowledge management: ESCO Fund Project. http://www2.dede.go.th/km_berc/menu3.html (accessed 19 October 2011)

du Pont, P. 1998. *Energy Policy and Consumer Reality: The Role of Energy in the Purchase of Household Appliances in the US and Thailand*. Dissertation. University of Delaware.

———. 2005. *Impact of energy conservation, DSM and renewable energy generation on EGAT's Power Development Plan (PDP)*. Bangkok: Danish Energy Management.

Electricity Generating Authority of Thailand. 2009a. Energy Label Number 5 Manual for Refrigerator. http://www2.egat.co.th/labelNo5/FileDownload/manual/air/air2009_04.pdf (accessed 10 September 2011).

———. 2009b. Energy Label Number 5 Manual for Air Conditioner (in Thai), http://www2.egat.co.th/labelNo5/FileDownload/manual/refrigerator/refrigerator2009-v3_0.pdf (accessed 10 September 2011).

———. 2010. Summary of Power Development Plan 2010–2030. http://www.egat.co.th/en/images/stories/pdf/Report%20PDP2010-Apr2010_English.pdf (accessed 10 August 2011)

———. 2011. *2010 Annual Report Electricity Generating Authority of Thailand*. Nonthaburi, Thailand.

Energy Conservation Promotion Fund. 2011. Budget Plan. http://www.enconfund.go.th/01-capital/05-expense.html (accessed 26 September 2011).

Energy Policy and Planning Office. 2008. *Energy Conservation Plan, Energy Conservation Fund (2008–2011).* Bangkok.

———. 2009. Summary of modification alternatives for promoting power generation from renewable energy. http://www.eppo.go.th/power/new_adder_policy.pdf (accessed 20 October 2010).

———. 2011. Independent Power Producer-Small Power Producer-Very Small Power Producer Data. http://www.eppo.go.th/power/data/index.html (accessed 17 October 2011)

———. Undated. *Energy Conservation Plan (ENCON Plan): Energy Conservation Fund (ENCON Fund) Phase 3 (2005–2011)*. Bangkok.

Greater Mekong Subregion Economic Cooperation Program, 2009. *Joint Ministerial Statement*.15th Ministerial Meeting. Petchburi.

Joint Graduate School for Energy and Management. 2010. *The Development Study for Developing Inventory and Model on Emission Inventory for Thailand.* Final report, for Thailand Greenhouse Gas Management Organization.

Limmeechokchai et al. 2009. Assessment of cost-effectiveness for renewable energy and energy efficiency investments in Thailand. Final report of Thailand Research Fund for the Energy Policy and Planning Office: June.

Ministry of Energy. 2009. 15-Year Renewable Energy Development Plan (Presentation). Available at: http://www.dede.go.th/dede/fileadmin/upload/nov50/mar52/REDP_present.pdf (accessed 9 June 2011).

———. 2011a. 20-Year Energy Conservation Plan. Bangkok.

———. 2011b. Phaplui Green Island. http://www.energy.go.th/index.php?q=node/615 (accessed on 20 August 2011).

Ministry of the Environment (Japan) and Global Environment Centre Foundation. 2011. Japan's Initiative toward Establishment of New Mechanisms: Lessons Learnt from Case Studies 2010. http://gec.jp/gec/en/Activities/fs_newmex/newmex-casestudies2010lessonlearnt.pdf (accessed 17 October 2011).

Na Phuket, S. R. and C. Prijyanonda. 2000. *How Energy Labeling Affected Production Decisions of Appliance Manufacturers in Thailand*. Bangkok. International Institute for Energy Conservation. Asia Regional Office.

Nakawiroa T., Bhattacharyyaa S. C., and B. Limmeechokchaib. 2008. Electricity capacity expansion in Thailand: An analysis of gas dependence and fuel import reliance. *Energy* 33:712–23.

National Economic and Social Development Board and Thailand Environment Institute. 2006. *The Development of Thailand's Sustainable Development Index Project: Phase II*.

National Institute of Development Administration. 2010. *Draft Final Report of the study of Thailand Long-term Economic Growth or Gross Domestic Products Project*.

Pollution Control Department. 2006. *Green Procurement Handbook*. Bangkok.

———. 2009. *Thailand State of Pollution Report 2008*. Bangkok.

Pongthanaisawan J. and C. Sorapipatana. 2010. Relationship between Level of Economic Development and Motorcycle and Car Ownerships and Their Impacts on Fuel Consumption and Greenhouse Gas Emission in Thailand. *Renewable and Sustainable Energy Reviews* 14:2,966–75.

PTT Public Company. 2011. Retail Prices for Gasoline. http://www.pttplc.com/TH/news-energy-fact-oil-price -bangkok.aspx (accessed 30 September 2011).

Royal Forest Department. 2011a. Forest Area in Thailand from 1973–2008 (in Thai). http://web2.forest.go.th/webmis/page/ .html (accessed 21 June 2011).

———. 2011b. National Forest Policy (in Thai). http://www.dnp.go.th/watershed/policy1.htm (accessed 20 July 2011).

Royal Thai Embassy Vientiane. 2011. Thailand–Laos PDR Cooperation: Economic. http://www.thaisavannakhet.com/vientiane/th/cooperation/cooperation3/ (accessed 20 October 2011).

Sajjakulnukit, B. 2011. Energy Policy and Measures. In Thailand's First Assessment Report on Climate Change 2011: Knowledge on Greenhouse Gas Mitigation. Working Group III: Greenhouse Gas Mitigation. Edited by S. Taoprayoon, C. Sorapipatana, and A. Chidthaisong. Bangkok: Thailand Research Fund.

Seres, S. 2008. *Analysis of Technology Transfer in CDM Projects*. Report submitted to the United Nations Framework Convention on Climate Change Registration and Issuance Unit CDM/SDM. http://cdm.unfccc.int/ Reference/Reports/TTreport/TTrep08.pdf (accessed 20 June 2011).

Siam Cement Group. 2011. *SCG Sustainability Report 2010*. Bangkok.

Singh, J. and C. Mulholland. 2000. DSM in Thailand: A Case Study. Joint United Nations Development Programme/World Bank Energy Sector Management Assistance Programme (ESMAP). Washington, DC: World Bank.

Spaargaren, G. 2003. Sustainable Consumption: A Theoretical and Environmental Policy Perspective. *Society and Natural Resources* 16:687–701.Srethasirote, B. 2011. Framework and Development of REDD and REDD Plus. In *REDD Plus: Hot Issue for Global Negotiation; Suitable Framework and Approach for Thai Society*, edited by B. Srethasirote, R. Thaworn, L. Puangchit, and S. Soonthornwong. Bangkok: Thailand Research Fund.

Sutabutr, T. 2010. *Thailand's Renewable Energy Development Plan (REDP)*. Presentation for the FRANCE Green Tech THAILAND 2010 at Centara Grand Hotel and Bangkok Convention Center at Central World, Bangkok on 12 October.

Thailand Business Council for Sustainable Development. 2011. Calculation of GHG emissions reduction of TBCSD members. Unpublished.

Thailand Environment Institute. 2011a. Certified Green Label products (in Thai). http://www.tei.or.th/GreenLabel/pdf/2011-05-Name-GL-th.pdf (accessed 20 June 2011).

———. 2011b. GHG Emissions Reduction from Carbon Reduction Certification for Building. Unpublished.

Thailand Greenhouse Gas Management Organization. 2011a. CoolMode Certified Products. http://thaicarbonlabel.tgo.or.th/CM_Certified_Product.php (accessed 21 October 2011).

———. 2011b. Status of CDM projects in Thailand. http://www.tgo.or.th/english/index.php?option=com_content&view=section&id=6&Itemid=56 (accessed 10 October 2011).

———. 2011c. Carbon Footprint Certified Products. http://thaicarbonlabel.tgo.or.th/CF_Certified_Product.php (accessed 21 October 2011).Vongvanich, N. 2011. Personal communication. 18 October 2011

Wibulswasdi, C., P. Piboolsavut, and P. Kobsak. 2010. *Sufficiency Economy Philosophy and Development*. Sufficiency Economy Research Project, Bureau of the Crown Property. Bangkok.

Watcharejyothin, M. and R. M. Shrestha. 2009. Regional Energy Resource Development and Energy Security under CO_2 Emission Constraint in the Greater Mekong Subregion Countries (GMS). *Energy Policy*. 37 (11): 4,428–41.World Bank. 2006. *WORLD BANK GEF Post-Implementation Impact Assessment: Thailand Promotion of Electrical Energy Efficiency Project*. Washington, DC.

Yogo, M. and S. D. Okuda. 2000. Liberalization of Trade in Services in Asia-Pacific Economic Cooperation: Assessment of Individual Action Plan and the General Agreement on Trade and Services Commitments. In *APEC in the 21st Century -Selected Issues for Deeper Economic Cooperation*. http://www.ide.go.jp/English/Publish/Download/Apec/pdf/2000_04.pdf (accessed 1 August 2010).

Zhai, Y. 2010. Energy Sector Integration for Low Carbon Development in Greater Mekong Sub-region: Towards a Model of South-South Cooperation. Background paper for The 21st World Energy Congress. Montreal. 11–16 September.

ANNEX I:

Table A1: Business-As-Usual Scenario

Sector	2008 2551	2009 2552	2010 2553	2011 2554	2012 2555	2013 2556	2014 2557	2015 2558	2016 2559	2017 2560	2018 2561	2019 2562	2020 2563
Agriculture Forestry Fis	11.9	14	14.6	15.2	16	16.6	17.5	18.3	19.2	20	21	21.9	22.9
Comm and Residential	6.4	6.2	6.4	6.6	6.9	7.1	7.4	7.7	7.9	8.2	8.5	8.8	9.1
ManuF. Industrial and Cons.	37	37	42.6	44.4	46.3	48.1	50.4	52.6	54.9	57.3	59.8	62.4	65.3
Petroleum Refining	9.2	9.6	8.5	8.9	9.3	9.7	10.2	10.7	11.2	11.7	12.2	12.8	13.3
Transport	60.3	62.2	63.8	65.9	68.2	70.4	73.7	76.8	80	83.4	86.7	90.3	94.2
Agriculture	57.2	57.6	58.4	59.2	60.1	61	61.9	62.8	63.7	64.7	65.7	66.7	67.7
Industrial Process	28.5	30.6	32	33.3	34.7	36.1	37.5	39.1	42.7	46.3	50	53.7	57.1
LULUCF	14.8	15.2	15.1	15.1	15	15.1	19.1	17.7	16.8	18.4	18.6	18.7	18.8
Waste GDP	10.1	13.5	13.8	14	14.3	14.4	14.7	15	15.3	15.6	15.9	16.3	16.6
Electricity Generation	87.7	86.6	90.2	94.3	98.3	102	106.1	110.1	114.6	119.4	124.3	128.8	133.6
Total	323	332.3	345.4	357	369	380.5	398.4	410.8	426.3	445.1	462.6	480.2	498.7

Sector	2021 2564	2022 2565	2023 2566	2024 2567	2025 2568	2026 2569	2027 2570	2028 2571	2029 2572	2030 2573	2031 2574	2032 2575	2033 2576	2034 2577	2035 2578
Agriculture Forestry Fis	24	25.1	26.2	27.3	28.5	29.8	31.1	32.5	33.9	35.4	37	38.6	40.3	42.1	44
Comm and Residential	9.4	9.8	10.1	10.4	10.7	11	11.4	11.8	12.1	12.5	12.9	13.3	13.7	14.2	14.6
ManuF. Industrial and Cons.	68.3	71.3	74.4	77.7	81.2	84.8	88.7	92.7	97	101.6	106.4	111.5	116.8	122.5	128.5
Petroleum Refining	14	14.6	15.2	15.8	16.5	17.2	17.9	18.7	19.5	20.3	21.2	22.1	23.1	24.1	25.1
Transport	98.2	102.1	106.2	110.4	114.7	119.3	124	128.9	134	139.3	144.8	150.5	156.5	162.7	169.2
Agriculture	68.8	69.9	71	72.2	73.4	74.6	75.8	77.1	78.4	79.7	81.1	82.5	83.9	85.4	86.4
Industrial Process	60.7	64.4	68.2	72.1	76	79.9	83.9	87.9	92	96.1	96.9	97.8	98.7	99.6	100.6
LULUCF	18.9	19	19.1	19.2	19.4	19.5	19.6	19.7	19.8	19.9	20.1	20.2	20.3	20.4	20.6
Waste GDP	16.9	17.3	17.6	18	18.4	18.8	19.2	19.6	20	20.4	20.9	21.4	21.8	22.3	22.9
Electricity Generation	138.7	143.7	148.8	154.1	159.5	165.2	171	177.1	183.4	189.9	196.6	203.6	210.8	218.3	226
Total	517.9	537.1	556.8	577.2	598.2	620	642.6	666	690.2	715.2	737.9	761.5	786	811.6	837.7

Sector	2036 2579	2037 2580	2038 2581	2039 2582	2040 2583	2041 2584	2042 2585	2043 2586	2044 2587	2045 2588	2046 2589	2047 2590	2048 2591	2049 2592	2050 2593
Agriculture Forestry Fis	45.9	47.9	50.1	52.3	54.6	57	59.5	62.1	64.9	67.7	70.7	73.9	77.1	80.5	84.1
Comm and Residential	15.1	15.6	16	16.6	17.1	17.6	18.2	18.8	19.3	20	20.6	21.2	21.9	22.6	23.3
ManuF. Industrial and Cons.	134.9	141.7	148.8	156.4	164.5	173.1	182.2	192	202.3	213.3	225.1	237.6	251	265.2	280.5
Petroleum Refining	26.2	27.3	28.4	29.7	30.9	32.2	33.6	35.1	36.6	38.1	39.7	41.4	43.2	45.1	47
Transport	175.9	183	190.3	197.8	205.7	214	222.5	231.4	240.7	250.4	260.4	270.9	281.8	293.2	305
Agriculture	87.3	88.3	89.3	90.3	91	92	92.8	93.8	94.9	95.9	97	98.1	99.2	100.3	101.5
Industrial Process	101.6	102.6	103.7	104.8	106	107.2	108.5	109.8	111.2	112.6	114.1	115.7	117.3	119	120.7
LULUCF	20.7	20.8	20.9	21	21.2	21.3	21.4	21.6	21.7	21.8	21.9	22.1	22.2	22.3	22.5
Waste GDP	23.4	23.9	24.5	25.1	25.7	26.3	27	27.7	28.4	29.1	29.8	30.6	31.4	32.2	33.1
Electricity Generation	234	242.3	250.9	259.8	269	278.5	288.4	298.6	309.2	320.2	331.5	343.3	355.4	368	381.1
Total	864.9	893.3	922.9	953.8	985.7	1019.3	1054.2	1090.8	1129.1	1169.2	1211	1254.8	1300.6	1348.5	1398.7

Agriculture Forestry Fis = agriculture, forestry, and fishery; Comm and Residential = commercial and residential; LULUCF = land use change and forestry; ManuF. Industrial and Cons. = manufacturing, industrial processes, and construction.

Note: The first line of the year is in Christian calendar year and the second line is in Buddhist calendar year (commonly used in Thailand). The measuring unit in this table is in million tons of carbon dioxide equivalent.

Source: Joint Graduate School for Energy and Management 2010.

Table A2: Power Development Plan 2010 Scenario

Sector	2008 2551	2009 2552	2010 2553	2011 2554	2012 2555	2013 2556	2014 2557	2015 2558	2016 2559	2017 2560	2018 2561	2019 2562	2020 2563
Agriculture Forestry Fis	11.9	14	14.6	15.2	16	16.6	17.5	18.3	19.2	20	21	21.9	22.9
Comm and Residential	6.4	6.2	6.4	6.6	6.9	7.1	7.4	7.7	7.9	8.2	8.5	8.8	9.1
ManuF. Industrial and Cons.	37	37	42.6	44.4	46.3	48.1	50.4	52.6	54.9	57.3	59.8	62.4	65.3
Petroleum Refining	9.2	9.6	8.5	8.9	9.3	9.7	10.2	10.7	11.2	11.7	12.2	12.8	13.3
Transport	60.3	62.2	63.8	65.9	68.2	70.4	73.7	76.8	80	83.4	86.7	90.3	94.2
Agriculture	57.2	57.6	58.4	59.2	60.1	61	61.9	62.8	63.7	64.7	65.7	66.7	67.7
Industrial Process	28.5	30.6	32	33.3	34.7	36.1	37.5	39.1	42.7	46.3	50	53.7	57.1
LULUCF	14.8	15.2	15.1	15.1	15	15.1	19.1	17.7	16.8	18.4	18.6	18.7	18.8
Waste GDP	10.1	13.5	13.8	14	14.3	14.4	14.7	15	15.3	15.6	15.9	16.3	16.6
Electricity Generation	87.7	86.7	86.2	88.5	92.1	94.8	99.1	100.8	99.3	100.5	104.2	107.9	107.8
Total	323	332.4	341.4	351.2	362.9	373.3	391.4	401.5	411	426.3	442.5	459.4	472.9

Sector	2021 2564	2022 2565	2023 2566	2024 2567	2025 2568	2026 2569	2027 2570	2028 2571	2029 2572	2030 2573	2031 2574	2032 2575	2033 2576	2034 2577	2035 2578
Agriculture Forestry Fis	24	25.1	26.2	27.3	28.5	29.8	31.1	32.5	33.9	35.4	37	38.6	40.3	42.1	44
Comm and Residential	9.4	9.8	10.1	10.4	10.7	11	11.4	11.8	12.1	12.5	12.9	13.3	13.7	14.2	14.6
ManuF. Industrial and Cons.	68.3	71.3	74.4	77.7	81.2	84.8	88.7	92.7	97	101.6	106.4	111.5	116.8	122.5	128.5
Petroleum Refining	14	14.6	15.2	15.8	16.5	17.2	17.9	18.7	19.5	20.3	21.2	22.1	23.1	24.1	25.1
Transport	98.2	102.1	106.2	110.4	114.7	119.3	124	128.9	134	139.3	144.8	150.5	156.5	162.7	169.2
Agriculture	68.8	69.9	71	72.2	73.4	74.6	75.8	77.1	78.4	79.7	81.1	82.5	83.9	85.4	86.4
Industrial Process	60.7	64.4	68.2	72.1	76	79.9	83.9	87.9	92	96.1	96.9	97.8	98.7	99.6	100.6
LULUCF	18.9	19	19.1	19.2	19.4	19.5	19.6	19.7	19.8	19.9	20.1	20.2	20.3	20.4	20.6
Waste GDP	16.9	17.3	17.6	18	18.4	18.8	19.2	19.6	20	20.4	20.9	21.4	21.8	22.3	22.9
Electricity Generation	107.4	109.8	112.4	110.4	107.5	113.5	116.1	120.5	124.8	129	133.6	138.3	143.2	148.3	153.6
Total	486.6	503.2	520.5	533.5	546.2	568.4	587.7	609.4	631.6	654.4	674.9	696.2	718.5	741.7	765.3

Sector	2036 2579	2037 2580	2038 2581	2039 2582	2040 2583	2041 2584	2042 2585	2043 2586	2044 2587	2045 2588	2046 2589	2047 2590	2048 2591	2049 2592	2050 2593
Agriculture Forestry Fis	45.9	47.9	50.1	25.3	54.6	57	59.5	62.1	64.9	67.7	70.7	73.9	77.1	80.5	84.1
Comm and Residential	15.1	15.6	16	16.6	17.1	17.6	18.2	18.8	19.3	20	20.6	21.2	21.9	22.6	23.3
ManuF. Industrial and Cons.	134.9	141.7	148.8	156.4	164.5	173.1	182.2	192	202.3	213.3	225.1	237.6	251	265.2	280.5
Petroleum Refining	26.2	27.3	28.4	29.7	30.9	32.2	33.6	35.1	36.6	38.1	39.7	41.4	43.2	45.1	47
Transport	175.9	183	190.3	197.8	205.7	214	222.5	231.4	240.7	250.4	206.4	270.9	281.8	293.2	305
Agriculture	87.3	88.3	89.3	90.3	91	92	92.8	93.8	94.9	95.9	97	98.1	99.2	100.3	101.5
Industrial Process	101.6	102.6	103.7	104.8	106	107.2	108.5	109.8	111.2	112.6	114.1	115.7	117.3	119	120.7
LULUCF	20.7	20.8	20.9	21	21.2	21.3	21.4	21.6	21.7	21.8	21.9	22.1	22.2	22.3	22.5
Waste GDP	23.4	23.9	24.5	25.1	25.7	26.3	27	27.7	28.4	29.1	29.8	30.6	31.4	32.2	33.1
Electricity Generation	159	164.7	170.5	176.5	182.8	189.3	196	202.9	210.1	217.6	225.3	233.3	241.5	250.1	258.9
Total	790	815.7	842.5	870.6	899.5	930.1	961.8	995.2	1030.1	1066.6	1104.8	1144.8	1186.7	1230.6	1276.5

Agriculture Forestry Fis = agriculture, forestry, and fishery; Comm and Residential = commercial and residential; LULUCF = land use change and forestry; ManuF. Industrial and Cons. = manufacturing, industrial processes, and construction.

Note: The first line of the year is in Christian calendar year and the second line is in Buddhist calendar year (commonly used in Thailand). The measuring unit in this table is in million tons of carbon dioxide equivalent.

Source: Joint Graduate School for Energy and Management 2010.

Table A2: Climate Plan Scenario

Sector	2008 2551	2009 2552	2010 2553	2011 2554	2012 2555	2013 2556	2014 2557	2015 2558	2016 2559	2017 2560	2018 2561	2019 2562	2020 2563
Agriculture Forestry Fis	11.9	14	14.6	15.2	16	16.6	17.5	18.3	19.2	20	21	21.9	22.9
Comm and Residential	6.4	5.9	6.1	6.3	6.2	6.4	6.7	6.9	7.2	7.1	7.3	7.6	7.8
ManuF. Industrial and Cons.	37	36.7	42.2	43.8	45.2	46.5	47.5	47.4	46.8	47.9	49.9	52.1	54.5
Petroleum Refining	9.2	9.6	8.5	8.9	9.3	9.7	10.2	10.7	11.2	11.7	12.2	12.8	13.3
Transport	60.3	62.1	62.8	64.2	66.2	68.1	71	73.7	76.5	79.7	82.7	86	89.5
Agriculture	57.2	56	56.7	56.7	57.1	57.8	58.4	58.4	58.4	58.5	58.5	58.5	59.2
Industrial Process	28.5	28.7	29.2	29.3	29.5	29.4	29.6	32.1	35	38.1	41.2	44.3	46.8
LULUCF	14.8	15.2	15.1	(6.1)	(6.1)	(6.1)	(5)	(5.5)	(5.7)	(5.3)	(5.3)	(5.3)	(5.3)
Waste GDP	10.1	6.6	6.8	6.3	6.5	6.5	6.7	6.8	7	7.1	7.4	7.5	7.6
Electricity Generation	87.7	85.5	84.8	86.5	89.3	90.8	94	94.8	92.4	92.9	94.7	96.2	95.1
Total	323	320.3	326.8	311.3	319.2	325.6	336.5	343.7	347.9	357.6	369.6	381.6	391.5

Sector	2021 2564	2022 2565	2023 2566	2024 2567	2025 2568	2026 2569	2027 2570	2028 2571	2029 2572	2030 2573	2031 2574	2032 2575	2033 2576	2034 2577	2035 2578
Agriculture Forestry Fis	24	25.1	26.2	27.3	28.5	29.8	31.1	32.5	33.9	35.4	37	38.6	40.3	42.1	44
Comm and Residential	8.1	7.9	8.1	8.4	8.7	8.9	8.7	8.9	9.2	9.5	9.7	10	10.3	10.6	10.9
ManuF. Industrial and Cons.	57	59.5	62.1	64.8	67.7	70.7	73.9	77.3	80.9	84.7	88.7	92.9	97.3	102	107
Petroleum Refining	14	14.6	15.2	15.8	16.5	17.2	17.9	18.7	19.5	20.3	21.2	22.1	23.1	24.1	25.1
Transport	93	96.4	100	103.6	107.3	111.1	115	119	123.1	127.3	132.1	137.1	142.4	147.8	153.5
Agriculture	59.8	60.4	61.1	61.7	62.4	63.2	64	64.7	65.5	66.4	67.2	68.1	68.9	69.8	70.3
Industrial Process	46.1	48.2	50.4	52.7	55	57.4	59.8	62.3	64.8	67.3	53.5	54.4	55.2	53.1	57
LULUCF	(5.3)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.2)	(5.1)	(5.1)
Waste GDP	7.8	7.9	8.1	8.2	8.4	8.6	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3
Electricity Generation	92.6	93.8	94.9	91.3	86.7	88.7	89.2	89.7	90.1	82.2	84.4	86.6	88.9	91.4	93.8
Total	397	408.4	420.8	428.8	436.1	450.4	463.2	477	491	497.1	498.1	514.3	531.2	548.8	566.8

Sector	2036 2579	2037 2580	2038 2581	2039 2582	2040 2583	2041 2584	2042 2585	2043 2586	2044 2587	2045 2588	2046 2589	2047 2590	2048 2591	2049 2592	2050 2593
Agriculture Forestry Fis	45.9	47.9	50.1	52.3	54.6	57	59.5	62.1	64.9	67.7	70.7	73.9	77.1	80.5	84.1
Comm and Residential	11.2	11.5	11.8	12.2	12.5	12.9	13.3	13.6	14	14.4	14.8	15.3	15.7	16.2	16.6
ManuF. Industrial and Cons.	112.3	117.9	123.9	130.2	136.9	144	151.6	159.6	168.2	177.3	187	197.4	208.4	220.2	232.8
Petroleum Refining	26.2	27.3	28.4	29.7	30.9	32.2	33.6	35.1	36.6	38.1	39.7	41.4	43.2	45.1	47
Transport	159.4	165.5	171.9	178.5	185.4	192.6	200	207.8	215.9	224.2	232.9	242	251.3	261.1	271.2
Agriculture	70.9	71.4	72	72.6	73.1	73.7	74.2	74.8	75.5	76.1	76.8	77.4	78.1	78.8	79.5
Industrial Process	58	59	60.1	61.2	62.3	63.5	64.7	66	67.3	68.7	70.2	71.7	73.3	74.9	76.6
LULUCF	(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5)	(5)	(5)	(5)	(5)
Waste GDP	10.5	10.8	11	11.2	11.2	11.3	11.3	11.3	11.4	11.4	11.4	11.5	11.5	11.6	11.6
Electricity Generation	96.4	99	101.7	104.5	107.4	110.3	113.4	116.5	119.8	123.1	126.5	130.1	133.7	137.5	141.2
Total	585.6	605.2	625.8	647.1	669.2	692.4	716.5	741.9	768.4	796.1	825.2	855.6	887.5	920.8	955.7

Agriculture Forestry Fis = agriculture, forestry, and fishery; Comm and Residential = commercial and residential; LULUCF = land use change and forestry; ManuF. Industrial and Cons. = manufacturing, industrial processes, and construction.

Note: The first line of the year is in Christian calendar year and the second line is in Buddhist calendar year (commonly used in Thailand). The measuring unit in this table is in million tons of carbon dioxide equivalent.

Source: Joint Graduate School for Energy and Management 2010.