Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy

THAILAND

Submitted under the Paris Agreement

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The COP, by its decision 1/CP 21, paragraph 35, invited Parties to communicate, by 2020, to the secretariat mid-century, long-term low greenhouse gas emission development strategies in accordance with Article 4, paragraph 19, of the Agreement.

In line with the Paris Agreement, Thailand aims to peak its greenhouse gas emissions in 2030, with the ambition to move towards net-zero greenhouse gas emissions as early as possible within the second half of this century, and towards carbon neutrality by 2065, while looking forward to enhanced international cooperation and support on finance, technology and capacity-building to achieve this ambition.

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Glossary of Abbreviations

AEDP	Alternative Energy Development Plan
AIM	Asia-Pacific Integrated Assessment Model
AIM/CGE	Asia-Pacific Integrated Model/Computable General Equilibrium
BAU	Business-as-usual
BEC	Building energy codes
BECCS	Bio-energy with carbon capture and storage
BEV	Battery electric vehicle
BHD	Bio-hydrogenated diesel
BUR	Biennial update report
CAGR	Compound annual growth rate
CCS	Carbon capture and storage
CCUS	Carbon capture utilization and storage
CECap	CO2 emissions per capita
CGE	Computable General Equilibrium
CH4	Methane
CO	Carbon Monoxide
COP	Coefficient of performance
COVID-19	Coronavirus disease 2019
EEP	Energy Efficiency Plan
EERS	Energy efficiency resource standards
EES	Energy storage system
ESCO	Energy service company
EV	Electric vehicle
FCEV	Fuel cell electric vehicle
GDP	Gross domestic product
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IPS	Independent power supply
ktoe	Kilotonnes of oil equivalent
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LT-LEDS	Long-term Low Greenhouse Gas Development Strategy
LULUCF	Land Use, Land-Use Change and Forestry
M&E	Monitoring and evaluation
MNRE	Ministry of Natural Resources and Environment
MRV	Measurement, Reporting and Verification
MSW	Municipal solid waste
NAMAs	Nationally Appropriate Mitigation Actions
NC	National communication
NCCC	National committee on climate change policy
NDC	Nationally Determined Contribution
NEP	National Energy Plan
NESDC	Office of the National Economic and Social Development Council

NMVOC	Non-methane volatile organic compounds
NOX	Nitrogen Oxides
ONEP	Office of Natural Resources and Environmental Policy and Planning
PM2.5	Fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller
RD&D	Research development and deployment
REDD+	Reducing Emission from Deforestation and Forest Degradation and role of conservation, sustainable management of forest and enhancement of forest carbon stock
SDGs	Sustainable development goals
Thailand's LEDS	Thailand's Long-term Low Greenhouse Gas Development Strategy
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WEEE	Waste electrical and electronic equipment

Preface

Climate change is perilously affecting all countries and has had an unprecedented impact across the globe. Past GHG emissions have led to many changes in the climate system, including increased heatwave frequency and intensity, heavy precipitation, as well as droughts. Current and future emissions rates will likely cause additional global warming that will further instigate such changes with irreversible impacts.

Recognizing the need for multilateral cooperation to keep the global average temperature within the limit of the Paris Agreement's goal and guided by the principles of common but differentiated responsibilities and respective capability, especially in consideration of different national circumstances, Thailand hereby formulates its Long-term Low Greenhouse Gas Development Strategy (LT-LEDS) to guide the country's national development agenda and contribute to global efforts to address climate change. Thailand's LEDS is science-based and has been prepared with the involvement of a wide range of stakeholders to ensure a balanced position based on economic growth, poverty eradication, just transition, food security, social welfare (with particular regard for vulnerable groups), and climate actions needed to mitigate climate change. It will, therefore, serve as a basis for the preparation of future NDCs and thus support Thailand's transition towards low GHG emissions and climate-resilient development.

In accordance with Article 4, paragraph 19 of the Paris Agreement, and responding to decision 1/CP.21, paragraph 35 of the Conference of the Parties, Thailand hereby communicates its mid-century, Long-term Low Greenhouse Gas Development Strategy to the Secretariat. To achieve the targets outlined in Thailand's LEDS, stringent GHG mitigation measures are needed in energy, IPPU, waste and agriculture sectors, including a drastic increase of carbon sink and removals in forestry and land uses. In this regard, international cooperation and financial, technological, and capacity-building support are critically important to support Thailand's efforts to make this necessary transition towards a sustainable future.

Although Thailand's LEDS primarily focuses on GHG mitigation, Thailand recognizes that adaptation and climate resilience are equally important. Thailand, therefore, looks forward to further elaborating its policies and priorities on climate change adaptation in future communications.

H.E. General Prayut Chan-o-cha (Ret.)
Prime Minister of the Kingdom of Thailand

Executive Summary

The Paris Agreement sets out a long-term temperature goal and underscores the urgency for Parties to reach global peaking of greenhouse gas emissions as soon as possible and to undertake rapid reductions thereafter, on the basis of equity and in the context of sustainable development and poverty eradication, while recognizing that peaking will take longer for developing country Parties. In this connection, Article 4, paragraph 19, of the Paris Agreement, suggests all Parties to strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 considering their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

The mid-century, long-term low greenhouse gas emission development strategy (LT-LEDS) of Thailand was developed through a participatory process through the establishment of various working groups from all sectors and stakeholders before gaining the final approval by the Cabinet. Thailand's LEDS set out clear targets and measures to be implemented towards achieving its net zero GHG emission. First, Thailand aims to reach its peak GHG emissions in 2030 at approximately 370 $MtCO_2eq$. Second, Thailand's net greenhouse gas emissions are projected to be approximately 200 $MtCO_2eq$ in 2050, which is consistent with the global 2-degree pathway. Third, post-2050 emissions will follow the IPCC 2-degree pathways, in which Thailand aims to achieve the balance between GHG emissions by sources and removals by sinks as early as possible within the second half of this century.

The main GHG mitigation measures identified in Thailand's LEDS focus on the energy and transport sectors. Measures identified in the energy sector include energy efficiency improvement, technology switching and the adoption of renewable energy and carbon capture and storage (CCS). In the transport sector, mitigation measures include modal shift, energy efficiency improvement and the promotion of new, efficient, vehicle fleets.

In addition, Thailand also aims to meet the carbon neutrality by 2065. As such it is expected that financial and technological support will be provided as early as possible. Thailand must prioritize and speedily develop its new infrastructure, especially the energy and transport system, by increasing the share of renewable electricity generation at least 50% of new power generation capacity by 2050 and the share of new vehicles in the market to be electric vehicles at least 69% by 2035. It also includes energy efficiency improvement, and adopt advanced carbon removal technologies, such as bio-energy with CCS, CCS and CCU. The energy system must be transformed through decarbonization, digitalization, decentralization, deregulation and electrification such as grid modernization, energy storage systems, net metering market, and EV infrastructure. Furthermore, it is foreseen that, the deployment of hydrogen renewable electricity and CCS will also play a vital role in meeting the target.

It is revealed that the implementation of Thailand's LEDS will lead to certain socio-economic impacts due to increasing energy system cost from greener energy production. This impact includes GDP and welfare losses after 2040 and large increasing carbon prices in 2050. Thailand needs to prepare a transitional plan for its transformation in the energy and transport infrastructure to increase the low-emission investments and businesses. This domestic preparation, together with the expected lower costs of advanced GHG mitigation technologies, will mitigate such economic impacts and result in a better economy in a long run. Meanwhile, its co-benefit includes a decrease in energy intensity and CO2 per capita which will help in reducing local air pollutants such as NO_X, CO, NMVOC and PM2.5.

A successful transition to a low-carbon society in Thailand requires the contribution of all sectors and stakeholders. Thailand is looking for more low-carbon business models from both domestic and international investors. This opportunity will enable Thailand to build forward better to become a green economy country after the COVID-19 pandemic and facilitate a move towards carbon neutrality and a net zero GHG emission, respectively. Lastly, to achieve Thailand's LEDS targets, international cooperation and support is needed in terms of policy development, research and technology development, development of appropriate mechanisms and instruments, and capacity building.

Chapter 1

National Circumstances

Climate change is among several major challenges to sustainable development. Economic activities since the industrial revolution have dramatically accelerated the release of greenhouse gases into the atmosphere and increased the severity of climate change. Thailand is one of the Southeast Asia countries severely affected by climate change, especially the long-term impacts such as increasing average temperature and increased severity and frequency of floods, droughts and storms. Such adverse effects jeopardize major economic sectors, including agriculture, tourism, and industry.

Economic activity, population growth and urbanization contribute to the greenhouse gas emissions in Thailand. Despite Thailand only contributing less than one percent of the global greenhouse gas emissions, it has set up the goal to become a low carbon society and efforts have been made to shift its energy policy towards green energy over the past decade. The renewable energy utilization has been greatly expanded to achieve the goal of sustainable green growth.

1.1 Country Profile

Thailand is located in a tropical area between latitudes N 5°37’ to N 20°27’ and longitudes E 7°22’ to E 105°37’, with a total area of 513,115 square kilometers, or approximately 200,000 square miles. The boundaries of Thailand with adjacent areas are: North: Myanmar and Laos; East: Laos, Cambodia and the Gulf of Thailand; South: Malaysia; and West: Myanmar and the Andaman (See Figure 1-1).

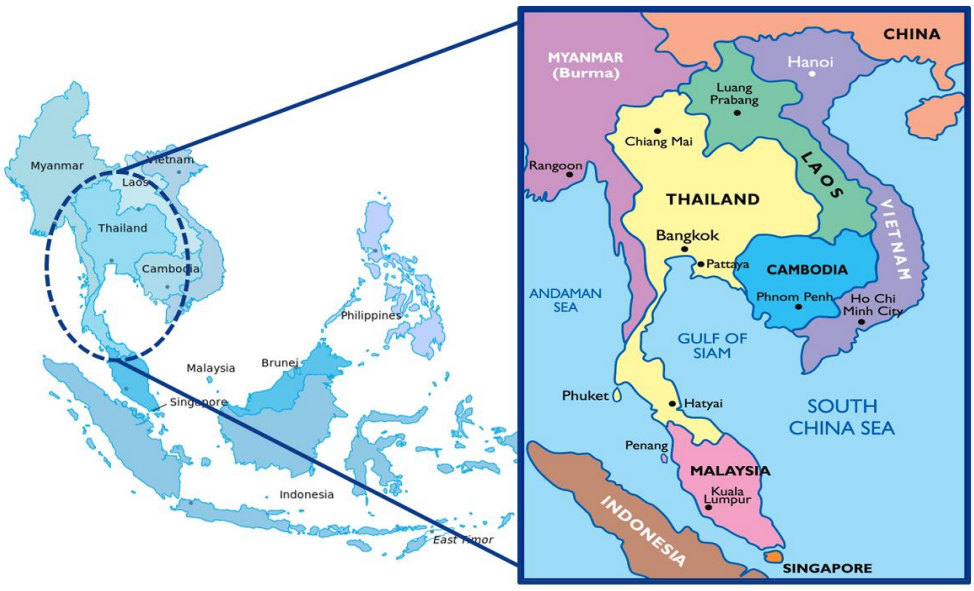


Figure 1-1: Map of the Kingdom of Thailand

Thailand has a coastline of approximately 2,700 km; it borders the Andaman Sea, with 865 km of coastline. Geographically, Thailand can be divided into six regions. The northern region is characterized as hilly and mountainous. The north-eastern region is naturally a high plain. The central region is a large low-level plain. The eastern regions are mostly plains and valleys with some small hills. The southern region is a peninsula with the Andaman Sea on the western side and the South China Sea on the eastern side. Lastly, the western region is hilly and mountainous.

1.1.1 Climate

Thailand's climate is influenced by two main seasonal monsoon winds: the southwest monsoon and the northeast monsoon. The southwest monsoon starts in May and brings a stream of warm, moist air from the Indian Ocean towards Thailand, causing abundant rain over the country, especially on the windward side of the mountains. The northeast monsoon starts in October and brings cold and dry air from the anticyclone in the Chinese mainland over major parts of Thailand, particularly focused on the north and northeast regions. Thailand's climate can be broadly divided into three seasons: 1) rainy, or the southwest monsoon season, from mid-May to mid-October 2) winter, or the northeast monsoon season, from mid-October to mid-February and 3) summer, from mid-February to mid-May. Figure 1-2 shows the annual mean maximum temperatures in Thailand, which indicate a trend of increasing temperatures is likely to continue.

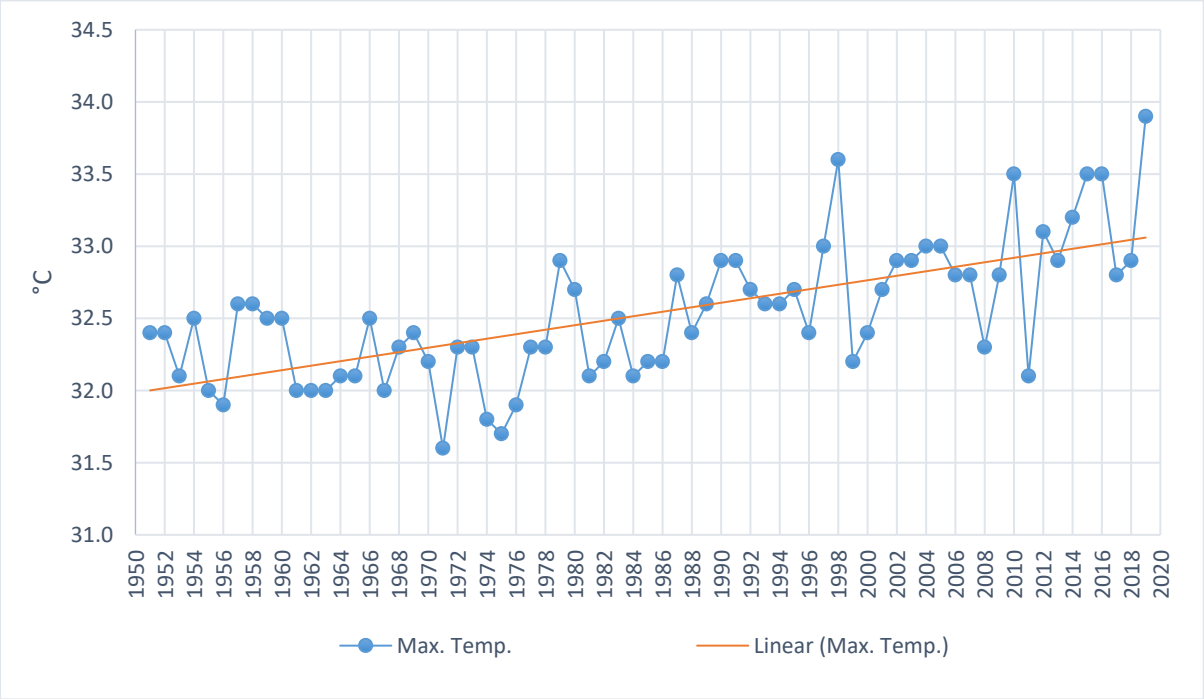


Figure 1-2: Annual mean maximum temperatures in Thailand

1.1.2 Population

Thailand's population is projected to gradually increase until around 2030, from which point it will start to decline. The forecast populations for 2025, 2030 and 2040 are 67.09, 67.14 and 65.37 million, respectively. A decline in birth rate with a concurrent increase in life expectancy has shaped Thailand's population structure into an 'aging society'. The percentage of people aged 60 and over divided by people aged younger than 15 – will increase steadily. The aging index will slightly exceed 120 before 2025, at which point Thailand will be officially categorized as an 'aged society'. Figure 1-3 shows that Thailand's population is projected to become a 'super aged society' by 2035, when the aging index is estimated to exceed 200. By 2040, the aging population will be more than double that of the youthful population. This transition is related to the care and support of aging members of society while the labor force is shrinking.

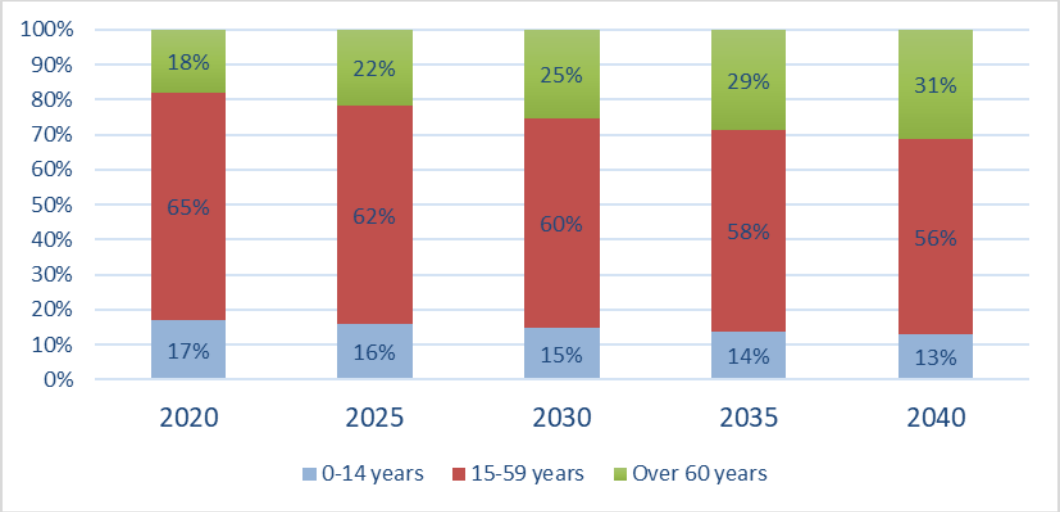


Figure 1-3: Age structure of Thailand during 2020-2040

1.1.3 Economy

Thailand's economic development follows the 12th National Economic and Social Development Plan (2017-2021), extended to 2022, which adhered to the National Strategy (2018-2037), a commitment to the sustainable development goals (SDGs), a philosophy of Sufficiency Economy, and the Thailand 4.0 Policy. Thailand has experienced low, single-digit GDP growth in the past decade, with the industrial and service sectors the main drivers of recent growth. Thailand has the second-largest economy in Southeast Asia, but its GDP per capita ranks fourth. The economy is heavily export-dependent, with exports accounting for more than one-third of GDP. Both exports and imports have faced negative growth over the past few years. Thailand has one of the lowest unemployment rates in the world, at about 1%, because a large proportion of the population works in subsistence agriculture or other vulnerable occupations.

Thailand's economy shrunk by 6.1% in 2020 due to the Coronavirus pandemic, down from 2.3% growth the previous year, which was the lowest expansion rate in the past 10 years. Export value decreased by 6.6% while private consumption and total investment decreased by 1.0% and 4.8%, respectively (see Table 1-1). However, in the long run when the Coronavirus pandemic is over, it is expected that the economic growth would follow the same trend.

Table 1-1: Thailand's economic indicators

Indicators	2016	2017	2018	2019	2020
Growth in Real GDP	3.3	4.0	4.1	2.3	-6.1
Investment	2.8	1.8	3.8	2.0	-4.8
• Private	0.5	2.9	3.9	2.7	-8.4
• Public	9.5	-1.2	3.3	0.1	5.7
Private Consumption	3.0	3.0	4.6	4.0	-1.0
Government Consumption	2.2	0.1	1.8	1.7	0.8
Export of Goods	0.1	9.8	7.7	-3.3	-6.6
• Volume	0.5	6.0	4.2	-3.7	-5.9
Import of Goods	-5.1	13.2	14.3	-5.6	-13.5
• Volume	-2.5	7.2	8.2	-5.7	-11.8
Current Account to GDP (%)	11.7	11.0	7.4	7.0	3.3
Inflation (%)	0.2	0.7	1.1	0.7	-0.8

Source: NESDC Economic Report and National Income of Thailand 2020, Office of the National Economic and Social Development Council

1.1.4 Natural Resources

Thailand has a total land area of approximately 513,115 km^2. As of 2018, 46.54% of the nation's total land area (or 238,791 km^2) was categorized as agricultural land. Forest land and non-agricultural land accounted for 31.96% and 21.50% of the total land area, respectively. Nearly half the agricultural land is attributed to paddy land, equal to 109,949 km^2 or 21.43% of Thailand's total land area.

According to the estimation by the Royal Forest Department, forest area in 2018 was almost 164,000 km^2, which is equivalent to 16.40 million hectares. There are a number of laws in place in Thailand related to the management and maintenance of the national forest estate, such as the Royal Forest Department Strategy (2017-2036), Forest Act, B.E.2484 (1941), National Park Act B.E. 2562 (2019) , National Reserved Forest Act, B.E.2507 (1964), Wild Animal Conservation and Protection Act B.E. 2562 (2019), Forest Plantation Act B.E. 2535 (1992) and its amendment, Chain Saws Act B.E. 2545 (2002), and Community Forest Act B.E. 2562 (2019). In addition, a range of projects and programmes have also been implemented to solve issues surrounding forest loss, including activities related to Reducing Emissions from Deforestation and Forest Degradation (REDD+).

1.1.5 State of the Environment

- **Air Quality**

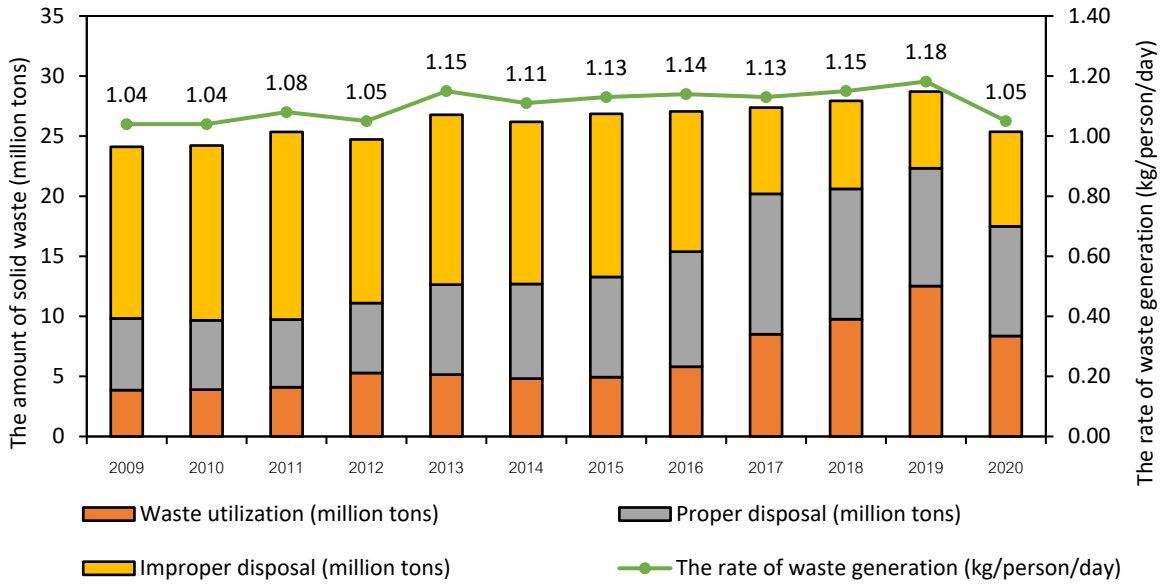
The five major air pollutants in Thailand are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3) and particulate matter (PM). PM10 is generated by building and road construction while SO_2 mainly comes from industrial activities. Air pollution in Thailand can be attributed to two main sources: 1) meteorological factors during the dry season, and 2) point source pollution. To address this problem, the Royal Thai Government has formulated the 20-Year Master Plan on Air Quality Management (2018-2037), set up standards for atmospheric air quality and emissions from specific sources of origin, and developed a national air quality reporting system for communicating information in order to improve air quality.

- **Water Quality**

Thailand's overall surface water quality was improved in 2018, remaining within 'fair' and 'good' quality ranges. Some water resources decreased in quality, mostly in estuaries in central Thailand, where municipal, industrial and agricultural waste are concentrated. The outcome of water quality testing of the country's 59 major rivers and 6 standing water sources showed results of 'good', 'fair' and 'poor' water quality indices in the proportion of 46%, 45% and 9%, respectively. Water quality monitoring in 64 provinces revealed 27 provinces (42%) with good quality, 29 provinces (45%) with fair quality and 8 provinces (13%) with poor quality. Thailand has formulated the 20-Year National Water Quality Management Plan (2018-2037), which prioritizes controlling wastewater discharge to natural water resources.

- **Waste**

The amount of municipal solid waste (MSW) generated in 2020 was 25.37 million tons; this is an 11.63% decrease from 2019, and is mainly a result of expanding urban communities and the shift from agricultural to urban society (See Figure 1-4). The volume of household hazardous waste generated in 2018 was 638,000 tons or a 3.2% increase from 2017. Around 65% of this hazardous waste (414,600 tons) was Waste Electrical and Electronic Equipment (WEEE), with the remaining 35% (223,400 tons) consisting of other household hazardous waste, such as batteries, dry cell batteries, chemical containers and spray bottles.



Source: Thailand State of Pollution Report 2020, Pollution Control Department

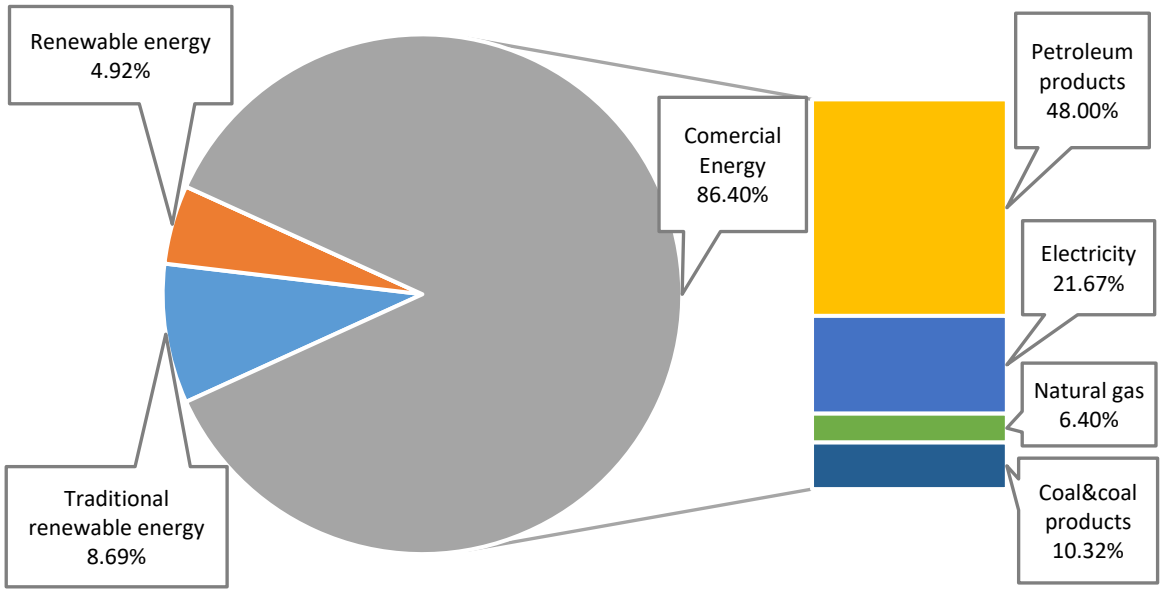
Figure 1 -4: Shares of solid waste generated, recycled, and disposed

The amount of industrial waste managed by an appropriate treatment in 2018 was 17.51 million tons, which decreased 33% from 2017. From that total amount, 20.82 million tons is non-hazardous industrial waste, of which 7.2 million tons were used as fuel to generate electric power, and 1.2 million tons were hazardous industrial waste. The 20-Year Strategic Plan on Pollution Management (2017-2036) was formulated to provide a framework to achieve sustainable waste management and a low-carbon society by 2036. In addition, the National Master Plan for Waste Management (2016-2021) has been adopted as a guideline for solid and hazardous waste management.

1.1.6 Energy Situation

- **Energy Consumption**

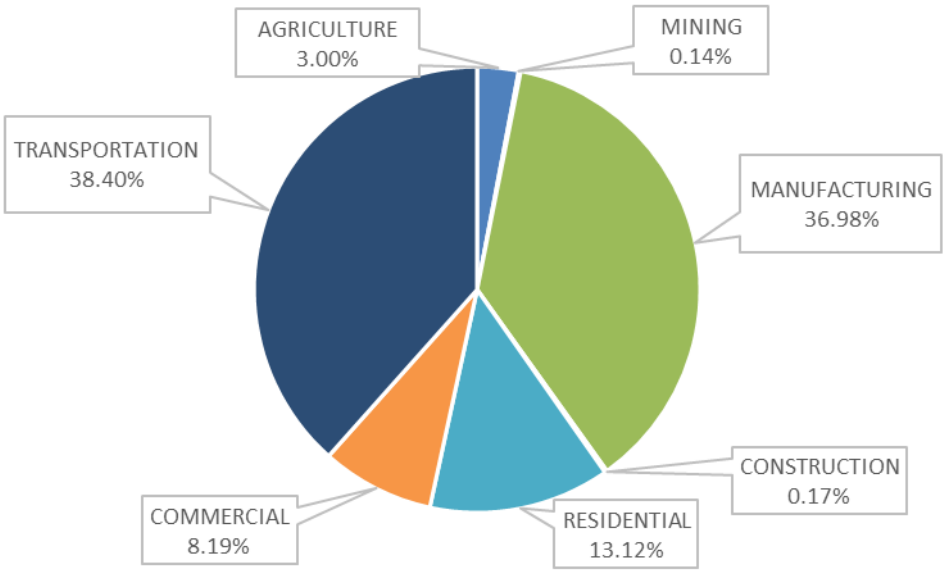
In 2020, most of the energy consumption was for commercial use, amounting to 66,821 ktoe (86.40% of total). Among the energy sources, petroleum products accounted for the largest proportion of consumption (48.00%), followed by electricity (21.67%), natural gas (6.40%), and coal and coal products (10.32%) (See Figure 1-5).



Source: Energy Balance of Thailand 2020, Department of Alternative Energy Development and Efficiency

Figure 1-5: Final energy consumption by fuel type 2020

The transportation sector contributed the largest share of final energy consumption, at around 38.40% of the final energy consumption, followed by manufacturing, residential, commercial, agriculture, construction and mining, respectively (See Figure 1-6).



Source: Energy Balance of Thailand 2020, Department of Alternative Energy Development and Efficiency

Figure 1-6: Share of final energy consumption by economic sectors 2020

- **Energy Production**

Energy production in 2020 was 65,821 ktoe, representing an 11.76% decrease from the previous year (Table 1-2). The commercial energy contributed the largest share of energy production at 41,871 ktoe (63.61% of the total), followed by renewable energy at 16,020 ktoe (24.34%), traditional renewable energy at 5,179 ktoe (7.87%), biofuel at 2,343 ktoe (3.56%), and, finally, other energy sources produced 408 ktoe (0.62%)

Table 1-2: Energy production by fuel type 2016-2019

Energy Production	Quantity (ktoe)			Growth (%)	
	2018	2019	2020	2019	2020
Total Energy Production	72,609	74,592	65,821	2.73%	-11.76%
Commercial Energy	45,828	46,188	41,871	0.79%	-9.35%
• **Crude Oil**	6,453	6,178	5,860	-4.26%	-5.15%
• **Lignite**	3,756	3,532	3,282	-5.96%	-7.08%
• **Natural Gas**	31,122	31,871	28,865	2.41%	-9.43%
• **Condensate**	4,497	4,607	3,864	2.45%	-16.13%
Renewable Energy*	17,156	18,670	16,020	8.82%	-14.19%
Traditional Renewable Energy**	7,012	6,842	5,179	-2.42%	-24.31%
Biofuel	2,113	2,422	2,343	14.62%	-3.26%
Other Energy***	500	470	408	-6.00%	-13.19%

** solar, wind, hydro geothermal, fuel wood, paddy husk, bagasse, agricultural waste, MSW and biogas*

*** fuel wood, charcoal, paddy husk and agricultural waste*

**** black liquor and residual gas*

In 2020, the total amount of energy imports was 77,064 ktoe, with crude oil comprising the largest share of 54.88%. The amount of energy exported was 10,812 ktoe, of which approximately 97.43% are petroleum products.

- **Alternative Energy**

Thailand's alternative energy consumption continued to increase between 2016 and 2018 (See Table 1-3). By 2018, Thailand's alternative energy consumption was 12,996 ktoe, representing an increase of 10.78% from the previous year. Alternative energy consumption from electricity, heat, and biofuel (ethanol and biodiesel) accounted for 15.48% of the total final energy consumption. The total electricity consumption from electrical alternative energy sources, including solar, wind, hydroelectricity, biomass, MSW and biogas in 2018 was 2,960 ktoe, while consumption for heat sources such as solar, biomass, MSW and biogas was 7,919 ktoe. Biofuel consumption was 2,117 ktoe, which constituted 781 ktoe from ethanol and 1,336 ktoe from biodiesel. Thailand has formulated the Alternative Energy Development Plan (AEDP) 2018 and an AEDP action plan aiming to promote alternative energy and reduce

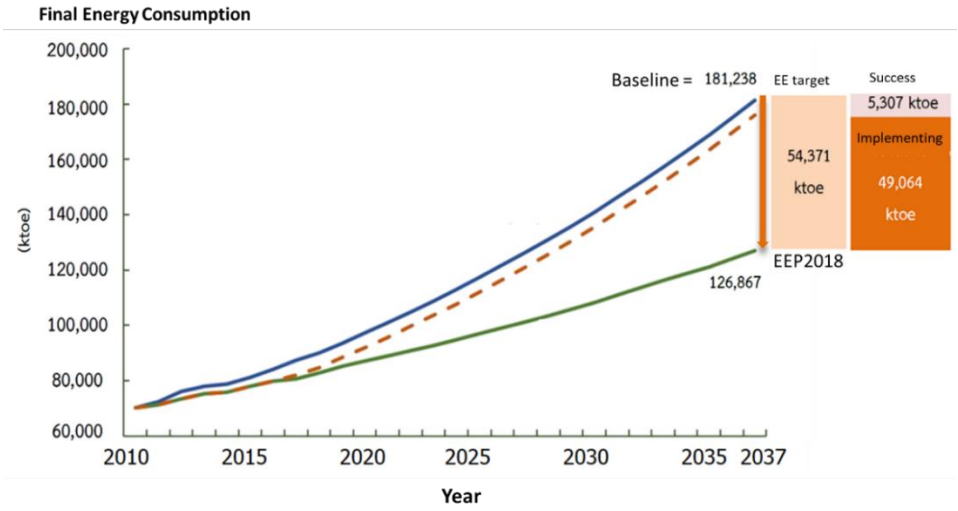
dependency on energy imports such as oil and natural gas. The overall goal of this plan is to increase the share of renewable energy consumption to 30% by 2037.

Table 1-3: Alternative Energy Development Plan (AEDP) 2018

Type of Fuel	Unit	Status at end of year			Target
		2016	2017	2018	2037
Electricity	**MW**	**9,437**	**10,238**	**11,369**	**29,411**
	ktoe	**2,122**	**2,473**	**2,960**	**7,298**
Solar	MW	2,446.10	2,697.20	2,962.45	12,139
Solar floating	MW	-	-	-	2,725
Wind	MW	507.00	627.80	1,102.82	2,989
Small hydro	MW	182.10	182.30	187.72	308
Biomass	MW	2,814.70	3,157.30	3,372.93	5,790
Biogas	MW	434.90	475.40	505.24	1,565
MSW	MW	145.30	191.50	317.82	975
Industrial waste	MW	145.30	191.50	317.82	975
Large hydro	MW	2,906.40	2,906.40	2,919.66	2,920
Heat	**ktoe**	**7,182**	**7,322**	**7,919**	**26,901**
Solar	ktoe	6.7	9.3	10.1	100
Biomass	ktoe	6,507	6,616	7,152	23,000
Biogas	ktoe	593	634	634	1,283
MSW	ktoe	75	63	123	495
Biomethane	ktoe	-	-	-	2,023
Biofuel	**Million liter/day**	**7.1**	**7.7**	**8.4**	**16.03**
	ktoe	**1,747**	**1,936**	**2,117**	**4,084**
Ethanol	Million liter/day	3.7	3.9	4.2	7.50
Biodiesel	Million liter/day	3.4	3.8	4.2	8.00
Pyrolysis oil	Million liter/day	-	-	-	0.53
Alternative energy consumption (ktoe)		**11,051**	**11,731**	**12,996**	**38,284**
Final energy consumption (ktoe)		**79,929**	**80,752**	**83,952**	**126,867**
Share of RE in final consumption (%)		**13.83**	**14.53**	**15.48**	**30**

- **Energy Efficiency**

Thailand has formulated the Energy Efficiency Plan (EEP) 2018 and an EE action plan aiming to promote its energy efficiency. The EEP2018 specifies a target of 30% energy intensity reduction by 2037 and aims to conserve 54,371 ktoe by the end of the plan from all demand side sectors (See Figure 1-7). The industrial sector is the major contributor, accounting for more than 40 percent of the energy conservation target. This sector is expected to conserve energy amounting to 49,064 ktoe. The transport, commercial/government buildings, residence, and agriculture sectors are expected to conserve energy 17,682 ktoe, 21,167 ktoe, 6,418 ktoe, 3,300 ktoe and 527 ktoe, respectively, by 2037 (Table 1-4).



Source: Energy Efficiency Plan (EEP) 2018, Department of Alternative Energy Development and Efficiency

Figure 1-7: The energy conservation target during the year 2010-2037

Table 1-4: Main features of the Energy Efficiency Plan (EEP) 2018

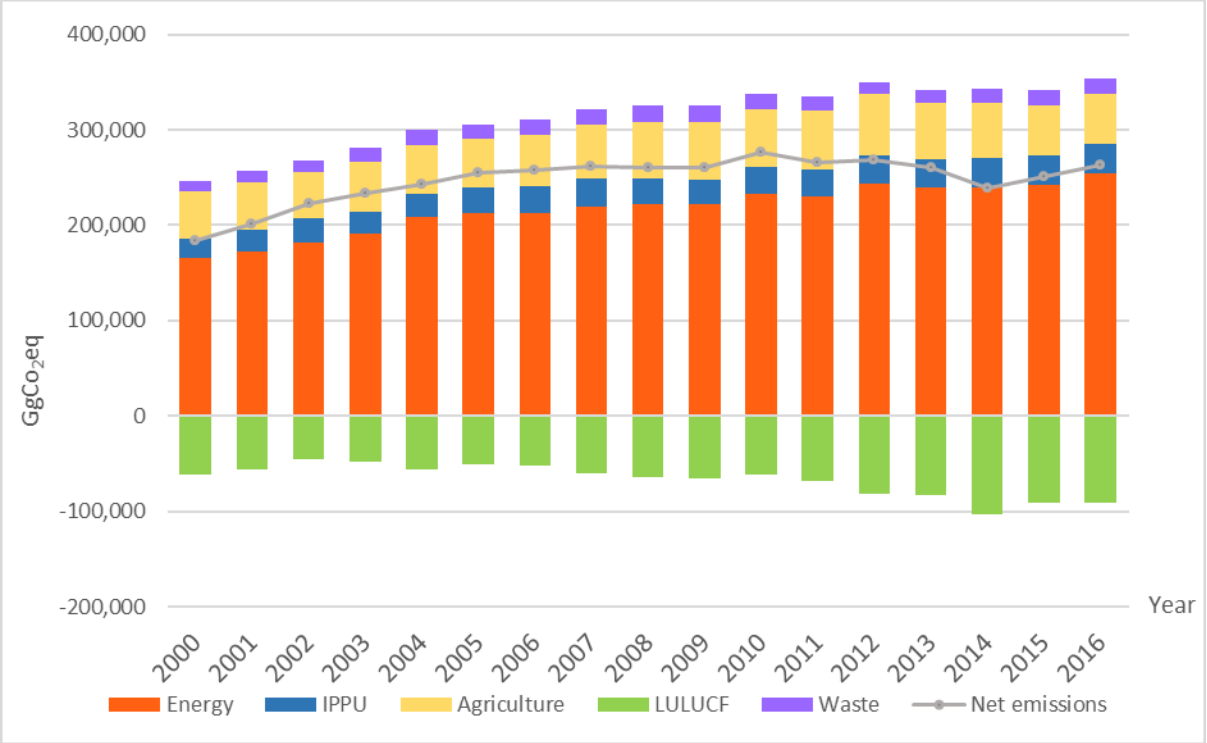
Economic sector	Electricity (ktoe)	Heat (ktoe)	Total (ktoe)
Energy Efficiency Plan 2018 target	**15,379**	**33,685**	**49,064**
1) Industry	6,777	14,360	21,137
2) Commercial	5,532	886	6,418
3) Residential	2,923	377	3,300
4) Agriculture	147	380	527
5) Transport	-	17,682	17,682

1.2 National GHG Emissions Profile

1.2.1 Overview of Historical Emissions

Thailand has continued to track GHG emissions, the six main types of which (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride) are required to be reported according to the UNFCCC. In December 2020, the national greenhouse gas (GHG) emissions reported in the third BUR of Thailand have been made in accordance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The total GHG emissions in 2016 (excluding those from LULUCF) were 354,357.61 $GgCO_{2eq}$ and net GHG emissions were 263,223.46 $GgCO_{2eq}$ (including those from LULUCF). In 2016, the Energy sector was the largest contributor to Thailand's GHG emission, accounting for 71.65% of total GHG emissions, while emissions from the Agriculture, IPPU and Waste sectors accounted for 14.72%, 8.90% and 4.73%, respectively. The LULUCF sector contributed to a net removal of 91,134.15 $GgCO_{2eq}$, showing a trend of increased net removals as total removals exceeded

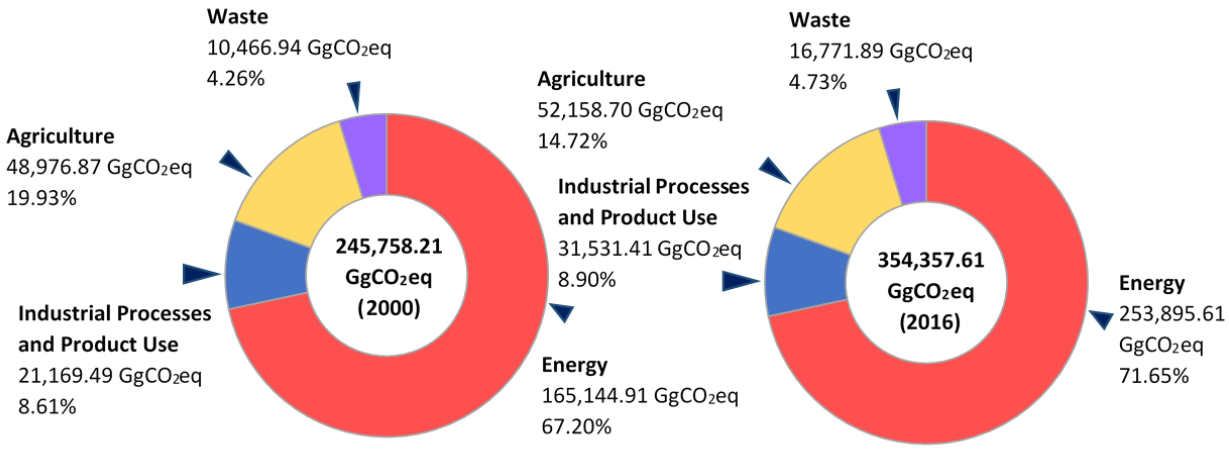
total emissions. In the global perspective, Thailand's GHG emissions represent less than 1% of global emissions and are lower than the world average. Figure 1-8 shows the trend of GHG emissions.



Source: Thailand Third Biennial Update Report, UNFCCC 2020.

Figure 1-8: National GHG emissions/removals by sector

Total GHG emissions (excluding those from LULUCF) increased from 245,757.14 $GgCO_2eq$ in 2000 to 354,357.61 $GgCO_2eq$ in 2016, with an average annual increase of 2.31%. The net removal of CO_2 increased from 61,960.76 $GgCO_2eq$ in 2000 to 91,134.15 $GgCO_2eq$ in 2016. Net GHG emissions therefore increased overall from 183,796.37 $GgCO_2eq$ in 2000 to 263,223.46 $GgCO_2eq$ in 2016, with an average annual increase of 2.27%. From 2000-2016, the main source of GHG emissions was the Energy sector, which saw an increase of 53.74% from 165,143.84 $GgCO_2eq$ in 2000 to 253,895.61 $GgCO_2eq$ in 2016. The proportion of GHG emissions in the Energy sector accounted for 67.20% of total emission sources in 2000, increasing to 71.65% of total emission sources in 2016. In the same period, the share of emissions from the Agriculture sector decreased from 19.93% in 2000 to 14.72% in 2016, while the share of emissions from the IPPU and Waste sectors remained constant (See Figure 1-9).



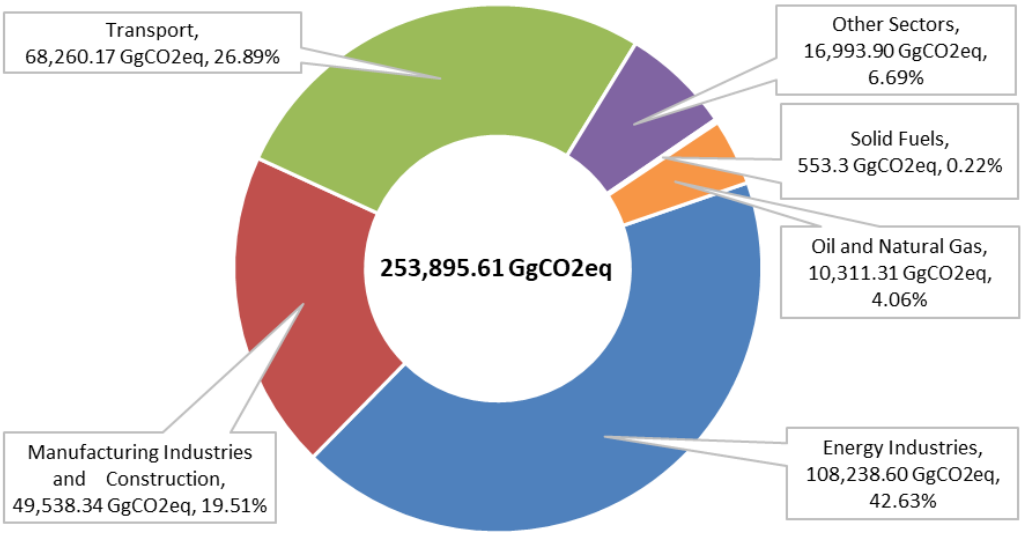
Source: Thailand Third Biennial Update Report, UNFCCC 2020.

Figure 1-9: Total GHG emissions by sector (excluding LULUCF) 2000 and 2016

1.2.2 Greenhouse Gas Emission by Sector

- **Energy**

Total direct GHG emissions from the Energy sector in 2016 were estimated to be 253,895.61 $GgCO_2eq$. The majority of GHG emissions in the Energy sector were generated by fuel combustion, consisting mostly of grid-connected electricity and heat production at around 108,238.60 $GgCO_2eq$ (42.84%). GHG emissions from Transport, Manufacturing Industries and Construction, and other sectors were 68,260.17 $GgCO_2eq$ (27.21%), 49,538.34 $GgCO_2eq$ (19.53%) and 16,993.90 $GgCO_2eq$ (6.10%), respectively. Fugitive Emissions from fuel comprised only 10,864.61 $GgCO_2eq$ or a little over 4.33% of total GHG emissions from the Energy sector. Details of GHG emissions in the Energy sector by gas type and source in 2016 are presented in Figure 1-10.

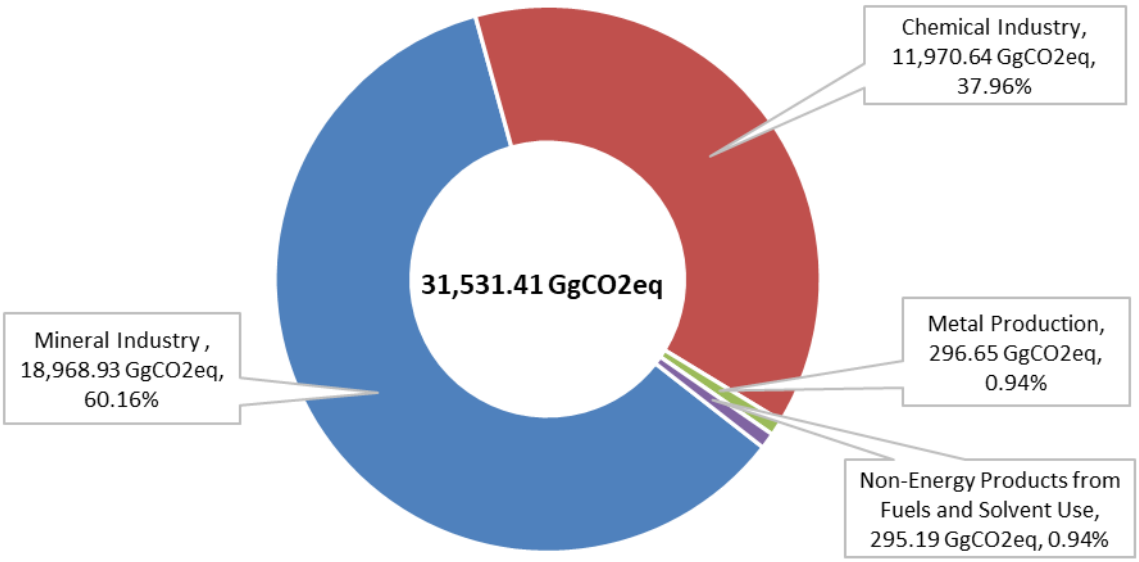


Source: Thailand Third Biennial Update Report, UNFCCC 2020.

Figure 1-10: GHG emissions in the Energy sector in 2016

- **Industrial Processes and Product Use (IPPU)**

The estimation of GHGs for the IPPU sector covered all gases indicated in the 2006 IPCC Guidelines, with the exception of the Fluorinated (F)-gases inventory due to a limitation on available activity data. Total direct GHG emissions from the IPPU sector in 2016 were estimated to be 31,531.41 $GgCO_2eq$. The majority of GHG emissions in this sector were attributed to mineral production, which accounted for approximately 18,968.93 $GgCO_2eq$ (60.16%). GHG emissions from the chemical industry, metal production and non-energy products were estimated at 11,970.64 $GgCO_2eq$ (37.96%), 296.65 $GgCO_2eq$ (0.94%) and 295.19 $GgCO_2eq$ (0.94%), respectively. Details of direct and indirect GHG emissions in the IPPU sector by gas type and source in 2016 are presented in Figure 1-11

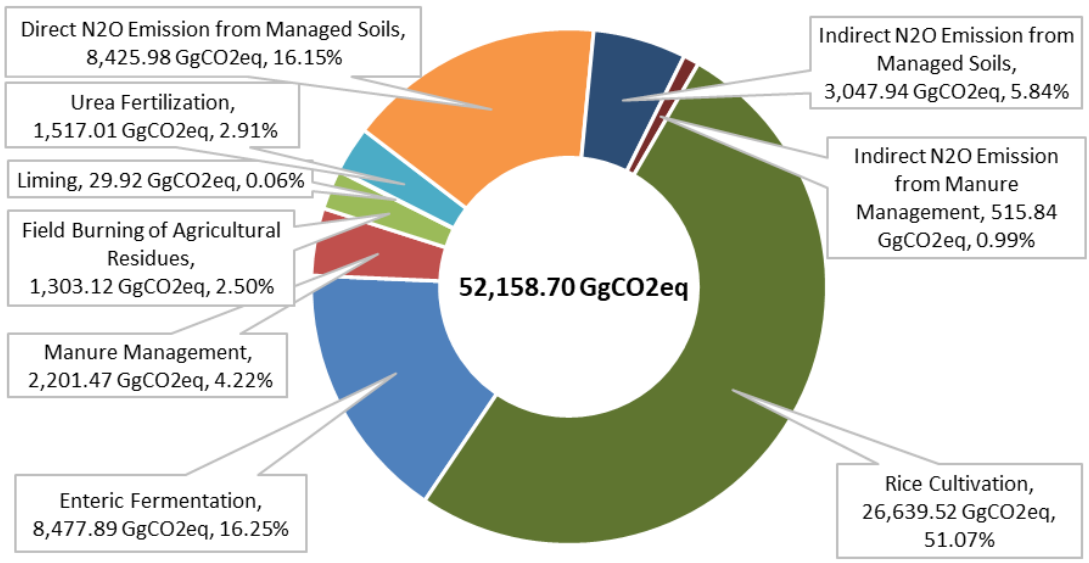


Source: Thailand Third Biennial Update Report, UNFCCC 2020.

Figure 1-11: GHG emissions in the IPPU sector in 2016

- **Agriculture**

Total GHG emissions from the Agriculture sector in 2016 were 52,158.70 $GgCO_2eq$. Livestock contributed 11,195.20 $GgCO_2eq$ (21.46%), comprising 8,477.89 $GgCO_2eq$ from enteric fermentation, and 2,201.47 and 515.84 $GgCO_2eq$ for direct and indirect manure management, respectively. Meanwhile, crop-related GHG emissions accounted for 40,963.49 $GgCO_2eq$ (78.54%). Rice cultivation was the main GHG contributor in Thailand's Agriculture sector, at 26,639.52 $GgCO_2eq$ (51.07%). Agricultural soils emitted 11,473.92 $GgCO_2eq$ (22.00%), with direct and indirect emissions contributing 8,425.98 and 3,047.94 $GgCO_2eq$, respectively. Field burning of agricultural residues and urea fertilizer contributed similar GHG emissions of 1,303.12 and 1,517.01 $GgCO_2eq$ (2.50% and 2.91%), respectively. Details of GHG emissions are presented in Figure 1-12.

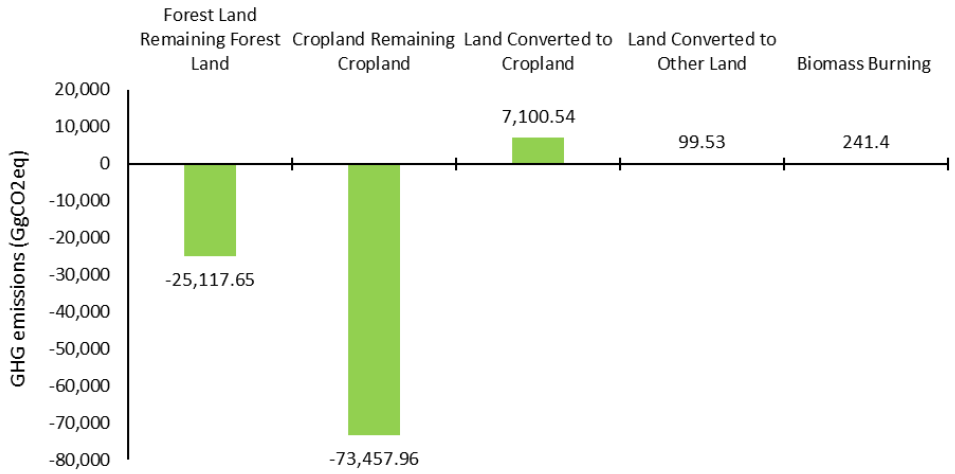


Source: Thailand Third Biennial Update Report, UNFCCC 2020.

Figure 1-12: GHG emissions in the Agriculture sector in 2016

- **Land Use, Land-Use Change and Forestry (LULUCF)**

The GHG emissions and sinks from LULUCF sector were estimated using the 2006 IPCC Guidelines for three land categories: forest land, cropland, and other land. Total CO_2 emissions/removals from Carbon (C) stock changes for each land use category was calculated based on the sum of each subcategory, taking into account three carbon pools: 1) above ground biomass, 2) below ground biomass, and 3) dead organic matter (deadwood and litter). The LULUCF sector in Thailand showed a trend of increased net removals as total removals exceeded total emissions. Croplands, therefore, dominated net removal estimates for Thailand's LULUCF sector. Details of GHG emissions/removals in LULUCF sector in 2016 are presented in Figure 1-13.

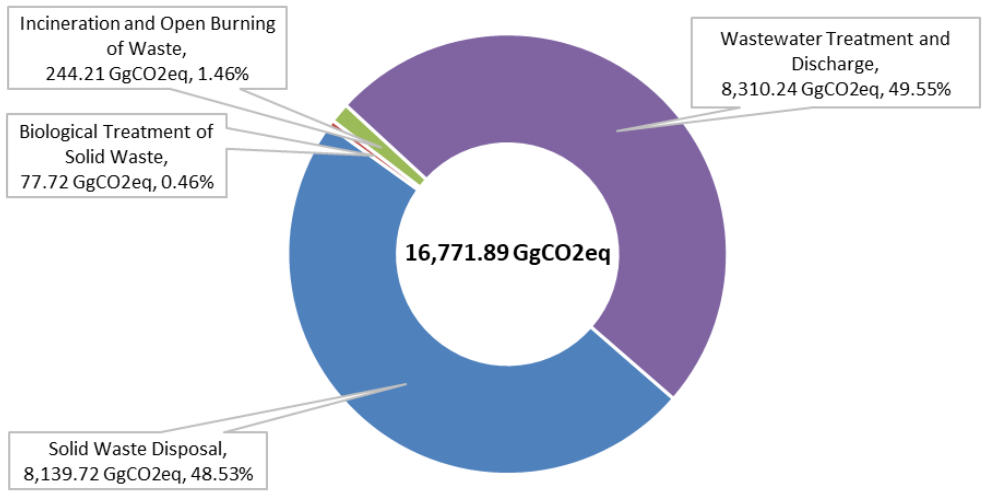


Source: Thailand Third Biennial Update Report, UNFCCC 2020.

Figure 1-13: GHG emissions in the LULUCF sector in 2016

- **Waste**

Total direct GHG emissions from the Waste sector in 2016 were estimated to be 16,771.89 $GgCO_{2eq}$. GHG emissions in the Waste sector were mainly from wastewater treatment and discharge, at an estimated 8,310.24 $GgCO_{2eq}$ (49.55%), and solid waste disposal, at 8,139.72 $GgCO_{2eq}$ (48.53%). The waste incineration accounted for 244.21 $GgCO_{2eq}$ (1.46%), while the biological treatment of solid waste was estimated at 77.72 $GgCO_{2eq}$ (0.46%). Details of GHG emissions in the Waste sector in 2016, are presented in Figure 1-14.



Source: Thailand Third Biennial Update Report, UNFCCC 2020.

Figure 1-14 GHG emissions in the Waste sector in 2016

It is clear that the drive to reduce greenhouse gas emissions is not just an environmental concern, but should also integrate agencies involved in economic and social development. The campaign must also attach importance to the energy and transport sectors, especially with regard to electricity generation and fuel combustion in the transport sector. The use of energy from fuel combustion and industrial electricity use, including at the household level, is a major source of greenhouse gas emissions. The energy and transport sectors form the basis for many forms of development, such as improving manufacturing industries and services that produce lower amounts of carbon, adapting economic structures so that they are more environmentally friendly, and creating sustainable low-carbon cities, among others. Therefore, it is imperative to moderate the structure of the energy and transportation industry to ensure low-carbon release and environmental friendliness in the near future. Otherwise, it will take a long time to implement the changes and the long-term impact on the country's greenhouse gas emissions. Due to the systematic nature of reporting and information collection, the energy and transportation sectors are sources of large amounts of emissions. The long-term plans should benefit the public in reducing GHG emissions by, for example, creating stability in the energy sector, saving time and increasing convenience in travel, and reducing air pollution to improve public health.

1.3 Thailand's Climate Change Policy and Institutional Arrangement

Global cooperation is needed to tackle climate change. The United Nations Framework Convention on Climate Change (UNFCCC) is a fundamental and most important international framework to address climate change. Thailand became a Party to UNFCCC in 1991, and ratified its Kyoto Protocol in 2002 and its Paris agreement in 2016.

To effectively address the threat of climate change to Thailand's economy and society and in response to the implementation of relevant provisions under UNFCCC, Thailand has gradually formulated and developed its climate change strategies, policies, plans and institutional arrangement. The first National Strategic Plan on Climate Change (2008-2013) was developed, in which the cabinet directed all government departments and agencies to take into consideration such strategy in their policies and planning. The most important policy framework for climate change in Thailand at the moment is the Climate Change Master Plan 2558-2593 B.E. (2015-2050), which aims to set a long-term direction that related agencies and sectors can use to guide the development of plans of action in their respective areas. In addition, issues under the Climate Change Master Plan have been integrated into the National Strategy (2018-2037), which will guide a national policy framework in the next 20 years.

1.3.1 Thailand's Climate Change Master Plan (2015-2050)

Thailand's Climate Change Master Plan (2015-2050) (ONEP, 2015) aims to aid Thailand in achieving its sustainable development and low carbon growth and climate change resilience by 2050. It consists of three key strategies: (i) Climate Change Adaptation, which aims to build climate resilience by integrating policies and measures in all sectors, (ii) Mitigation and Low Carbon Development, which facilitates the development of mechanisms for GHG emissions reduction and leads to sustainable low carbon growth, and (iii) Enabling Environment for Climate Change Management which desires to build capacity for climate change implementation by enhancing potential and awareness of stakeholders and developing database, knowledge, and technology to support climate change adaptation and mitigation.

Thailand's climate actions are divided into short-term, medium-term and long-term targets up to 2050. For the mitigation actions, **short-term targets include:** (i) develop medium- and long-term GHG emission reduction targets and prepare roadmaps for the implementation by sector, including the GHG emission reduction target on a voluntary basis (pre-2020 target), Nationally Appropriate Mitigation Actions (NAMAs) roadmaps, and measurement, reporting, and verification mechanisms, (ii) establish domestic incentive mechanisms to encourage low carbon development. **The medium-term targets include:** (i) reduce GHG emissions from energy and transport sectors by 7-20% against BAU level by 2020, subject to the level of international support, (ii) supply at least 25% of energy consumption from renewable energy sources by 2021 and (iii) increase the ratio of municipalities with more than 10 m^2 of green space per capita. **The long-term targets include:** (i) reduce energy intensity by at least 30% by 2036 compared to a business as usual scenario, (ii) increase use of public transportation

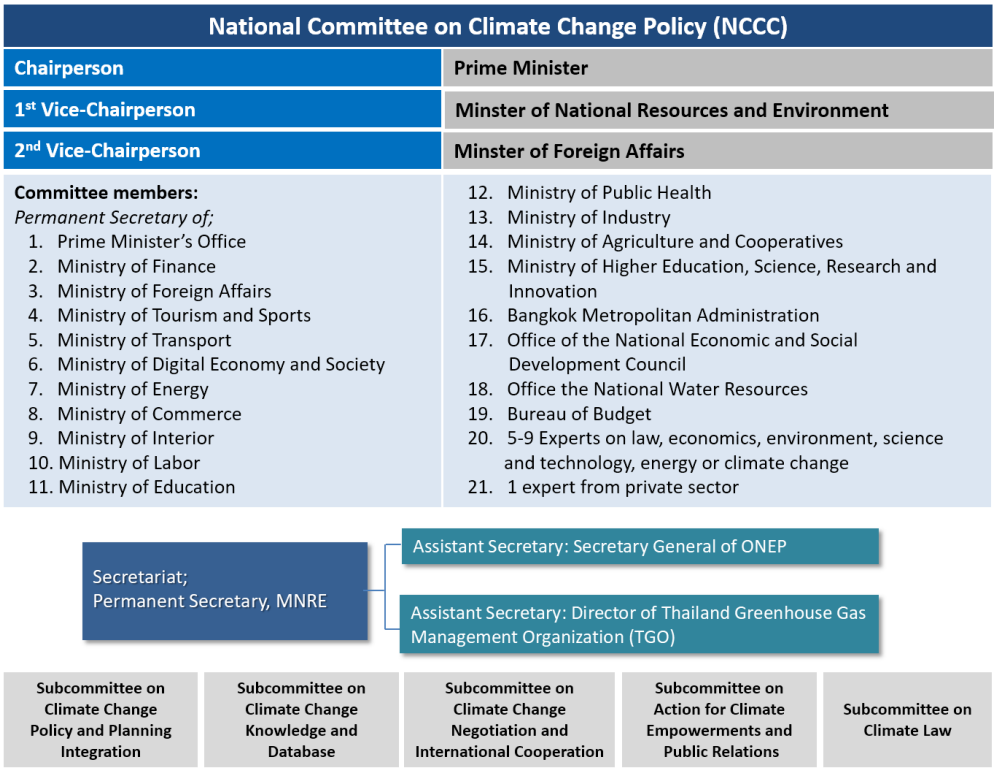
services, (iii) reduce GHG emissions from land transport, (iv) increase investment in low carbon and environmental friendly industries, (v) reduce open waste dumping areas, (vi) reduce open biomass burning, (vii) increase organic and GAP-certified farming and (viii) reduce GHG emissions per GDP.

At the moment, Thailand is in the process of revising its Climate Change Master Plan to be in line with the current circumstances and to take into account the efforts undertaken in implementing the Sustainable Development Goals and the Paris Agreement.

1.3.2 Existing Institutional Arrangement

The National Committee on Climate Change Policy (NCCC) was established in 2007 as the main decision-making body for climate change management in Thailand. The NCCC is chaired by the Prime Minister and consists of members representing relevant agencies from both public and private sectors, experts and relevant stakeholders. The key responsibilities of the NCCC include the formulation of national climate policies and the establishment of guidelines and mechanisms for international collaboration on climate change.

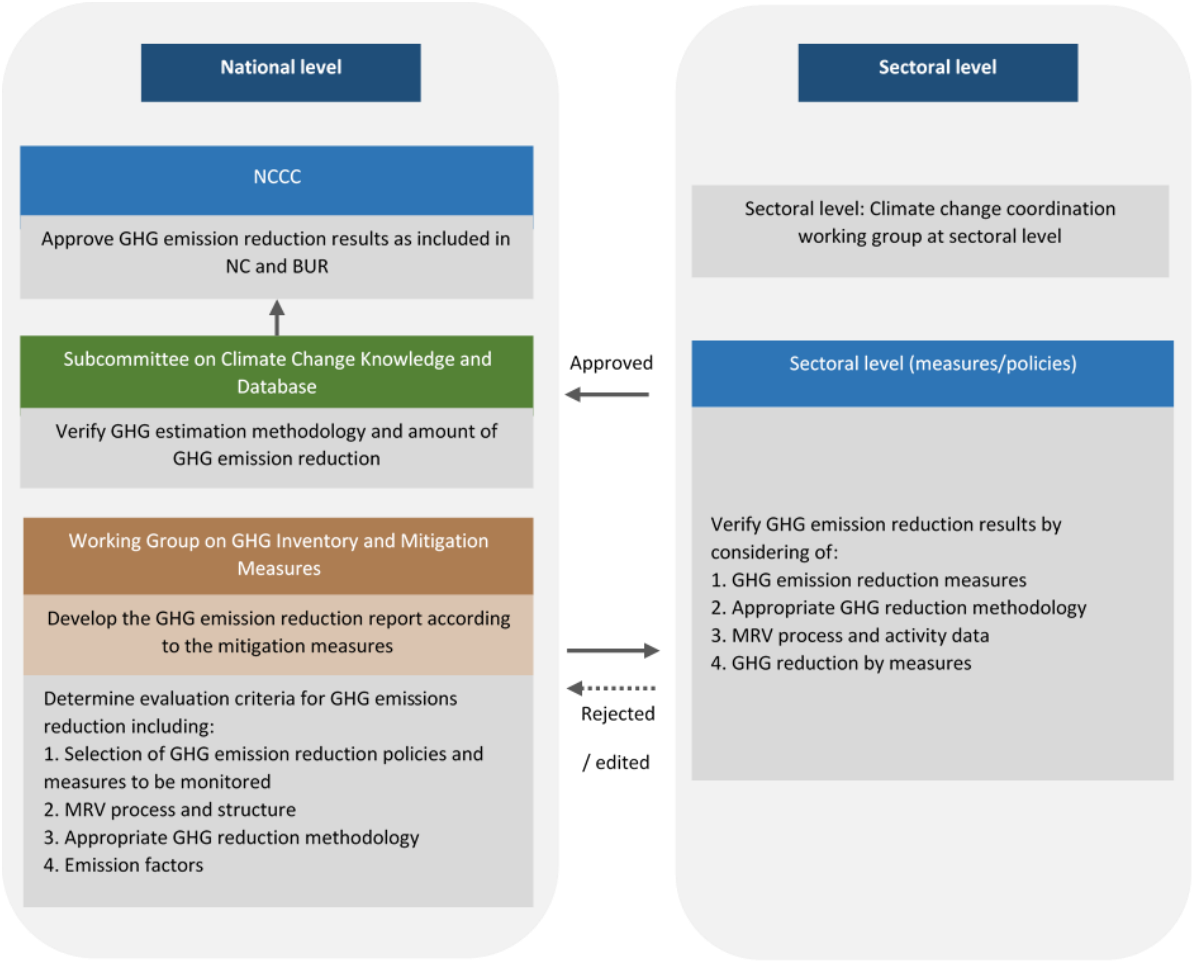
Five subcommittees are established under the NCCC, namely (1) Subcommittee on Climate Change Policy and Planning Integration, (2) Subcommittee on Climate Change Knowledge and Database, (3) Subcommittee on Climate Change Negotiation and International Cooperation, (4) Subcommittee on Public Relations and Actions for Climate Empowerment and (5) Subcommittee on Climate Law. Figure 1-15 shows the institutional arrangements of Thailand's NCCC.



Source: Office of Natural Resources and Environmental Policy and Planning (ONEP)

Figure 1-15: Structure of the National Committee on Climate Change Policy

To effectively implement, monitor, report and verify greenhouse gas emission reduction, Thailand has developed the domestic Measurement, Reporting and Verification (MRV) system at both national and sectoral levels (See Figure 1-16):



Source: Office of Natural Resources and Environmental Policy and Planning (ONEP)

Figure 1-16: The structure of domestic MRV system for GHG emissions reduction

National level:

- The Working Group on GHG Mitigation Measures is responsible for (i) selection of appropriate measures for monitoring and evaluation (M&E) of GHG emission reduction, identification of emission factors and implementation of MRV processes for activity data and (ii) revision and providing feedback on the GHG emission reduction report.
- The Subcommittee on Climate Change Knowledge and Database is responsible for consideration and approval on the report submitted from sectoral level.
- The National Committee on Climate Change (NCCC) is responsible for the final approval on the GHG emission reduction report which will be included in the national reports such as the Biennial Update Report (BUR) and National Communication (NC).

Sectoral level:

The relevant implementing agencies responsible for GHG emissions reduction at the sectoral level are in charge of the verification of the following key data and approaches after the finalization by the working groups on GHG mitigation measures, including (i) appropriate measures for M&E of GHG emissions reduction, (ii) methodology for the calculation of GHG emission reduction, (iii) MRV process for activity data and (iv) results and GHG emissions reduction report.

Chapter 2

Thailand's Mitigation Actions

Being among of the top 10 countries most vulnerable to climate risk, Thailand has placed climate change on its national agenda and taken proactive steps to address this urgent threat. Climate change has been integrated and embedded into development policies, strategies and plans across sectors and at all levels. Climate change has been incorporated into Thailand's national economic and social development plans since 2007. Climate change is currently addressed at the highest policy level under the National Strategy (2018-2037) to ensure a long-term continuity of sustainable low-carbon development. Tremendous efforts have been made in mitigating the country's GHG emissions with available resources and capabilities. In addition, Thailand as a party to the UNFCCC has voluntarily submitted its Nationally Appropriate Mitigation Actions (NAMAs) in 2014. In 2016, Thailand's 1st Nationally Determined Contribution (NDC) was communicated to UNFCCC upon its ratification of the Paris Agreement, indicating its mitigation and adaptation contribution to the global efforts to address climate change. The updated NDC was later communicated in 2020. NAMAs and NDCs are key policy instruments that shape Thailand's climate actions in pursuing its low GHG emission and climate-resilient development.

2.1 Nationally Appropriate Mitigation Actions (NAMAs)

In 2014, Thailand submitted its NAMAs to UNFCCC, pledging to reduce its greenhouse gas emissions in energy and transportation sectors by 7-20 percent from the projected business as usual level by 2020. The target of 7% GHG mitigation in 2020 is intended to be achieved using domestic resources, while additional emission reduction up to 20% is subject to sufficient international support under the UNFCCC.

Strong and positive progress has been achieved during Thailand's NAMAs implementation. In 2019, Thailand reduced its greenhouse gas emissions by 64.20 $MtCO_2eq$, or 17 % from its projected business as usual level (See Figure 2-1). This achievement demonstrates robust climate actions currently undertaken which lay a solid foundation for NDC and Thailand's LEDS implementation in the next phases.

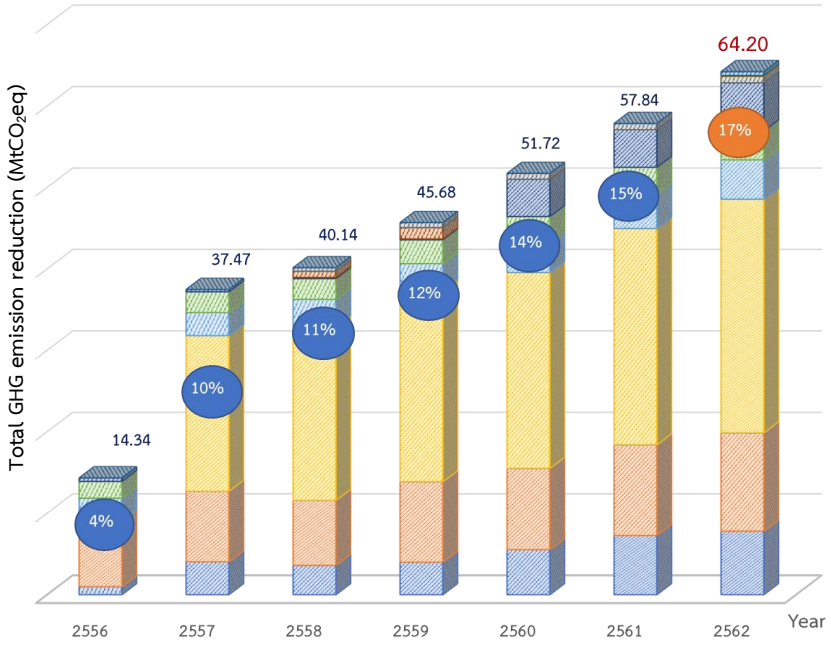


Figure 2-1: Thailand's NAMAs implementation

2.2 Nationally Determined Contribution (NDC)

Thailand submitted its Intended Nationally Determined Contribution (INDC) to UNFCCC in 2015, which was later to become Thailand's first NDC. The NDC was formulated in accordance with the Philosophy of Sufficiency Economy and the principle of Sustainable Development, and based on relevant national plans already approved or in the pipeline for approval by the Cabinet. It also builds upon measures, and takes into account lessons learnt and good practices during NAMAs implementation. Thailand's first NDC indicates an emission reduction of 20% from the projected business-as-usual (BAU) level by 2030. The level of contribution could increase up to 25%, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support through a balanced and ambitious global agreement under UNFCCC. Besides, adaptation priorities and support need are clearly outlined.

In 2020, Thailand communicated its updated NDC to the UNFCCC, confirming its mitigation contribution by 2030. It also provided the most up-to-date information on its progress in the implementation of its pre-2020 action, concrete implementation plans, and key information of adaptation component and support needs.

2.3 Implementation of Mitigation Measures

The heart of Thailand's NDC development and implementation is being realistic and achievable and with a balanced consideration between emission reduction and economic development. Climate change mitigation policies have been integrated and translated from

the 12th National Economic and Social Development Plan (2017- 2021, extended to 2022) to sectoral and local levels.

Specifically, the NDC Roadmap and sectoral action plans are developed in 4 sectors, namely energy, transportation, industrial processes and product use, and waste management. Strong collaboration among key stakeholders and supporting mechanisms are also key success factors in achieving this target.

2.3.1 NDC Roadmap (2021-2030)

Following the submission of Thailand's first NDC, the Cabinet endorsed the NDC Roadmap (2021-2030) in 2017 as a clear guidance to achieve its NDC targets. Developed under a participatory approach and through a national consultative process, this Roadmap identifies a set of mitigation actions in the energy, transportation, IPPU and waste management sectors. NDC Roadmap to strive towards the reduction of 115.6 $MtCO_{2eq}$, which accounts for a 20.83% reduction in 2030 when compared to the BAU level. Mitigation actions in the NDC Roadmap are identified based on the following policies and plans:

- 12th National Economics and Social Development Plan 2017-2021, extended to 2022
- Climate Change Master Plan 2015-2050
- Power Development Plan 2015-2036
- Thailand Smart Grid Development Master Plan 2015-2036
- Energy Efficiency Plan 2015-2036
- Alternative Energy Development Plan 2015-2036
- Environmentally Sustainable Transport System Plan 2013-2030
- National Industrial Development Master Plan 2012-2031
- Waste Management Roadmap

Mitigation measures under NDC Roadmap (2021-2030) can be summarized as shown in Table 2-1.

Table 2-1: Mitigation measures under Thailand's NDC Roadmap (2021-2030)

Sector	Mitigation measure	$MtCO_{2eq}$
1. Energy	*Energy Generation* 1. Increase power generation efficiency 2. Renewable energy generation *Energy Consumption in Households* 3. Increase energy efficiency in households 4. Renewable energy in households *Energy Consumption in Buildings (Commercial and Public)* 5. Increase energy efficiency in buildings	72.0
2. Transportation	1. Avoid/Reduce traveling 2. Shift/Maintain travel modes 3. Improve energy efficiency in transport	41.0

Sector	Mitigation measure	$MtCO_{2eq}$
3. IPPU	1. Clinker substitution 2. Refrigerant replacement/modification	0.6
4. Waste Management	*Waste Management* 1. Reducing the amount of waste (e.g. reducing disposal rates, increasing recycling and waste utilization, etc.) *Wastewater Management* 2. Increasing biogas production from industrial wastewater through re-utilization of methane 3. Industrial wastewater management 4. Municipal wastewater management	2.0
Total		**115.6**

2.3.2 NDC Sectoral Action Plans 2021-2030

The NDC Sectoral Action Plans 2021-2030 were developed to support the implementation of NDC Roadmap (2021-2030) in four sectors, namely energy, transport, industrial processes and product use, and waste management. It allocates emission reduction targets for each identified measure with the aim to facilitate the relevant sectoral agencies in fulfilling their respective emission reduction targets. These sectoral action plans were prepared by relevant sectoral agencies, with a wide range of stakeholder consultation and public participation processes. They include the details of potential activities/projects, objectives, indicators and source of funding/budget.

It is estimated that measures under the NDC Sectoral Action Plans have the potential to reduce greenhouse gas emissions by 156.86 $MtCO_{2eq}$ in 2030 as shown in Figure 2-2. This provides a concrete implementation roadmap in achieving Thailand's first NDC mitigation target.

Figure 2-2: GHG reduction potential in 2030 according to the NDC sectoral action plans

The summary of the NDC sectoral action plans are as follows.

- ***The NDC Action Plan in Energy Sector***, prepared by the Energy Policy and Planning Office, Ministry of Energy, identifies potential mitigation measures such as increasing energy efficiency and promoting renewable energy (Energy Policy and Planning Office, 2019).
- ***The NDC Action Plan in Transport Sector***, prepared by the Office of Transport and Traffic Policy and Planning, Ministry of Transport, identifies potential mitigation measures from relevant plans such as travel demand management (TDM), transit-oriented development (TOD), expansion of railway network, and bus fleet upgrades (Office of Transport and Traffic Policy and Planning, 2019).
- ***The NDC Action Plan in Industrial Processes and Product Use including Industrial Wastewater Sector***, prepared by the Department of Industrial Works, Ministry of Industry, identifies potential mitigation measures such as clinker substitution, refrigerant replacement and industrial wastewater management (Department of Industrial Works, 2019).
- ***The NDC Action Plan in Municipal Waste Management Sector***, prepared by the Pollution Control Department, Ministry of Natural Resources and Environment, identifies potential mitigation measures such as municipal solid waste management and municipal wastewater management (Pollution Control Department, 2018).

Additionally, supportive mechanisms for effective implementation of the sectoral action plans are considered in the areas such as research and development, economic tools and mechanisms, laws and regulations, MRV system, capacity building and stakeholder engagement.

2.3.3 Existing Economic Mechanisms

National climate change implementation plans, strategic plans or other medium-term plans are important to secure political commitments and reaffirm country's commitment to global mitigation efforts under the Convention. To enhance an effective implementation of mitigation actions, unprecedented change and deep reductions in GHG emissions across the country's economy are needed. Investment in state-of-the-art technologies would be necessary to achieve the stringent emission reduction targets. The development of economic mechanisms is one of many critical factors in supporting greenhouse gas reduction activities for entrepreneurs and civilians.

The Office of the Board of Investment (BOI) is a government agency under the Office of the Prime Minister whose primary mission is to promote valuable investment in Thailand. In 2021, the BOI approved a series of incentives to promote investments that reduce environmental impacts, support sustainable development, and contribute to the development of the BCG (Bio, Circular and Green economy) model, which the Thai government has identified as a priority to lead the post-COVID 19 recovery. These measures include the following:

(1) The grassroots economy support scheme will also include support for local organizations involved in developing sustainable agricultural activities such as low methane rice farming. It is expected that this new addition will encourage competent businesses to participate in the sustainable agriculture movement. It also extends the deadline for applications under the grassroots economy support scheme to the end of 2022.
(2) A 3-year tax exemption will be granted for investments in upgrading machinery to reduce greenhouse gas emissions. This is in addition to the existing productivity enhancement scheme. It is expected that this new measure will contribute to the country's commitments to reduce greenhouse gas emissions.
(3) Adjustments to the conditions and benefits for some categories of business to encourage eco-friendly technologies:
    - Investments in cold storage facilities and refrigerated transport that use natural refrigerants and reduce environmental impact will be granted 3-year corporate income tax exemptions.
    - Petrochemical production facilities that use Carbon Capture Utilization and Storage (CCUS) technologies will be granted 8-year corporate income tax exemptions.
(4) Introduction of a new promotion category for natural gas separation plants which if they are implementing CCUS technologies will be granted 8-year corporate income tax exemptions.

Moreover, Thai government envisions the country becoming the largest electric vehicle investment hub in one of the world's fastest-growing economic blocs. The National Electronic Vehicles Policy Committee, set up by the Thai government, recently introduced a master plan that sets out a framework for the development of electric vehicles. The main objective of this master plan is to establish Thailand as "ASEAN's center of excellence" in three areas, namely zero-emission vehicles, next-generation automotive technology, and innovation in the next-generation business models by 2035. Investment promotion policies have also been introduced for the production of all types of electric vehicles (EVs) to further boost the EV sector. The investment promotion will extend to the production of BEV platforms, which consist of an energy storage system, a charging module, and a front and rear axle module. The concept of shared platforms is a new trend in the automotive industry, offering greater flexibility, shorter product development times and economies of scale. In addition, the promotion of electric bicycles (E-bikes) also offers tax incentives, i.e. exemption from corporate income tax for at least 3 years.

Chapter 3

Long-term Low Greenhouse Gas Emission Development

The Paris Agreement sets out a long-term temperature goal and underscores the urgency for Parties to play their part to enable global GHG emissions to peak and decline as soon as possible. In accordance with Article 4, paragraph 19, of the Paris Agreement, all Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2, considering their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

In this regard, the mid-century, long-term low greenhouse gas emission development strategy was formulated to guide Thailand towards a climate-resilient and low GHG emissions development and serves as a basis for enhancing its pre-2050 mitigation actions. The preparation and approval process of Thailand's LEDS includes a national consultative process among various sectoral working groups and relevant stakeholders with the objective to identify a set of national long-term GHG mitigation actions in the energy, transport, IPPU, waste, agriculture and LULUCF sectors. A national consultation was organized to hear comments and encourage discussion on the outcome of the study before submitting it for consideration by the national working group on integration of GHG mitigation policy and planning, the Subcommittee on Climate Change Policy and Planning Integration, and the NCCC and Cabinet before submitting it to the UNFCCC. (See Figure 3-1)

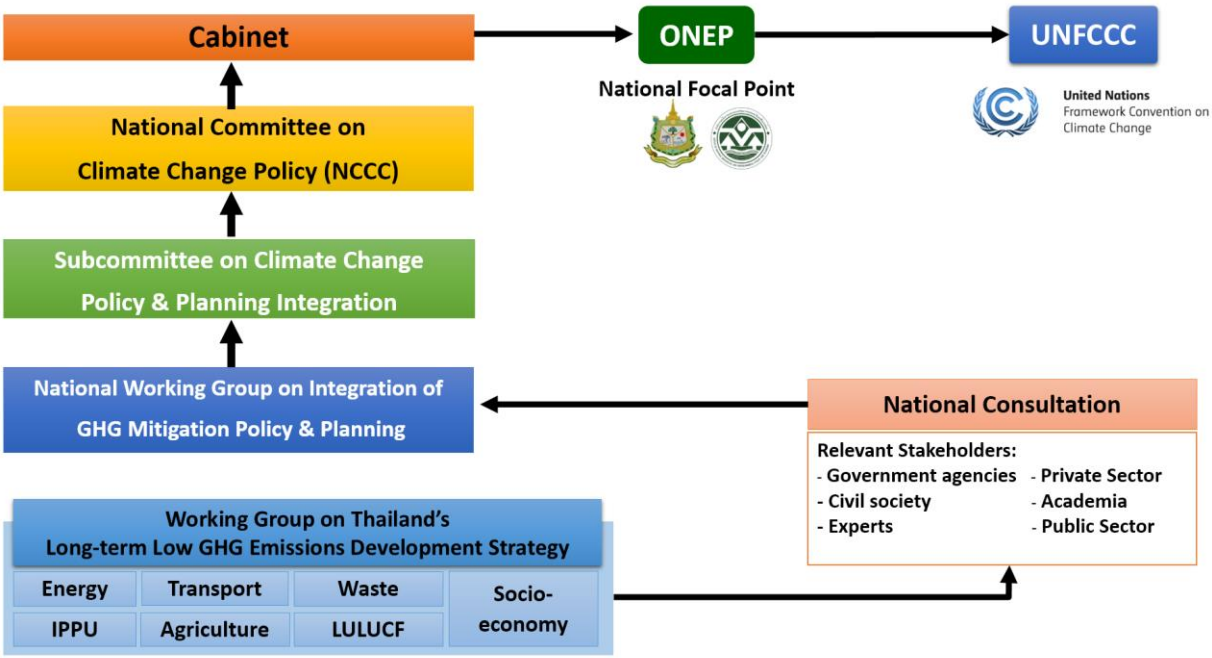


Figure 3-1: Preparation and approval process of Thailand's LEDS

The Subcommittee on Climate Change Policy and Planning Integration is responsible to provide input and recommendation on the development and integration of climate change policy, strategy and plan, in relation to both mitigation and adaptation; provide suggestions on mechanisms and measures, such as legal regulations, and financial measures; and push forward an integrated budget allocation system on climate change. In the development of Thailand's LEDS, this subcommittee considers and provides suggestions on the draft document in which the working group on national GHG reduction policy and plan integration has integrated relevant information among the ministerial agencies and academic institutes related to climate change to formulate mid-century low greenhouse gas emissions. However, the other four subcommittees will be informed of the progress of Thailand's LEDS formulation through the existing mechanism when it is submitted to the NCCC for consideration.

3.1 Methodology for the Development of Long-term Low Greenhouse Gas Emission Pathways

3.1.1 Model for Low Greenhouse Gas Emission Pathways

Thailand's mid-century, long-term low greenhouse gas emission development strategy was developed based on the scenario of net-zero greenhouse gas emissions in the second half of this century, in line with science and the Paris Agreement. The BAU scenario was developed using input information of the current country's circumstances and status provided by related ministerial agencies into the Asia-Pacific Integrated Assessment Model (AIM) (Figure 3-2).

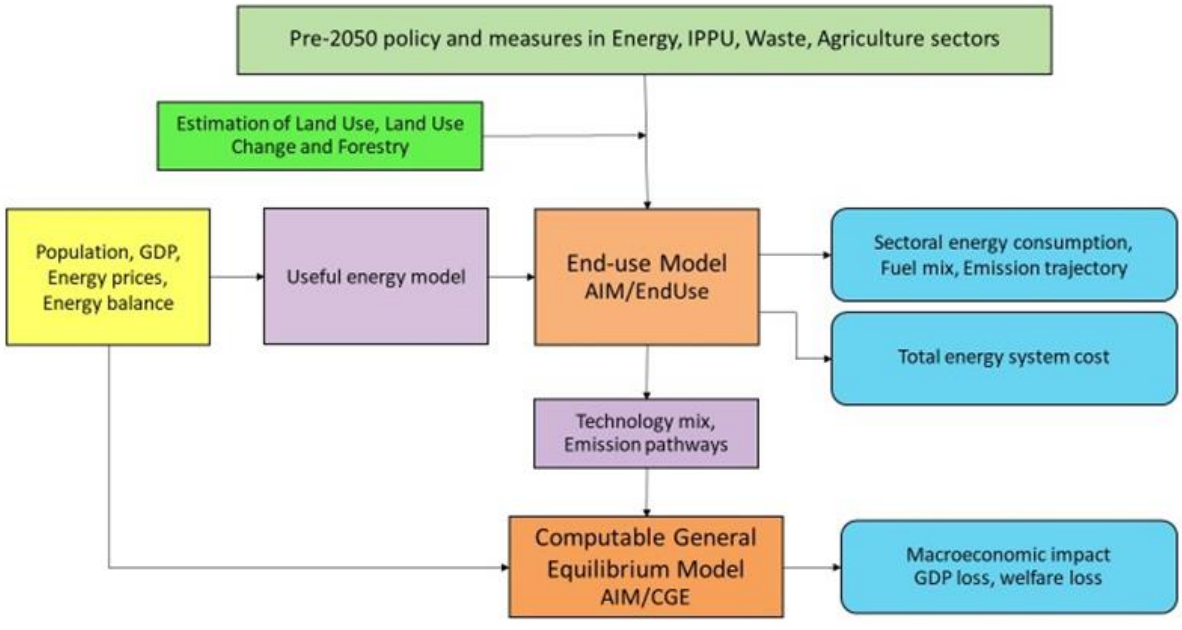


Figure 3-2: Framework of Thailand's LEDS Development

- **The AIM/EndUse**

The AIM model has been developed through the collaboration between the National Institute for Environmental Studies (NIES) Japan, Kyoto University, the Mizuho Information & Research Institute, and other researchers in Asia, including Thailand. The AIM model focuses on relevant policies to support low-carbon pathways.

The AIM/EndUse model was used to quantify climate change assessment and relevant policies to mitigate GHG emissions. The model is a recursive dynamic model, a partial equilibrium, which can simulate the calculation for numerous years with several case studies, including policy countermeasures for mid-century mitigation actions to examine the effect of energy savings and GHG emission abatement. It is a bottom-up model with detailed technology information. The technological selection is based on a linear optimization framework which minimizes the total system cost with the introduction of various constraints, for example, the availability of biomass in biomass power plants, satisfaction of the end-user demand and CO_2 emission tax applied for energy intensive activities. The total system cost consists of the annualized initial investment costs of technologies, annualized operating and maintenance costs of technologies, energy costs, taxes (both energy tax and carbon tax) and subsidies, etc. In order to calculate the annualized cost, the capital recovery factor is used.

Thailand's LEDS were modeled in a bottom-up approach with detailed-technology information. The technological selection is based on an optimization framework which minimized the total system cost subject to various constraints, e.g. the potential of solar, wind and bio-energy used in power generation, and satisfying the end-user demand among the economic sectors. In the model, CH_4 and N_2O are converted into CO_2-equivalent emissions by applied global warming potential (GWP) provided by the IPCC. Under this modeling approach, it is projected that the Business-as-usual of the economy-wide GHG emissions (excluding LULUCF) in 2050 will be approximately 661 $MtCO_{2eq}$.

The AIM/EndUse model consists of both demand side and supply side. The manufacturing industry is classified into 9 sub-sectors which is in line with the classification by the Department of Alternative Energy Development and Efficiency, Ministry of Energy. The analyses in the industrial system can be separated into heating systems (thermal) and electricity systems. The technologies introduced in the manufacturing industries include efficient kilns in the non-metallic industry, LED lamps and efficient lighting, efficient air conditioners, etc. The residential sector can be divided into three types, namely, the greater Bangkok area, municipal areas, and rural areas. The technologies introduced in the residential sector include efficient air conditioners with high COP, LED lamps and efficient lighting, solar water heating systems, etc. The commercial building sector is divided into eight types, which are offices, hotels, hospitals, department stores, schools, hyper-mart, condominium, and other buildings. Technologies introduced in this sector include efficient boilers, LED lamps and efficient lighting, efficient heating systems, etc. Both residential and commercial building sectors, hereafter called the "building sector", are investigated in terms of energy use and

GHG emissions. Transport service can be classified into passenger transport and freight transport. Furthermore, the transport sector has been divided into road, rail, air and water modes. However, the policy assessment and CO_2 emissions mitigation mainly focuses on road transport. There are nine vehicle types considered in the transport sector: sedans, vans, tri-cycles, taxis, motorcycles, buses, pick-ups, trucks, and others. Diesel (locomotive) and electric trains are considered in the rail mode. Technologies introduced in the transport sector include plug-in hybrid and battery electric vehicles, electric trains, etc. Figure 3-3 shows an overview of the input of the AIM/EndUse model in developing Thailand's LEDS.

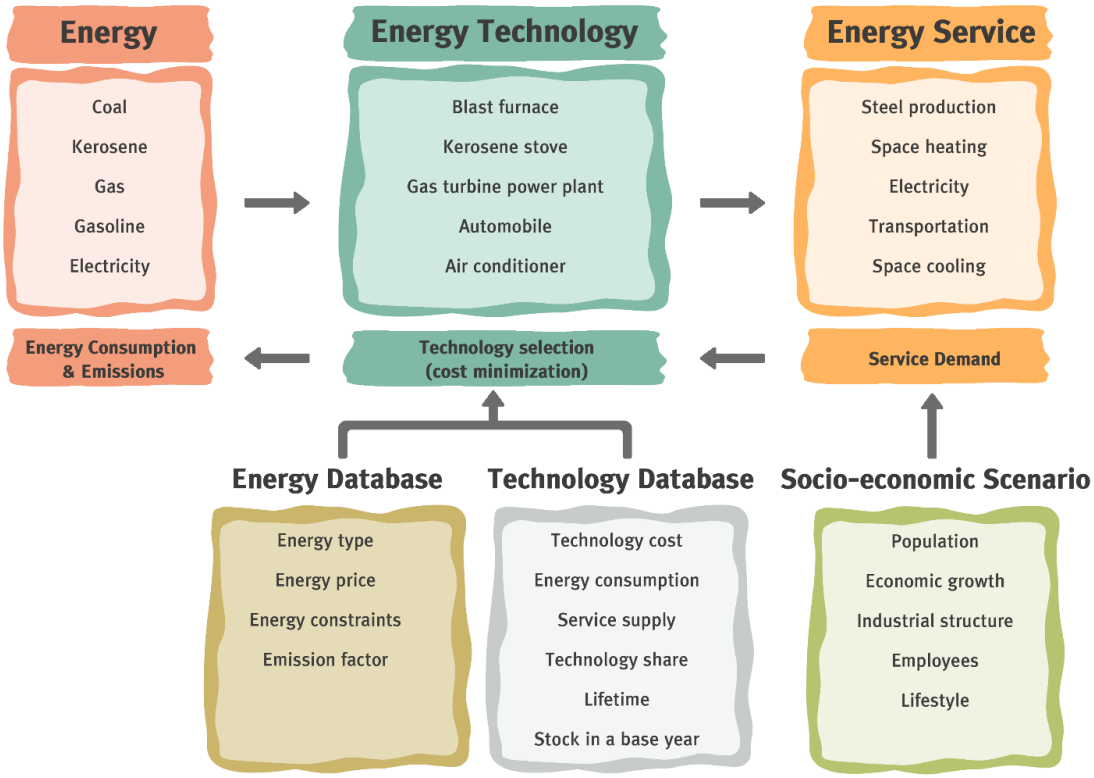


Figure 3-3: Overview of the input of the AIM/EndUse model in developing Thailand's LEDS

- **The AIM/CGE**

To understand the macroeconomic impacts of Thailand's LEDS, a multi sector, dynamic recursive Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) model is used. The CGE model is known for its strength in evaluating economy-related policies, so it has been widely adopted to assess the economic and environmental impacts of various energy and climate policies at the global, national, and sub-national levels. It is noted that in Thailand's LEDS, the carbon dioxide (CO_2) emissions, methane (CH_4) and nitrous oxide (N_2O) are treated as GHG emissions in the model.

The model consists of four main blocks, namely production, government and household income, expenditure blocks and market block that considers both the domestic and international transactions (see Figure 3-4).

The CGE model used for the development of Thailand's LEDS uses the input-output table obtained from the Office of the National Economic and Social Development Council (NESDC) to calibrate the model. The model considered in the analysis is disaggregated into detailed production sub-sectors (see Table 3-1).

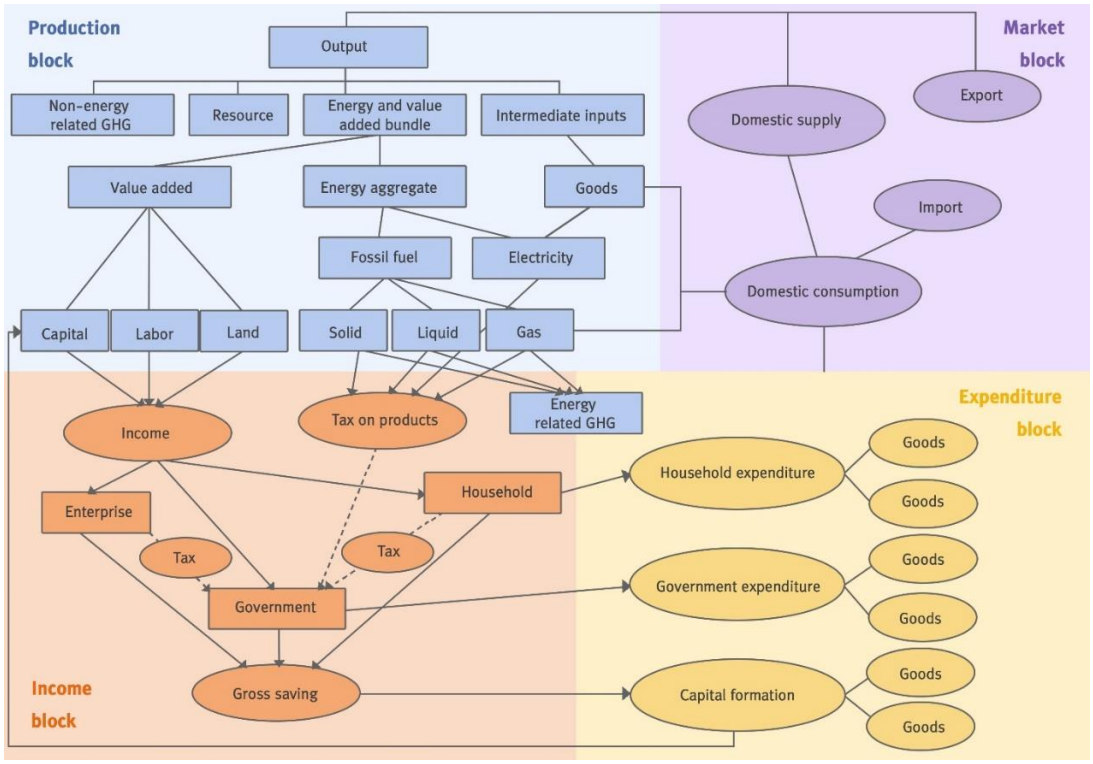


Figure 3-4: An overview of the AIM/CGE Model for Thailand's LEDS

Table 3-1: Sectoral classification in the Thailand's LEDS CGE Model

Non-energy Sectors	
Agriculture and forestry	Crops, Livestock, Forestry, Fishery
Transport	Railways, Road transport, Water transport, Air transport
	Other transport services
Services	Water supply system, Communication, Trade
	Other services
Industries	Metal and non-metallic, Food, beverage, Textile, Paper
	Chemical industries, Rubber and plastic products
	Non-metallic products
	Basic metal, Fabricated metal products, Machinery
	Construction
	Other manufacturing products
Energy Sectors	
1. Coal and lignite, 2. Crude oil, 3. Petroleum products, 4. Gas	

- **Existing Plans used in Thailand's LEDS development**

  Existing plans used in the formulation of Thailand's LEDS are:

  1) *National Strategy (2018 – 2037*) prepared by the Office of the National Economic and Social Development Board, Prime Minister's Office. It is Thailand's first national 20-year strategy with the vision that Thailand will become "a developed country with security, prosperity and sustainability in accordance with the sufficiency economy philosophy" and will ensure happiness and well-being for all Thais by 2037.

  2) *Climate Change Master Plan (2015-2050)* prepared by the Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment. The master plan aims to drive Thailand towards sustainable development, low carbon growth and climate change resilience by 2050. Three key missions are: (i) building climate resilience by integrating policies and measures in all sectors, (ii) creating mechanisms to reduce GHG emissions, leading to sustainable low carbon growth, (iii) building readiness by enhancing capacity and awareness of stakeholders and (iv) developing a database, knowledge, and technology to support climate change adaptation and mitigation.

  3) *Thailand's NDC Roadmap (2021-2030)* prepared by the Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment. This roadmap identifies mitigation measures in energy sector, including renewable electricity and energy efficiency; IPPU sector such as the substitution of raw materials in cement production; and waste sector such as waste management and waste incineration. Measures under the NDC roadmap 2030 are projected to have the potential to reduce GHG emissions by 113 MtCO2eq by 2030.

  4) *NDC Action Plan in the energy sector, 2021 – 2030,* prepared by the Energy Policy and Planning Office, Ministry of Energy. This action plan integrated policy and measures on greenhouse gas emissions reduction from the Energy Efficiency Plan (EEP2018), the Alternative Energy Development Plan (AEDP2018), and the Power Development Plan (PDP2018) and is projected to contribute to the GHG emission reduction of 117.66 Mt-CO_{2eq} by 2030.

  5) *NDC Action Plan in the transport sector, 2021 – 2030,* prepared by the Office of Transport and Traffic Policy and Planning, Ministry of Transport. This plan identifies measures of green transport, transport efficiency, and inclusive transport and is expected to contribute to the GHG emissions reduction of 35.42 $MtCO_{2eq}$ in 2030.

  6) *NDC Action Plan in the industrial processes and product use including industrial wastewater sector, 2021 – 2030,* prepared by the Department of Industrial Works, Ministry of Industry. This action plan identifies GHG emission reduction measures, including the modification of industrial production processes by clinker substitution and substitution of refrigerant, and in industrial wastewater management by increasing biogas production from industrial wastewater by recycling methane gas. Measures under this

action plan are expected to contribute the GHG emission reduction of 2.25 $MtCO_{2eq}$ in 2030.

7) *NDC Action Plan in municipal waste management sector, 2021 – 2030,* prepared by the Pollution Control Department, Ministry of Natural Resources and Environment. This action plan consists of work plans/activities on municipal solid waste management and municipal wastewater management that have the potential to reduce greenhouse gas emissions. These measures is expected to contribute the GHG emission reduction of 2 $MtCO_{2eq}$ in 2030.

8) *Energy Efficiency Plan 2018 – 2037 (EEP2018)* prepared by Department of Alternative Energy Development and Efficiency, Ministry of Energy. It aims to achieve a target of 30% energy intensity reduction by 2037 compared to the 2010 level. It is projected to conserve a total of 54,371 ktoe by the end of the plan, in which the priority sectors are transport, industry, commercial/government buildings, residence and agriculture with energy saving targets of 17,682 ktoe, 21,137 ktoe, 6,418 ktoe, 3,300 ktoe and 527 ktoe, respectively, by 2037.

9) *Alternative Energy Development Plan 2018 – 2037 (AEDP2018)* prepared by the Department of Alternative Energy Development and Efficiency, Ministry of Energy. It aims to increase the portion of renewable power generation from 17.29% in 2019 to 30% of total power requirement in 2037 which accounts for 29,358 MW.

10) *Power Development Plan* 2018 – 2037 (PDP2018) prepared by the Energy Policy and Planning Office, Ministry of Energy. It aims to improve energy efficiency and enhance energy security in Thailand, focusing on the following aspects: (1) energy security to cope with the increasing demand for electricity according to National Economic and Social Development Plan and considering fuel diversification, (2) economy to maintain reasonable cost of power generation for long-term economic competitiveness, and (3) environment to reduce carbon dioxide emissions of power generation and focus on renewable energy sources.

11) *Master Plan for Sustainable Transport Development and Climate Change Mitigation and the transport system development* prepared by the Office of Transport and Traffic Policy and Planning, Ministry of Transport. This plan aims to improve economic security, increase economic competitiveness, increase capacity, promote quality of life and equity, promote green growth, and enhance good governance. The key areas identified include (i) integrated transport systems, (ii) improved transport services, (iii) regulations and institution, (iv) human resource development and (v) innovation & technology strategies. It is estimated that GHG emission reduction in the transport sector will contribute to approximately 36.3% of Thailand's NDC Roadmap in 2030.

12) *National Industrial Development Master Plan 2012 – 2031* prepared by the Office of Industrial Economics, Ministry of Industry. This plan highlights global climate change as

one of the four major key factors for national industrial development by promoting an environmental-friendly manner.

13) *Thailand Industrial development strategy 4.0 (2017 – 2036)* prepared by the Office of Industrial Economics, Ministry of Industry. The strategy aims to reform to smart industries, reduce carbon emission and industrial waste.

14) *Thailand's Forest Reference Emission Level and Forest Reference Level for REDD+ under the UNFCCC* prepared by the Technical Working Group on REDD+ of Thailand, Department of National Parks, Wildlife and Plant Conservation, Ministry of Natural Resources and Environment.

15) *20-year Forest Strategic Plan (2017-2036)* prepared by the Royal Forest Department, Ministry of Natural Resources and Environment. This strategic plan aims at increasing forest area covering up to 40% through local community participation, particularly in upstream basin and mangrove forests. It would enhance greenhouse gas removals through forest-related actions.

Details of these plans can be found in the bibliography.

3.2 Long-term sectoral emissions

3.2.1 The business-as usual

The business-as usual (BAU) emissions were developed based on technical analyses and consultation with relevant stakeholders by the working group on Thailand's LEDS, including energy, industrial processes and product use (IPPU), waste, agriculture, and land use, land-use change and forestry (LULUCF) sectors. The energy consumption pattern and the GHG trajectory in the BAU follow the past trend during 2010-2020. Climate policies intervention is excluded from the BAU. Results reveal that Thailand's GHG emissions of sources will increase from 305 $MtCO_2eq$ in 2005 to 661 $MtCO_2eq$ in 2050, increasing at a compound annual growth rate (CAGR) of 1.7%. The energy sector will be the largest source of GHG emissions, followed by the agriculture, the IPPU, and the waste sectors, while the LULUCF sector will play a vital role in the removal of emissions in the BAU (see Figure 3-5). The GHG removal from the LULUCF sector will gradually increase from 50 $MtCO_2eq$ in 2005 to 100 $MtCO_2eq$ in 2050, at the rate of 1.5% annually. It is noted that Thailand's Third Biennial Update Report (BUR3) indicated an average GHG removal by LULUCF of 73 $MtCO_2eq$ between 2005 and 2016.

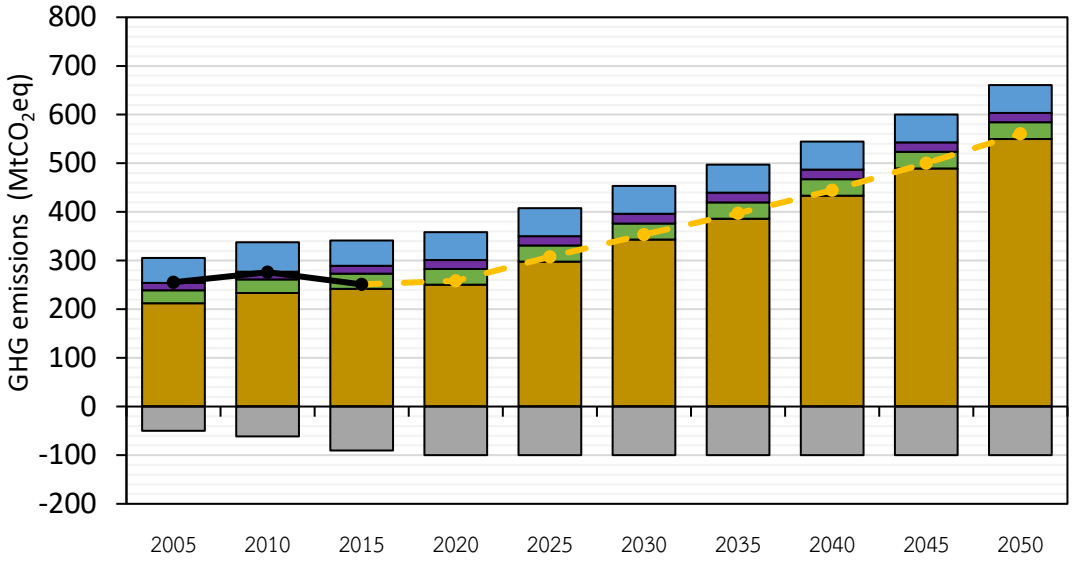


Figure 3-5: GHG emissions/removals by sector in 2005 – 2050 in the BAU scenario

Despite the fact that the removal of greenhouse gases will moderately increase, it will be slowly increasing compared to GHG emissions of sources. In order to achieve the Paris Agreement goal, it is necessary for Thailand to focus its attention on increasing its ambition in GHG emissions reduction.

3.2.2 Long-term Low Greenhouse Gas Emission Development Strategy

The GHG removal in the LULUCF sector will be slightly increased to 120 $MtCO_{2eq}$ by 2037 and maintain stable through the end of this century. This projection is based on forest and green area target identified in the National Strategy (2018 – 2037) that aims to increase forest and green areas. Thus, Thailand will achieve the net GHG emissions of 200 $MtCO_2eq$ in 2050 or a decrease of 64% compared to emissions in the BAU (See Figure 3-6). The GHG emissions from sources will reach the peak level of 370 $MtCO_2eq$ by 2030. In 2050, the energy sector will play a key role in mitigating GHG emissions. In addition, the LULUCF sector will contribute the removal of 5.6% of total GHG reduction in 2050. The post-2050 emissions will follow the IPCC 2-degree pathways, in which under this scenario, Thailand will achieve the balance between GHG emissions by sources and removals by sinks in 2090.

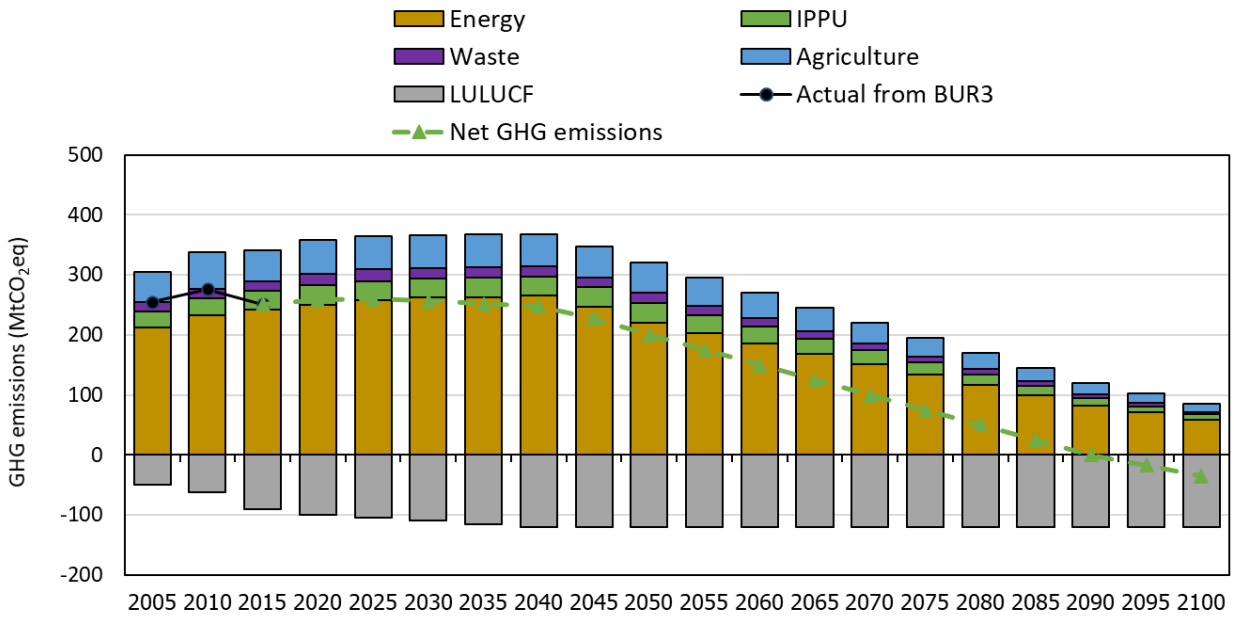


Figure 3-6: Thailand's long-term low greenhouse gas emission scenario

Energy system

The energy sector plays an important role in the reduction of GHG emissions in Thailand's LEDS (Figure 3-6). Therefore, stringent GHG mitigation measures are needed to implement in the energy sector. The GHG mitigation measures implemented in the energy sector are generally classified into three main measures: energy efficiency improvement/technology switching, implementation of renewable energy, and carbon capture and storage (CCS). GHG mitigation measures identified for energy system are:

- Power generation: The energy efficiency improvement and the deployment of natural gas with CCS and coal with CCS power plants, will increase to 43% in 2050 when compared to the current technology.

  In 2050, the share of renewable electricity will increase to 33% of total electricity generation. In addition, bio-energy with CCS (BECCS) power plant is needed to achieve the 2-degree target in 2050.

- Transport sector: The energy efficiency improvement will be achieved by behavioral changes, road surface improvement and engine performance improvement. Currently, the proportion of new efficient vehicle fleets is increasing, including hybrid, plug-in hybrid, and battery electric vehicles. Under Thailand's LEDS, the transport sector needs to increase the energy efficiency to 68% of total final energy consumption in 2050. Though the share of energy efficiency improvement decreases, the energy consumption in the efficient vehicle increases.

  Liquid biofuels have been promoted as clean alternative fuels in the transport sector. To achieve the targets under Thailand's LEDS, the share of liquid biofuel use will have to increase from 8% in 2030 to 34% of total final energy consumption in 2050.

- Manufacturing industries: Final energy consumption in manufacturing industries varies depending on the activities. For example, the heating system is used mainly in the food and beverage industries, and the chemical industries. The textile industries demand large amounts of electricity in their processes. The energy efficiency improvement of electrical devices has to increase to 77%. In the heating systems, the share of renewable energy will have to increase to approximately 46% and 50% of total final energy consumption in 2030 and 2050, respectively.

  Moreover, the deployment of CCS in industries will play a significant role in the chemical and the non-metallic sub-industries. The estimated captured carbon dioxides will be 18 $MtCO_2eq$ in 2050.

- Residential sector: Electricity accounts for the highest energy consumption in the residential sector. Household air conditioners are one of the key drivers of electricity demand in Thailand. The energy efficiency improvement of energy devices in the residential sector will have to increase to 29% of total final energy consumption in 2050.

  The share of renewable energy use in households will have to increase to 49% of total final energy consumption in 2050. Such a heating demand is driven by the cooking system. Though the share of renewable energy used for heating is decreasing, the amount of renewable energy consumption will increase.

- Commercial buildings: The energy efficiency improvement of energy devices in the commercial buildings will have to increase to 33% of total final energy consumption in 2050. Solar water heating devices have to be promoted to produce hot water in hotels, condominiums, and hospitals. The share of solar water heating will have to increase to 5% of total final energy consumption in 2050.

Therefore, the GHG emissions in the energy sector is projected to be approximately 220.0 $MtCO_{2eq}$ in 2050.

IPPU

Thailand's LEDS of the IPPU sector is developed based on the mitigation measures identified in the NDC Action Plan in the industrial processes and product use including industrial wastewater sector 2021 – 2030. These mitigation measures consist of the modification of industrial production processes including clinker substitution, substitution of refrigerant and industrial wastewater management, including increasing biogas production from industrial wastewater by recycling methane gas. Then, the emission trajectory during 2031-2050 was modelled and estimated in Thailand's LEDS process. Results indicate that the GHG emissions in the IPPU sector will be 34.0 $MtCO_{2eq}$ in 2050.

Waste

Thailand's LEDS of the waste sector is developed based on the mitigation measures identified in the NDC Action Plan in Municipal Waste Management 2021 – 2030. The action plan consists

of work plans/activities on community solid waste management and community wastewater management that has the potential to reduce greenhouse gas. The GHG emissions reduction measures include waste reduction, landfill gas, waste to energy, semi aerobic landfill, composting, anaerobic digestion and mechanical biological treatment. The emission trajectory in the waste sector during 2031-2050 was modelled and estimated in Thailand's LEDS process. Therefore, it shows a potential to reduce greenhouse gas emissions from community solid waste management and community wastewater management in which the GHG emissions from the waste sector is projected to be approximately 16.0 $MtCO_{2eq}$ in 2050.

Agriculture

The development of Thailand's LEDS of the agriculture sector takes into consideration adaptation measures identified in the existing policies and plans that have mitigation co-benefits such as enteric fermentation, and manure management. In this study, it is perceived that adaptation measures in rice cultivation and agricultural soil will contribute to lower GHG emissions in the agriculture sector post-2050. The emission trajectory in the agriculture sector during 2031-2050 was modelled and estimated in Thailand's LEDS process. Thus, the GHG emissions from the agriculture sector is projected to be approximately 50.0 $MtCO_{2eq}$ in 2050.

LULUCF

The development of the Thailand's LEDS of the LULUCF sector is based on the National Strategy (2018-2037). The implementation of the strategy will drastically increase carbon sinks as the key measures include increasing and remaining primary forest and regenerated natural forest area, increasing economic forest area, increasing and remaining cropland, and reducing biomass burning. It is expected that the implementation of the strategy will lead to carbon dioxide removals in the LULUCF of approximately 120.0 $MtCO_{2eq}$ in 2050.

3.3 Macroeconomic Impact Assessment

The development of national policies, including in relation to climate change should carefully consider the direction and pattern of local and global development. A country's development patterns are greatly influenced by public health policy, energy security, transport and urban infrastructure and capital investment, particularly investment in the manufacturing and service sectors, which are key drivers of a country's economy. To achieve the 2-degree pathway by 2050, the intensive climate policy packages are needed. Therefore, it is imperative to understand the economic impacts as a result of the adoption and implementation of such packages. In the development of Thailand's LEDS, the macroeconomic impacts are mainly considered in terms of total energy system cost, GDP and welfare. In addition, the carbon prices by 2050 were also estimated.

3.3.1 Total energy system cost

Thailand requires additional investment in the infrastructure in power generation, transportation, manufacturing industries, and buildings. In the power sector, the present worth of the power system cost will be increased by 62.0% compared to the BAU level (see Table 3-2). The natural gas power plants with CCS and bio-energy with CCS require the highest investment in 2050, followed by wind and solar powers. The transport system cost will be increased by 16.2% compared to the BAU level. Electric trucks and electric pick-ups will account for the highest share of investment followed by electric buses and trucks. In the manufacturing industries, the energy efficiency improvement in the heating and the motor systems and the deployment of CCS require the highest investment in the non-metallic and the chemical industries in 2050. The manufacturing industries system cost will be increased by 15.3% compared to the BAU level. The heating systems, cooling systems, and the installation of solar water heating systems require the highest investment in the building sector; however, building sector shows almost unchanged investment compared to the BAU level because of the reduction in technology prices and greater use of the energy efficient technology during 2030-2050.

Table 3-2: Change of net present value of total energy system cost

Sector	Change of total energy system cost compared to the BAU (%)
Power generation	62.0
Transportation	16.2
Manufacturing industries	15.3

3.3.2 Gross Domestic Product (GDP)

The GDP is one of the important primary macroeconomic indicators. It measures the status of a country's economy. The assessment concludes that measures identified in Thailand's LEDS of the 2-degree pathway will lead to a decline in the GDP compared to the BAU 2050. There will be a slight GDP loss during 2021-2037. The GDP loss in 2030 is estimated to be 2.61% while stringent nation-wide GHG mitigation measures after 2037 will result in higher GDP losses of 6.6% in 2040 and 18.01% in 2050, respectively. In order to avoid this GDP loss, Thailand will need to prepare a transitional plan for its transformation in the energy and transport infrastructure to create the opportunities and increase the value of investment in low-emission and environmentally friendly businesses. This domestic preparation, together with the expected lower costs of advanced GHG mitigation technologies, will mitigate such economic impacts and result in a better economy in a long run.

3.3.3 Welfare

Government and household consumption form the major components in the national GDP. The 2-degree pathway by 2050 will result in a significant increment in the government consumption and a drastic decline in the household consumption. The average welfare loss is estimated at 5.0% during 2020-2030. The steep decline in the household consumption, in the attempt to attain the emission target by 2050, will lead to a sharp increase in the welfare losses. Thailand's economy will face severe damages at a welfare loss of 21.3% during 2030-2050. Thailand may increase government expenditures to boost economic activities. The implementation of emission reduction measures under Thailand's LEDS will increase government spending on welfare benefits, education, research and training, manufacturing industries, power generation, transportation, infrastructure investments, etc.

3.3.4 Carbon Price

Carbon price is estimated to be 88 US$/$tCO_{2eq}$ in 2025 and 109 US$/$tCO_{2eq}$ in 2030, respectively. However, carbon price will exponentially increase to 368 US$/$tCO_{2eq}$ in 2050 due to the stringent GHG mitigation measures after 2037, which is similar to the study by IIASA that found the average carbon price in Asia will be 390 US$/$tCO_{2eq}$ by 2050.

A higher carbon price leads to a larger reduction in the household consumption of goods and services as well as demands for switching to cleaner energy resources and technologies. To lower the carbon prices, Thailand's economy needs to enhance the deployment of energy efficient technologies.

The macroeconomic assessment also shows that in the absence of technological progress, reaching a more ambitious emission reduction goal beyond the 2-degree pathway to attain the 1.5-degree pathway by 2050, or balancing between GHG emissions by sources and removals by sinks in 2050, will yield a prohibitively high economic cost. In addition, there is a need for extensive investments in low carbon technology options and attempts to limit the macroeconomic loss to meet the 1.5-degree pathway by 2050. Considering Thailand's current economic development and industrial structure, an intensive transformation of the entire system is required to move from the fossil fuel-based economy. To balance emissions reduction with economic growth, all sectors need to be transformed, including the basic patterns of people's daily activities.

3.4 Co-benefits of Long-term Low Emissions

Key mitigation actions are needed to reduce the proportion of fossil fuel use. These measures are necessary for the private sector, especially the industrial sector, even though the impact would be short term. If all sectors do not begin to make this transition, the losses will be even greater. Despite some potential negative socio-economic impacts, the implementation of Thailand's LEDS is likely to have positive impacts such as an increase in domestic eco-investment and green consumption and the creation of green employment. This will bring about a paradigm shift and lead to long-term sustainable development in Thailand.

In terms of energy security, an indicator based on the diversity of primary energy, which is an indicator of the diversity of energy sources to support the energy needs in the country, shows that Thailand's LEDS and the BAU 2050 will have almost the same value of diversity of primary energy. This is because Thailand has limited options of energy resources. The new form of energy, such as hydrogen, would improve the energy security of Thailand. However, the indicator on net gas import dependency in Thailand's LEDS will be much lower than that in the BAU 2050.

The mitigation co-benefit is a key consideration for the development of Thailand's LEDS. There are two types of co-benefits examined under Thailand's LEDS, which are energy intensity and CO_2 emissions per capita (CECap). It is projected that the energy intensity and CO_2 emissions per capita (CECap) in the BAU 2050 will be 0.62 ktoe/USD and 7.37 ton-CO_2 per capita, respectively, while in Thailand's LTS 2050 they will be 0.50 ktoe/USD and 2.42 ton-CO_2 per capita, respectively. This finding clearly reveals a good improvement of these indicators.

In conclusion, the results of co-benefit analysis under Thailand's LEDS indicates a decreasing in energy intensity of 19.4% and a decrease in CECap of 67.2% compared to the BAU 2050. In addition, the measures implemented under Thailand's LEDS will help reduce local air pollutants generated from combustion of fossil fuels, such as NOx, CO, NMVOC and PM2.5.

3.5 Thailand Carbon Neutrality

With global warming requiring rapid and comprehensive actions to reduce greenhouse gas emissions, many countries have stepped up efforts to shift to clean energy and decarbonized activities. Thailand also has focused its attention on reducing carbon dioxide emission in the energy sector, which is the largest contributor of GHG emission, in order to support the achievement of Thailand's LEDS goal. Thailand has formulated the National Energy Plan (NEP 2022) framework as a policy framework to guide the related agencies to achieve the transformational change to clean energy systems and will achieve the goal of becoming a carbon neutral country in 2065-2070. In addition to Thailand's LEDS, Thailand considered two additional scenarios focusing on only carbon dioxide emissions in the energy, IPPU, waste and agriculture sectors as follows:

- **Thailand carbon neutrality by 2070 scenario**. In this scenario, the share of renewable electricity generation will be at least 50% of new power generation capacity by 2050 and new vehicles in the market will be electric vehicle (Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV)) with the share of 69% by 2035. Under this scenario, carbon dioxide emissions in the IPPU, waste and agriculture sectors will follow the 2-degree pathway.
- **Thailand carbon neutrality by 2065 scenario.** This scenario employs the same policy and measures in the 2070 scenario and also includes energy efficiency improvement.

The 2070 and 2065 carbon neutrality scenarios are presented in Figures 3-7 and 3-8, respectively. The net nationwide carbon dioxide emissions under the 2070 scenario and the

2065 scenario will be 62 $MtCO_2$ and 41 $MtCO_2$ in 2050, respectively. Consequently, Thailand will achieve a net zero carbon dioxide emission by 2070 with 50% share of renewable electricity plants in the new power generation capacity and 69% share of new electric vehicles on the market by 2035. Furthermore, Thailand will achieve net zero carbon dioxide emissions as early as 2065 if it applies the same policies and measures as in the 2070 scenario and incorporates energy efficiency improvement.

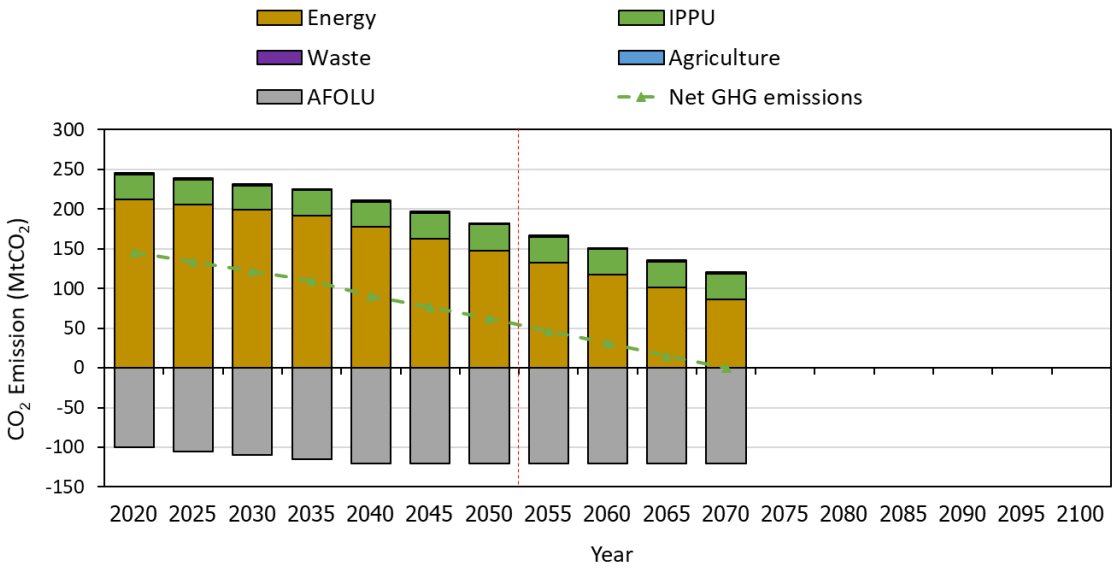


Figure 3-7: Thailand carbon neutrality by 2070 scenario

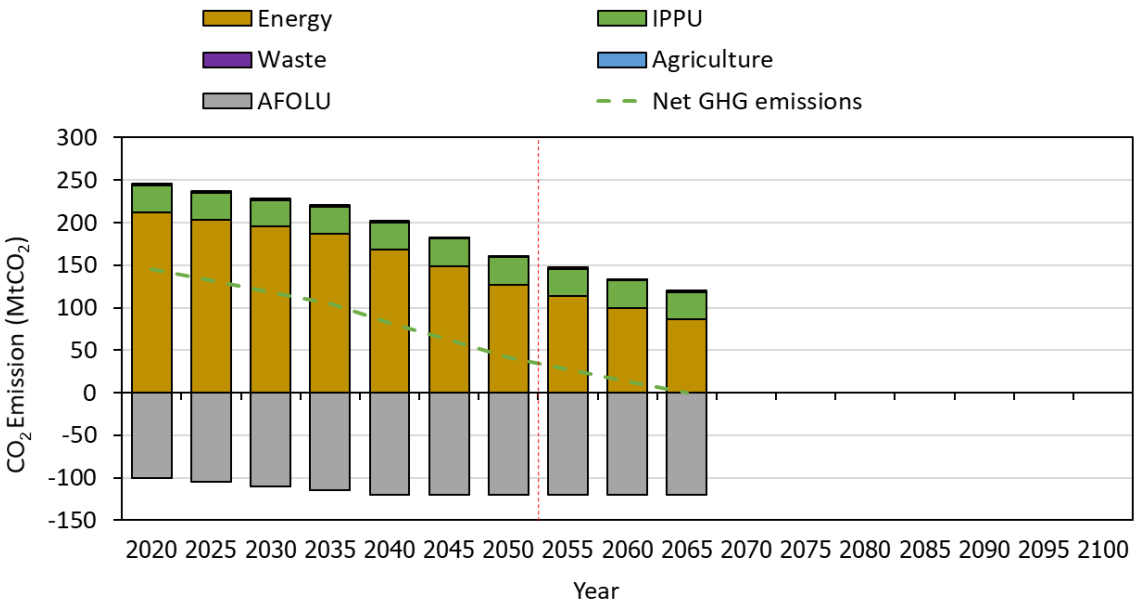


Figure 3-8: Thailand carbon neutrality by 2065 scenario

To achieve the carbon neutrality by 2065, Thailand emphasizes the importance of innovation and RD&D, especially in the areas for low carbon electricity generation, CCS, bio-energy with CCS and hydrogen economy. Public transport infrastructure and networks will be priorities to

decarbonize the transport sector. A complete transformation of the vehicle fleet, the development of public EV fast charging networks, and hydrogen fueling stations are required as early as possible. The new energy policy framework of Thailand's carbon neutral target set by Ministry of Energy in 2021 includes:

1) Policy direction to increase the share of new renewable electricity generation to be at least 50%, increase the share of electric vehicles to be at least 30% by 2030, increase energy efficiency by reduce energy intensity at least 30% by 2037, and promote energy system transformation through decarbonization, digitalization, decentralization, deregulation, and electrification.

2) Framework of energy system transformation in the power sector includes (i) low carbon power generation to achieve Thailand's carbon neutrality by 2065-2070, (ii) carbon capture and storage (CCS), (iii) carbon capture utilization and storage (CCUS), (iv) grid modernization to support disruptive technologies such as smart energy management and energy storage systems, (v) distributed generation through smart micro grids to support peer-to-peer and net-metering markets and (iv) low carbon electrification such as battery electric vehicles and EV infrastructure.

3) Framework of energy system transformation in natural gas includes (i) promoting liquefied natural gas (LNG) in industries and transportation, (ii) improving natural gas system management, (iii) infrastructure development of LNG, and (iv) good governance of natural gas market.

4) Framework of energy system transformation in oil includes (i) improving petroleum distillation process to meet EURO5 and EURO 6 standards, (ii) promoting low carbon fuels such as biofuels used in transportation including removing petroleum subsidy, (iii) improving the infrastructure and modern management system and (iv) promoting battery electric vehicles and revising management system of liquefied petroleum gas (LPG), including shifting from LPG stoves in households to electric stoves.

5) Framework of alternative energy to increase renewable electricity generation to 50% by 2050 and integration of energy storage in the long term to lessen impacts of increasing energy prices. The energy system transformation needs to (i) increase domestic renewable energy production, (ii) promote distributed generation, micro-grids and grassroots economy, (iii) digitalize renewable energy control center platform for both on-grid and off-grid areas, (iv) provide incentives and policies that support renewable energy investment and markets, and (v) promote renewable energy technology investment, bio-economy, research and development of hydrogen, and bio-jet.

6) Framework of energy efficiency improvement includes digital technology and innovation to help reduce greenhouse gas emissions and reduce investment in new

power plants. The energy efficiency business will help promoting Energy Service Companies (ESCO) and job opportunities. The supportive actions include (i) increasing energy efficiency target measures such as Building Energy Codes (BEC), Energy Efficiency Resource Standards (EERS) and ESCO business, (ii) promoting Green Buildings and Industries by using smart energy management, and (iii) promoting digital platform for energy savings, smart energy management, EV data platforms and EV infrastructure, including sufficient number of EV charging stations.

Thailand's carbon neutral target is fundamental for achieving its net zero greenhouse gas emissions target. It is an ambitious move for developing countries that have limited access to modern energy infrastructure. The NEP 2022 is a starting point for energy transition in Thailand as it contains concrete measures to reduce carbon emissions in the near future.

3.6 Support Needs

Transition to a low-carbon society in Thailand, through the implementation of policies and measures identified in Thailand's LEDS and the carbon neutral pathway, requires a contribution of all sectors and actors. Thailand is looking for more low-carbon business models from both domestic and international investors. This opportunity will enable Thailand to build forward better to become a green economy country after the COVID-19 pandemic. The green economy ecosystem will be accelerated with the goal of reducing greenhouse gas emissions to net-zero. However, to achieve Thailand's LEDS targets, international cooperation and support is needed for policy development, research and technology development, mechanisms and instruments, and capacity building, as follows:

Policy implementation

- Build capacity in the public and private sectors to integrate mitigation action into their respective plans or enterprises.
- Raise awareness on climate change, Thailand's LEDS and NDCs among relevant stakeholders and the general public.

Research development and deployment (RD &D) in the following priority areas:

Energy and transport sector

- Renewable energy technologies (such as solar, wind) and approaches in advanced energy storage system (EES) and demand-side management.
- Carbon capture and storage (CCS) or carbon capture, utilization and storage (CCUS) in power plant and industries
- Bio-energy with CCS
- Electric Vehicle (xEV), battery and Infrastructures
- Grid Modernization, smart energy management and Independent Power Supply (IPS)
- Other technologies related to carbon neutrality (Hydrogen, Bio-hydrogenated diesel (BHD)

Other sectors

- Smart energy management in the industrial sector
- Waste-to-energy technologies in the waste sector
- CH_4 reduction technologies in agriculture such as enteric fermentation and manure management and rice cultivation.

Mechanisms and instruments

- Financial instruments, incentives, mechanisms and approaches to engage the private sector in the shift to green investment.
- Share knowledge and best practices on legal frameworks and modalities to support Thailand's LEDS and NDC implementation.

3.7 Implementation Approach

Thailand's first best practices during NAMAs implementation will be used in the NDC and LT-LEDS implementation. As Thailand's LEDS is a national framework on climate change mitigation, it is crucial that it is implemented in a methodical and holistic manner across sectors and levels.

The implementation of Thailand's LEDS will be in line with the timeframe of existing and subsequent NDCs. During 2021-2030, Thailand's LEDS will be implemented through the NDC roadmap and sectoral action plans which provide detailed guidance on measures and realistic actions to achieve the 1st NDC target by 2030, as well as regular monitoring and evaluation of the progress and achievement.

The monitoring and evaluation of the mitigation measures relating to the Thailand's LEDS will be carried out to ensure its effectiveness and efficiency in achieving its objectives and key performance indicators. Because it is a long-term plan spanning many years during which many changes can occur, it is envisaged that it will be subject to a comprehensive review every five years. This is consistent with the approach under the Paris Agreement that assigned Parties to submit their NDCs to the UNFCCC every five year. There is an opportunity to improve the alignment of LT-LEDS with the five-year revision cycles of NDC submission. The review will provide a chance to reassess current policy pathways and new developments which may affect the range of possible ambition. Thailand will review the information and situation regarding the implementation of the national strategy along with relevant information available domestically and internationally to revise Thailand's LEDS accordingly. The revision of Thailand's LEDS can take into account the following factors:

- Trend and progress in the development of related technologies or the rapid decline in the investment cost of technologies
- The major changes in national strategy or related national policy direction
- The readiness of the line ministries and local administration
- Awareness, understanding and engagement among the various stakeholders
- Evaluation of the problems and obstacles to implementation

Consideration will also be given to any gaps or unmet needs that arise within the effort to reduce GHG emissions, which will be used to revise and refine the next phase of the plan. The implementation approach will be established to ensure a clear guideline for this monitoring and evaluation.

Addressing climate change requires full engagement of all stakeholders and sectors, including government, private sector and civil society across all levels of administration and organization. They are key to the implementation of climate actions under Thailand's LEDS. The development of practical tools and mechanisms which promote wider participation and collaboration will support building climate change resilience and contribute to low-carbon growth.

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