THAILAND'S
FOURTH BIENNIAL
UPDATE REPORT

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UPDATE REPORT

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THE KINGDOM OF THAILAND

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT
OFFICE OF NATURAL RESOURCES AND ENVIRONMENTAL POLICY AND PLANNING
CLIMATE CHANGE MANAGEMENT AND COORDINATION DIVISION

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FOREWORD

Thailand is pleased to submit Biennial Update Reports (BURs) on its climate change response to the UNFCCC on a consistent basis; the BURs shall be prepared in accordance with the guidelines contained in Decision 2/CP.17 (decision 2/CP17). Thailand acknowledges the international consultation and analysis (ICA) process through the Subsidiary Body for Implementation (SBI), as evidenced by improved reporting of subsequent BURs. The expert review team's recommendations assist Thailand's national GHG inventory in narrowing knowledge gaps and increasing efficiency in the preparation process.

According to the conclusions of COP24 in Katowice, the Modalities, Procedures and Guidelines (MPGs) for the Enhanced Transparency Framework (ETF) were the most important component. In this regard, the Biennial Update Report (BUR) serving under the Convention will be replaced by the Biennial Transparency Report (BTR), which will serve as the transparency report under the ETF. The first BTR must be submitted at the latest by December 31, 2024. According to the MPGs in the annex to decision 18/CMA.1, parties are preparing their BTR.

Therefore, Thailand's Fourth Biennial Update Report (BUR4) has been prepared in accordance with UNFCCC guideline which is the final BUR of Thailand. The main purposes are to present updated information on the nation's circumstances, gender equality, institutional arrangement, the national GHGs Inventory between 2000 and 2019, achievement of GHG emission reduction under the overall implementation of NAMA's measures, and the transition towards the NDC implementation, together with constraints, gaps, and supports needed and received to implement its climate action in adaptation, mitigation, and enabling environment as well as fulfilling its transparency requirement under the Paris Agreement. Furthermore, BUR4 has been updated the Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS) and the 2nd updated NDC were revised and submitted to UNFCCC by COP27. The revisions focus on the alignment of mitigation measures and 2050 carbon neutrality and 2065 net-zero GHG emissions, just transition, and optimization of socio-economic impacts. In the 2nd updated NDC, Thailand elevated the contribution level to 40%, with 30% from our domestic effort and 10% from international support. This target is challenging for the energy, transport, and agriculture sectors. The challenge also includes raising awareness and participation from all relevant sectors, particularly the private sector, which urgently needs to adapt and enhance its capacity for business competition to keep pace with the rapidly changing global circumstances and trends.

On behalf of the Office of Natural Resources and Environmental Policy and Planning (ONEP), Ministry of Natural Resources and Environment (MONRE), I would like to emphasize that Thailand devotes great endeavours from all relevant national resources entirely, collaborating with the United Nations Development Programme (UNDP), a coordinating and implementing agency, for its technical support in order to transfer our commitment, reflecting on the success of the BUR4. My appreciation also extends to representatives from Ministries, sub-national government agencies, academic institutions, private sectors, civil societies, non-governmental organizations, and international agencies for their contributions in the preparation of this report.

Thailand, as a developing country, has realized these capacity needs for improvement, and continuously required financial and technical support in enhancing its national capacities to mitigate these gaps, more stringent measures applied under the Paris Agreement's framework, Katowice Climate Package, specified implementation MPGs for the transparency framework, as well as BTR preparation. The climate change issues and their impacts have tremendous increased. The country bears more responsibility to escalate the level of its implementation by encouraging more stakeholders' participation, and intensifying national readiness in tackling the issues. Finally, Thailand will continue to put the utmost effort into prioritizing and implementing our policies to combat climate change and limit the increase of global average temperature under the Paris Agreement according to the country's vision toward net-zero GHG emissions by the second half of this century.

Dr. Phirun Saiyasitpanich
Secretary - General
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3Rs	Reduce, Reuse, and Recycle
ACE	Action for Climate Empowerment
AD	Activity data
ADF	Activity data factor
AEDP	Alternative Energy Development Plan
AgWG	Agriculture Working Group
AIM	Asia-Pacific Integrated Assessment Model
BAU	Business-As-Usual
BCG	Bio-Economy, Circular Economy, and Green Economy
BECC	Basic Education Core Curriculum
BUR	Biennial Update Report
CB	Capacity Building
CBD	Convention on Biological Diversity
CCFF	Climate Change Financing Framework
CCMP	Climate Change Master Plan
CCUS	Carbon Capture Utilization and Storage
CDM	Clean Development Mechanism
CGEOs	Chief Gender Equality Officers
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CRADR	Climate-resilient Agriculture for Disaster Risk Reduction
CRI	Global Climate Risk Index
CSR	Corporate Social and Environmental Responsibility
DET	Data Entry Template
DMWG	Disaster Mitigation Working Group
DRR	Disaster Risk Reduction
EE	Estimated Elsewhere
EEP	Energy Efficiency Plan
EF	Emission Factor
EI	Energy Intensity
EPR	Extended Producer Responsibility
EST	Environmentally Sustainable Transport Master Plan
EV	Electric vehicles
F-Gases	Fluorinated Gases
FS	Financial Support
GBO5	Fifth Global Biodiversity Outlook
GCF	Green Climate Fund
GDP	Gross Domestic Product

GEF	Global Environment Facility
GFPs	Gender Focal Points
GFSI	Global Food Security Index
GHG	Greenhouse Gas
GSI	Gender and Social Inclusion
GWP	Global Warming Potential
HNAP	Health National Adaptation Plan
I&FF	Investment and Financial Flows Assessment
ICC	International Coastal Cleanup
IKI	International Climate Initiative
INDC	Intended Nationally Determined Contribution
IPPU	Industrial Processes and Product Use
IUU	Illegal, Unreported, and Unregulated Fishing
JCM	Joint Crediting Mechanism
KCA	Key Category Analysis
LCC	Low Carbon Growth in Cities through Sustainable Urban System Management in Thailand Project
LCCP	Low Carbon Cities Programme
LESS	Low Emission Support Scheme
LGBTI	Lesbian, gay, bisexual, transgender, and intersex
LPG	Liquefied Petroleum Gas
LT-LEDS	Long-Term Low Greenhouse Gas Emission Development Strategy
LULUCF	Land Use, Land-Use Change and Forestry
M&E	Monitoring and Evaluation
MPI	Multi-Dimension Poverty Index
MRV	Measurement, Reporting and Verification
MSW	Municipal Solid Waste
NA	Not Applicable
NAMA	Nationally Appropriate Mitigation Action
NAP	National Adaptation Plan
NbS	Nature-based Solutions
NC	National Communication
NCCC	National Committee on Climate Change Policy
NDC	Nationally Determined Contribution
NDE	National Designated Entity
NE	Not Estimated
NO	Not Occurring
PDP	Power Development Plan
PM	Particulate Matter
PPP	Polluter Pays Principle

QA	Quality Assurance
QC	Quality Control
RAC	Refrigeration and Air Conditioning
RDF	Refuse Derived Fuel
RE	Renewable Energy
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD); and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in Developing countries (+)
SDGs	Sustainable Development Goals
TACCC	Transparency, Accuracy, Consistency, Completeness, and Comparability
TGCP	Thai-German Climate Programme
TGEIS	Thailand Greenhouse Gas Emission Inventory System
TOD	Transit-oriented development
T-PLAT	Thailand Climate Change Adaptation Information Platform
TS	Technical Support/Assistance
TT	Technology Development and Transfer
T-VER	Thailand Voluntary Emission Reduction Program

GASES

CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
HFCs	Hydrofluorocarbons
N_2O	Nitrous Oxide
NMVOCs	Non-Methane Volatile Organic Compounds
NO_2	Nitrogen Dioxide
NOX	Nitrogen Oxides
O_3	Ozone
PFCs	Perfluorocarbons
PM	Particulate matters
SF_6	Sulphur Hexafluoride
SO_2	Sulphur Dioxide
VOCs	Volatile Organic Compounds

UNITS

$	United States Dollar (USD)
¥	Japanese Yen
€	Euro (EUR)
°C	Degree Celsius

µg/m³	Micrograms (one-millionth of a gram) per cubic meter
A$	Australian Dollar
Bpd	Barrels per day
EUR	Euro
Gg	Gigagram = 10⁹ grams or 10³ tonnes
kg	Kilogram
km	Kilometer
km²	Square kilometer
ktoe	kilo ton of oil equivalent
M	Million
m²	Square meter
m³	Cubic meter
mm	Millimeter (represents a factor of 10-3)
MMscf	Million standard cubic feet
tCO_2eq	Ton of Carbon Dioxide Equivalent
THB	Thai Baht
USD	United States Dollar

ORGANIZATIONS

APAN	Asia-Pacific Advanced Network
ASEAN	Association of Southeast Asian Nations
BAAC	Bank for Agriculture and Agricultural Cooperatives
BMA	Bangkok Metropolitan Administration
CAA	Climate Action Academy
CAAT	The Civil Aviation Authority of Thailand
CCMC	Climate Change Management and Coordination Division
DEDE	Department of Alternative Energy Development and Efficiency
DEQP	Department of Environmental Quality Promotion
DIW	Department of Industrial Works
DLA	Department of Local Administration
DLD	Department of Livestock Development
DMCR	Department of Marine and Coastal Resources
DMF	Department of Mineral Fuels
DNP	Department of National Parks, Wildlife and Plant Conservation
DOA	Department of Agriculture
DOAE	Department of Agricultural Extension
DOEB	Department of Energy Business
DOF	Department of Fisheries
DOH	Department of Health

DOT	Department of Tourism
DPIM	Department of Primary Industries and Mines
DWF	Department of Women's Affairs and Family Development
ED	The Excise Department
EGAT	Electricity Generating Authority of Thailand
EPPO	Energy Policy and Planning Office
ERCT	Environmental Research and Training Center
EU	European Union
FLMO	Forest Land Management Office
FPO	Fiscal Policy Office
GISTDA	Geo-Informatics and Space Technology Development Agency
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (German development agency)
IGES	Institute for Global Environmental Strategies
IPCC	Intergovernmental Panel on Climate Change
ISIT	Iron and Steel Institute of Thailand
IUCN	International Union for the Conservation of Nature
JICA	Japan International Cooperation Agency
LAOs	Local Administrative Organizations
LDD	Land Development Department
MD	Marine Department
MEA	Metropolitan Electricity Authority
MOAC	Ministry of Agriculture and Cooperatives
MOE	Ministry of Education
MOI	Ministry of Interior
MONRE	Ministry of Natural Resources and Environment
NCCC	National Committee on Climate Change Policy
NESDC	Office of the National Economic and Social Development Council
NRCT	National Research Council of Thailand
NSO	National Statistical Office
NXPO	Office of National Higher Education Science Research and Innovation Policy Council
OAE	Office of Agricultural Economics
OBEC	Office of the Basic Education Commission
OCSB	Office of the Cane and Sugar Board
OEC	Office of the Energy Regulatory Commission
OIE	The Office of Industrial Economics
ONEP	Office of Natural Resources and Environmental Policy and Planning
ONLB	Office of the National Land Policy Board
OTP	The Office of Transport and Traffic Policy and Planning

PCD	Pollution Control Department
PTIT	Petroleum Institute of Thailand
RAOT	Rubber Authority of Thailand
RD	Rice Department
REO	Regional Environment Office
RFD	Royal Forest Department
RID	Royal Irrigation Department
RU-CORE	Ramkhamhaeng University, Center of Regional Climate Change ana Renewable Energy
SDSN	Sustainable Development Solutions Network
SRT	State Railway of Thailand
TCMA	Thai Cement Manufacturers Association
TCNN	Thailand Carbon Neutral Network
TGO	Thailand Greenhouse Gas Management Organization
TMD	Thai Meteorological Department
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WMA	Wastewater Management Authority

EXECUTIVE SUMMARY

Thailand, as a Non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC), is obligated to submit Biennial Update Reports (BURs) every 2 years. The BURs shall be prepared in accordance with the guidelines contained in decision 2/CP.17. Thailand submitted its first, second, and third BUR on 29 December 2015, 29 December 2017, and 25 December 2020, respectively. This report, the fourth BUR (BUR4), contains updates of national Greenhouse Gas (GHG) inventories, including a national inventory report and information on mitigation actions, needs and support received. It has demonstrated the country's intention to actively implement climate actions and share the results with UNFCCC and the global community. This BUR consists of four chapters as follows:

NATIONAL CIRCUMSTANCES

The physical context reveals the country's vulnerability to climate impacts as above-average temperatures tend to rise, precipitation has fluctuated over time, population structure is becoming an "aging society," and its long coastal zone faces coastal erosion and sea-level rise. The country's natural resources exhibit not only abundance and absorptive capacity but also the degrading conditions from climate-induced disasters. Thailand relies largely on commercial energy production and consumption but share of renewable energy has continued increasing.

The COVID-19 pandemic caused a significant economic contraction during 2020-2022.

In particular, the tourism sector, which has always been a significant part of Thailand's economic growth generating approximately 20-22 % of GDP, suffered a drastic decline. The COVID-19 controlling measures resulted in reduction of energy consumption and production, and economic activities.

In terms of institutional arrangement for climate change management, Thailand established National Committee on Climate Change Policy (NCCC). The NCCC serves as a national institute overseeing climate policy development and implementation. It was initially composed of 5 Subcommittees, but 2 Subcommittees have been recently instituted to advance Thailand's climate actions—the Subcommittee on the Mobilization of GHG Mitigation with Carbon Sequestration in LULUCF Sector and the Subcommittee on the Mobilization of GHG Mitigation with CCUS application and Implication.

NATIONAL GREENHOUSE GAS INVENTORY

This inventory report was prepared using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and presented Thailand's national GHG emissions from 2000 to 2019 by sources and removals by sinks. The GHG emissions estimated in this report include both direct and indirect emissions: Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Sulphur Hexafluoride (SF_6), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs) and Sulphur Dioxide (SO_2). The emissions are calculated by using the Thailand Greenhouse Gas Emission Inventory System (TGEIS).
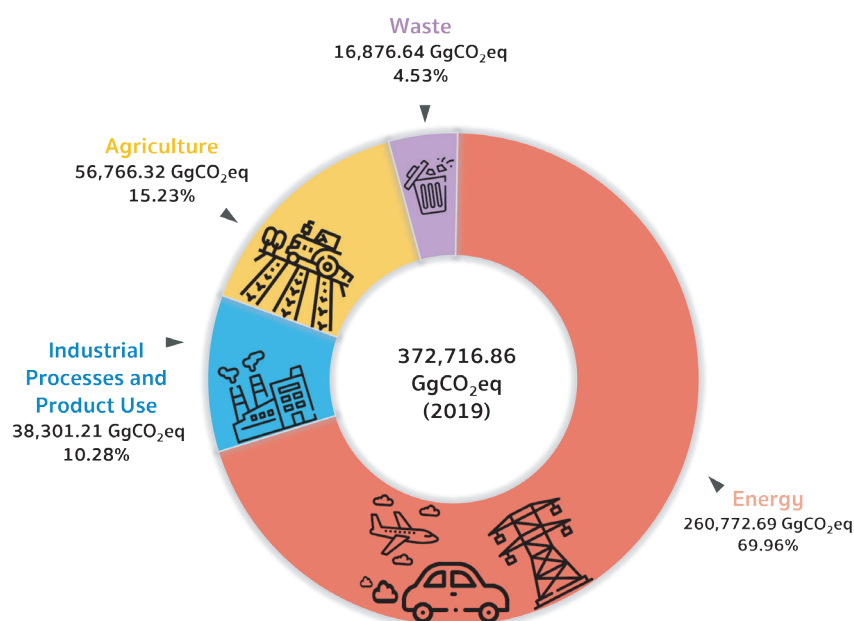
Figure: Total GHG emissions by sector (excluding LULUCF), 2019

In 2019, total GHG emissions (excluding those from LULUCF) were 372,716.86 $GgCO_2$eq. Net GHG emissions were 280,728.34 $GgCO_2$eq (including those from LULUCF) resulting from the Energy sector (260,772.69 $GgCO_2$eq), Agriculture sector (56,766.32 $GgCO_2$eq), IPPU sector (38,301.21 $GgCO_2$eq), and Waste sector (16,876.64 $GgCO_2$eq). The Energy sector remained the major contributor to Thailand's GHG emissions, accounting for 69.96% of the total GHG emissions. The share of emissions from the Agriculture, IPPU, and Waste sectors were 15.23%, 10.28%, and 4.53%, respectively. LULUCF contributed to a net removal of 91,988.52 $GgCO_2$eq.

MITIGATION MEASURES

Thailand made efforts to uphold its commitment under the Convention by integrating climate change mitigation into its national policies and sectoral plans and implementing mitigation measures to achieve the NAMA's target of GHG emissions reduction in a range of 7-20% from the business-as usual (BAU) by 2020. Furthermore,

Thailand's 2nd updated nationally determined contribution (NDC) aligns with the ambitious pledge to reduce GHG emissions unconditionally by 30 % from the BAU by 2030. The contribution level increases up to 40%, subject to adequate and enhanced access to technology development and transfer, financial resources, and capacity-building support. Thailand continues effort to meet the long-term goals of carbon neutrality by 2050 and net-zero GHG emissions by 2065.

Thailand had implemented NAMA's mitigation measures and successfully achieved a GHG reduction of 56.54 $MtCO_2$eq in 2020 from 10 mitigation measures in the energy and transport sectors which is 15.40% lower than its BAU level. In the post-2020 mitigation, Thailand has transitioned toward NDC, which aims at reducing GHG emissions in the energy, transport, industrial process and product use, agriculture, and waste sectors. In addition, Thailand has developed supporting mechanisms and voluntary actions to mitigation GHG emissions, such as the carbon market and carbon label schemes.
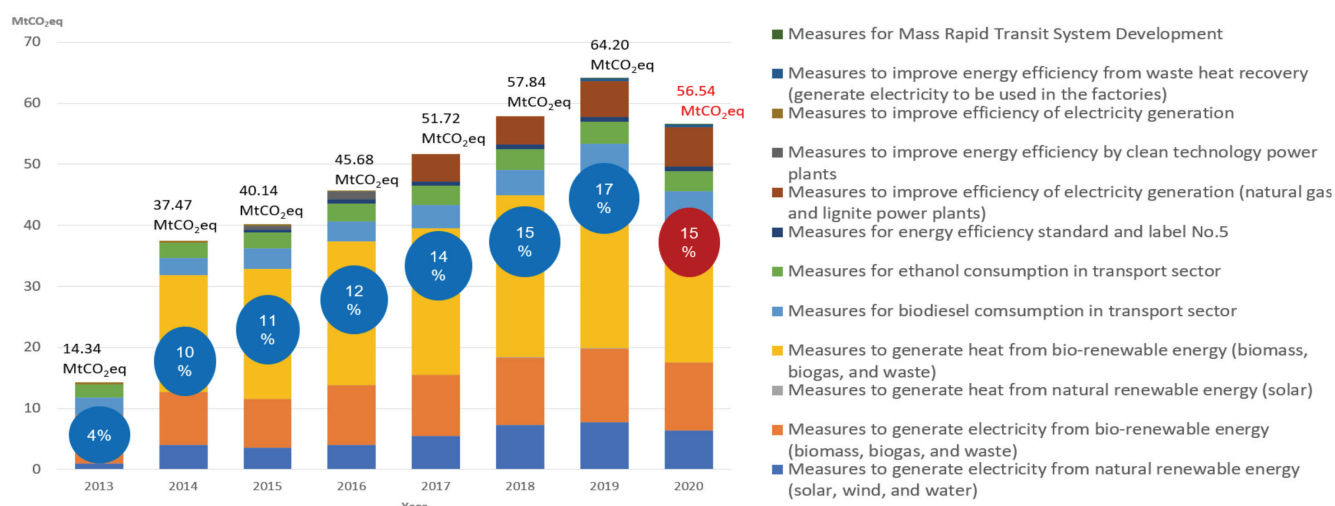
Figure: Thailand's GHG emission reduction from NAMA implementation: 2013-2020

CONSTRAINTS, GAPS, NEEDS, AND SUPPORT RECEIVED

The existing TGEIS database needs to be updated to reflect the progress of GHG inventory quality. Under the Enhanced Transparency Framework (ETF), the national GHG inventory must follow the Common Reporting Table (CRT) format of the Biennial Transparency Report (BTR). Thailand is preparing to fulfil the completeness of its first BTR for submission by 2024. The mapping exercise of the categories in the 2006 IPCC Guidelines and the CRT needs to be well prepared. In addition to the support needed for the electronic reporting in the CRT, Thailand needs capacity building to support the electronic reporting in the Common Tabular Format (CTF) in order to understand and track progress of implementation and achievement of its NDC in accordance with the modalities, procedures, and guidelines (MPGs)

Thailand has received support from various international partners to facilitate climate actions in mitigation, adaptation, and enabling environment, including the preparation of Thailand's NC4 and BUR4. From 2020-2022, Thailand has received support from multilateral and bilateral partners for a total of 34 projects, entailing 18 mitigation projects with a total amount of 31,438,771 USD,

10 adaptation projects with a total amount of 48,667,056 USD, and 6 enabling environment projects with a total amount of 3,419,548 USD.

However, considering remaining constraints and gaps, Thailand needs support in terms of finance, technical expertise, technology transfer, and capacity building to ensure the achievement of the mid-century long-term low greenhouse gas emission development strategies (LT-LEDS). Thus, Thailand needs support for energy system transformation towards greener energy technologies such as solar and wind, Carbon Capture Storage (CCS) & Carbon Capture, Utilization, and Storage (CCUS) technologies, and advance technologies to achieve the net-zero emissions targets. To enhance the enabling environment, Thailand needs support for developing and strengthening mechanisms, instruments, and policy implementation, such as financial instruments and incentives to engage private sectors in green investment and capacity building of all stakeholders.
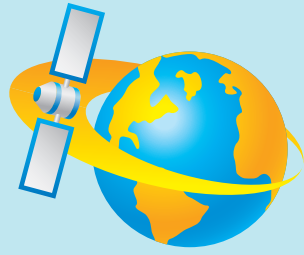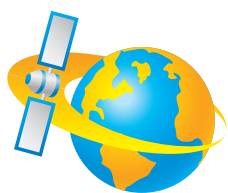
CHAPTER 1 :
NATIONAL
CIRCUMSTANCES

Figure 1-1: Map of the Kingdom of Thailand

1.1 Physical Context

1.1.1 Geography

The Kingdom of Thailand is situated in the tropical zone between latitudes 5° 37' N and 20° 27' N and longitudes 97° 22' E and 105° 37' E, encompassing a total area of 513,115 km^2 (see Figure 1-1). Thailand has territorial borders with Myanmar and Laos in the North, Laos and Cambodia in the East, Malaysia in the South, and Myanmar in the west. The significant topography of Thailand is a peninsula with a total coastal length of 3,151.02 km, consisting of the Andaman Sea coast of 1,111.04 km in the west and the Gulf of Thailand coast of 2,039.97 km in the east.

Source: 1) Thai Meteorological Department 2) Department of Marine and Coastal Resources

1.1.2 Ministrative Area

Region: Thailand comprises the Northern high mountains, the Central plains, the Northeast plateau, and the Southern coastal plain. It is officially geographically divided into six regions:

1) North, 2) Northeast, 3) Central, 4) East, 5) West, and 6) South.

Province: Thailand is divided into 76 provinces, excluding Bangkok. The public administration is divided into three tiers: central, provincial, and local administration. The central administration comprises the ministries, bureaus, and departments. The provincial government consists of provinces, and each province is divided into districts. The Local administration consists of Provincial Administrative Organization, Municipality, and Sub-district Administrative Organization. There are also two special local governments under local administration: Bangkok and Pattaya. While Pattaya is a part of Chonburi Province, Bangkok is governed by the Bangkok Metropolitan Administration (BMA) unlike the other seventy-six provinces.

1.1.3 Population

1.1.3.1 Population Density
Population density: Total population of Thailand as registered in 2021 was 66,171,439 making it the 20th most populated country in the world. Over the past decade, the average annual population growth rate has been around 0.4% (see Figure 1-2).

1.1.3.2 Population Projections
Population projections: The population projection remains the same as reported in the BUR3. It is projected to gradually increase and start to decline
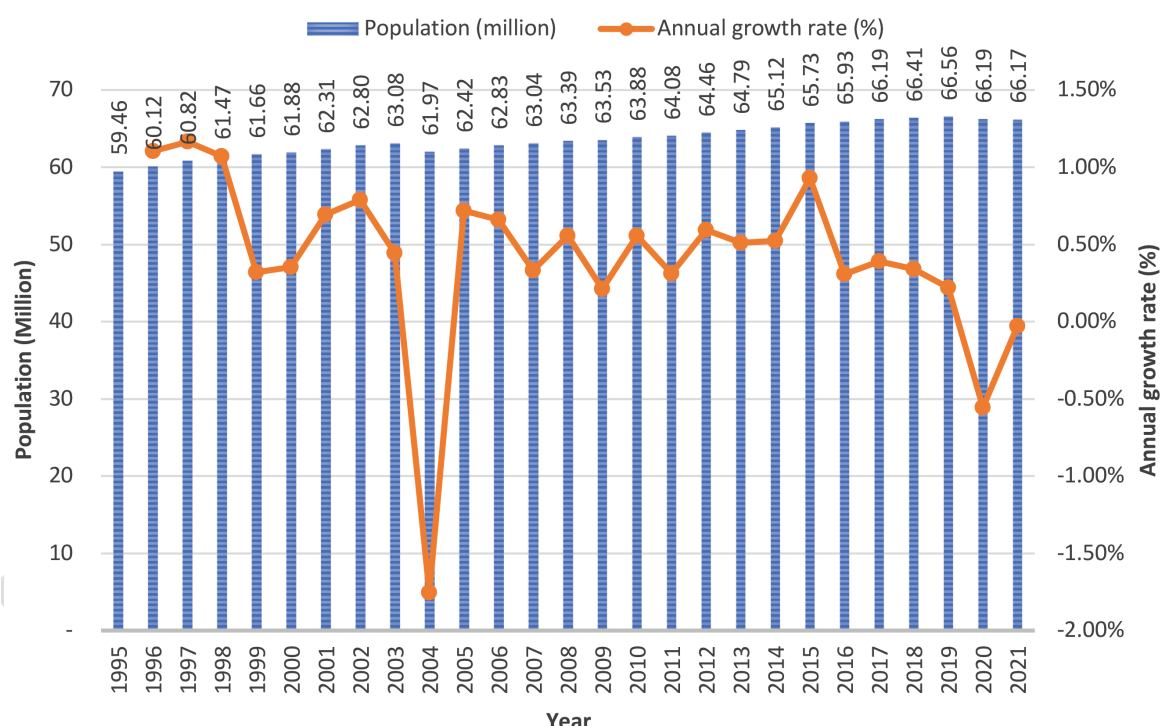
Figure 1-2: Population and annual growth rate: 1995-2021

Remark: *In 2004, The Department of Provincial Administration reviewed and made necessary corrections to remedy double counting issues in Thailand's total population figures. Accordingly, this chart reflects the accurate, corrected figure of the country's total population.*
Source: 1) *National Statistical Office 2) Department of Provincial Administration 3) UN World Population Prospects 2019*

after 2030 (see Table 1-1). Thailand's population structure is becoming an "aging society." This demographic transition translates into two challenges: 1) the development of a mechanism to support aging members of society, and 2) the development of national policies and plans to promote social and health services for mothers and newborns.

Table 1-1: Thailand's population projections: 2020-2040

Population Projections	2020	2025	2030	2035	2040
1. Population					
• 0-14 years	11,225,072	10,637,212	9,916,612	9,149,160	8,363,327
• 15-59 years	43,269,391	41,917,127	40,105,230	38,334,858	36,498,965
• Sixty and over	12,040,221	14,534,657	17,118,697	19,102,768	20,510,045
Total	66,534,684	67,088,996	67,140,539	66,586,786	65,372,337
2. Fertility Rates	1.53	1.47	1.41	1.36	1.30
3. Life Expectancy at Birth (years)					
• Men	73.23	74.33	75.27	76.07	76.75
• Women	80.35	81.28	82.04	82.66	83.15

Source: *1) Population Projections 2013 and Study Report on Population Projection in Thailand 2019, Office of the National Economic and Social Development Council 2) Department of Provincial Administration*

Urbanization rate: The urbanization rate remains the same as reported in the BUR3. The projection from 2010-2040 reveals that the population living in urban areas has been steadily increasing. It is estimated that 74.3% of the population live in urban areas by 2040 (see Figure 1-3).
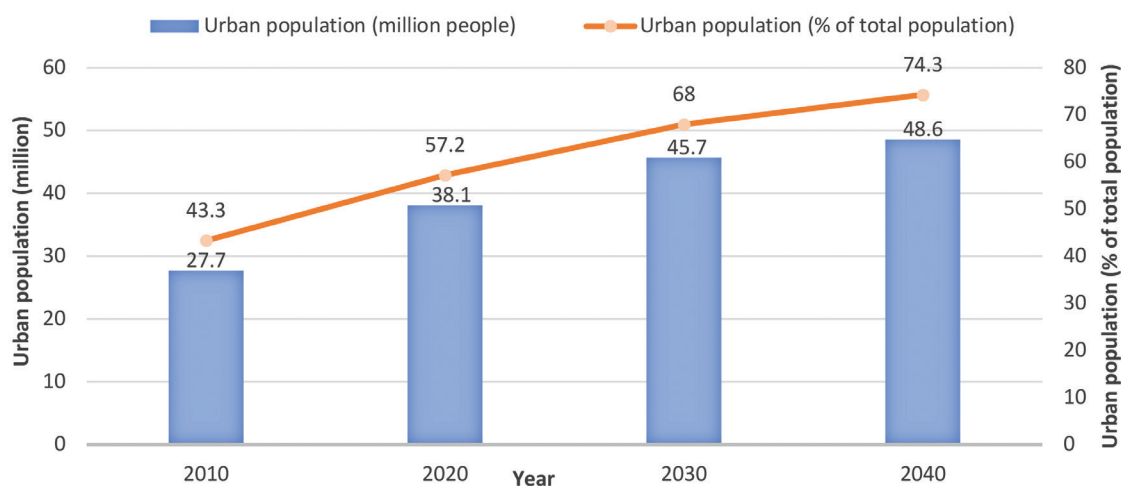
Figure 1-3: Urbanization rate: 2010-2040

Source: *Office of the National Economic and Social Development Council*

1.1.4 Climate

1.1.4.1 Seasons and Temperature

Thailand's climate is influenced by two seasonal monsoons: 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. The northeast monsoon starts in October and brings cold, dry air from China over the north and northeast regions. The climate of Thailand can be broadly divided into three seasons: 1) Rainy, from mid-May to mid-October 2) Winter, from mid-October to mid-February, and 3) Summer, from mid-February to mid-May. Temperature records in Thailand during 1951-2021 show slightly increasing trends (see Figure 1-4).
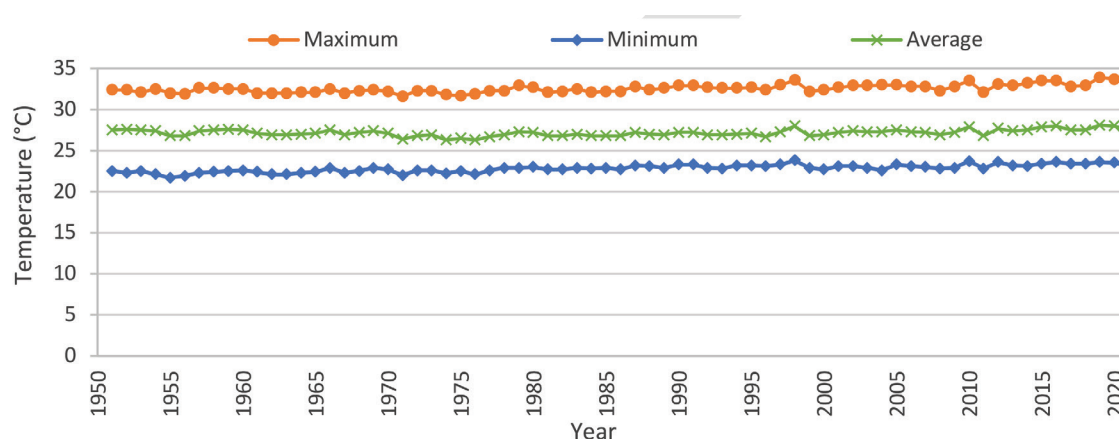
Figure 1-4: Annual mean maximum and minimum temperatures in Thailand: 2021

Source: *Thai Meteorological Department*

1.1.4.2 Precipitation

The variation of precipitation and the number of rainy days has oscillated over time. In the last 7 years (2015-2021), the rainfall variation has fluctuated, with the lowest rainfall in 40 years in 2019 (1,343.4 mm) since 1979 (1,332.3 mm) (see Figure 1-5). The highest annual rainfall in Thailand was recorded in 2017 (2,017 mm). The annual rainfall in 2020 and 2021 was recorded at 1,528.8 mm and 1,759.3 mm, respectively.
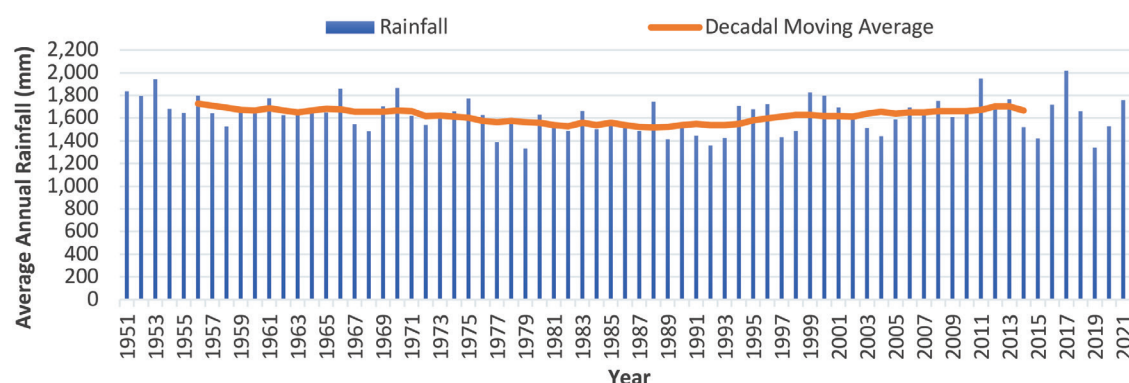
Figure 1 5: Annual mean rainfall in Thailand: 1951-2021

Source: *Thai Meteorological Department*

1.2 Energy

1.2.1 Energy Consumption

In 2020, Thailand's final energy consumption was 77,340 ktoe, a decrease of 9.76% from 2019 due to Coronavirus disease 2019 (COVID-19) pandemic in 2020 (see Table 1-2). Commercial energy consumption was 86.4% of the total final energy consumption, while renewable energy was 8.7%, and traditional renewable energy was 4.9%. Of this amount, consumption of petroleum products played the greatest proportion, 48.0% of the total final energy consumption, followed by electricity, coal and its products, renewable energy, natural gas, and traditional renewable energy shared 21.67%, 10.32%, 8.69%, 6.40%, and 4.92%, respectively (see Figure 1-6). In 2020, shares of final energy consumption of the transport, the industrial, the residential, the commercial and the agricultural sectors are 38.4%, 37.29%, 13.12%, 8.19%, and 3.0%, respectively.

Table 1-2: Final energy consumption by fuel type

Final energy consumption by fuel type	Quantity (ktoe)			Growth (%)	
	2018	2019	2020	2019	2020
Final Energy Consumption	83,952	85,708	77,340	2.09	-9.76
Commercial Energy	70,822	72,126	66,821	1.84	-7.36
• **Petroleum Products**	41,383	42,084	37,124	1.69	-11.79
• **Electricity**	16,805	17,358	16,761	3.29	-3.44
• **Coal and Coal Products**	6,865	7,116	7,983	3.66	12.18
• **Natural Gas**	5,769	5,568	4,953	-3.48	-11.05
Renewable Energy	7,919	8,525	6,717	7.65	-21.21
Traditional Renewable Energy	5,211	5,057	3,802	-2.96	-24.82

Source: Energy Balance of Thailand 2020, Department of Alternative Energy Development and Efficiency
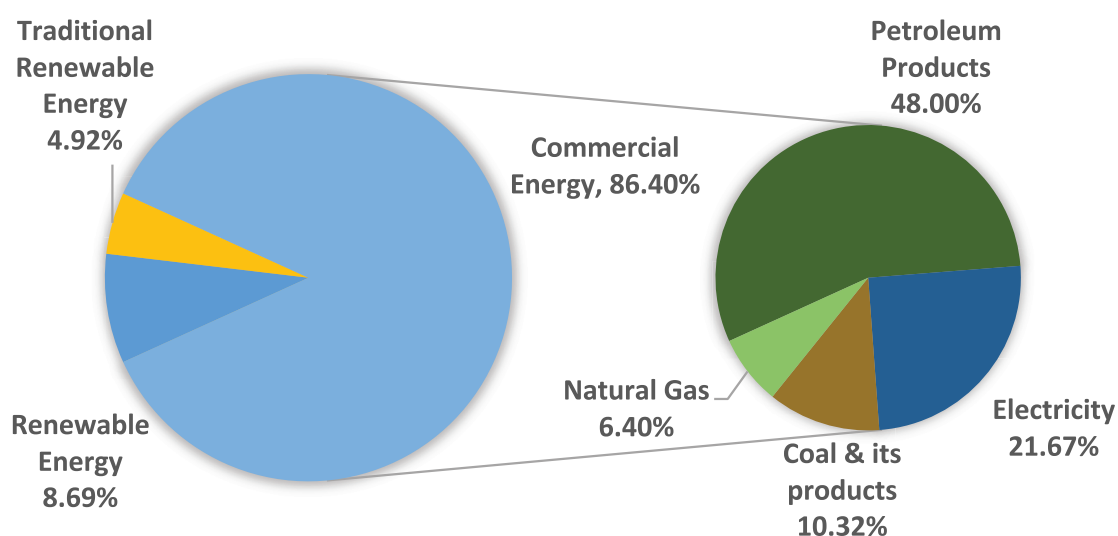
Figure 1-6: Final energy consumption by fuel type, 2020

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

1.2.2 Energy Production

In 2020 energy production was 65,821 ktoe, a decrease of 11.76% from 2019 (see Table 1-3). Commercial energy production, renewable energy, traditional renewable energy, biofuel, and others contributed 63.61%, 24.34%, 7.87%, 3.56%, and 0.62% of total energy production, respectively (see Figure 1-7).

Table 1-3: Energy production by fuel type, 2020

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[a]	17,156	18,670	16,020	8.82	-14.19
Traditional Renewable Energy[b]	7,012	6,842	5,179	-2.42	-24.31
Biofuel	2,113	2,422	2,343	14.62	-3.26
Other Energy[c]	500	470	408	-6.00	-13.19

Note: [a]*solar, wind, hydro geothermal, fuelwood, paddy husk, bagasse, agricultural waste, MSW, and biogas*
  [b]*fuelwood, charcoal, paddy husk, and agricultural waste*
  [c]*black liquor and residual gas*
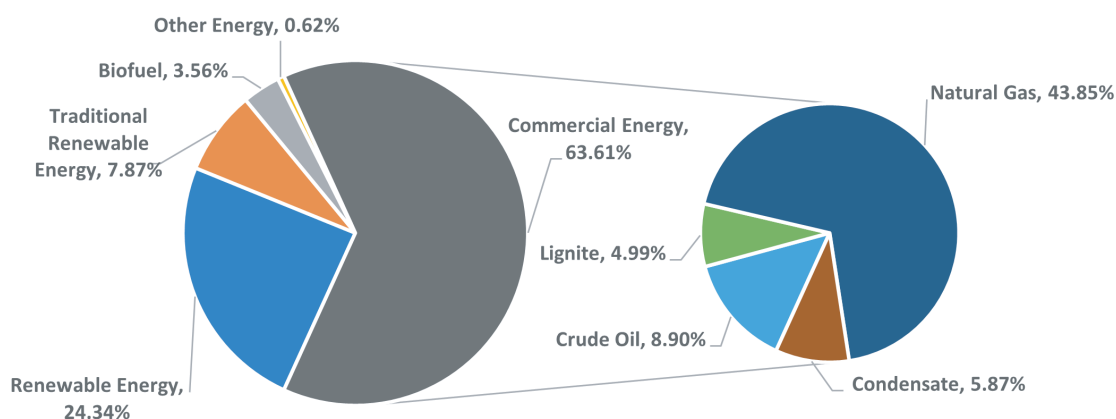
Figure 1-7: Energy production by fuel type, 2020
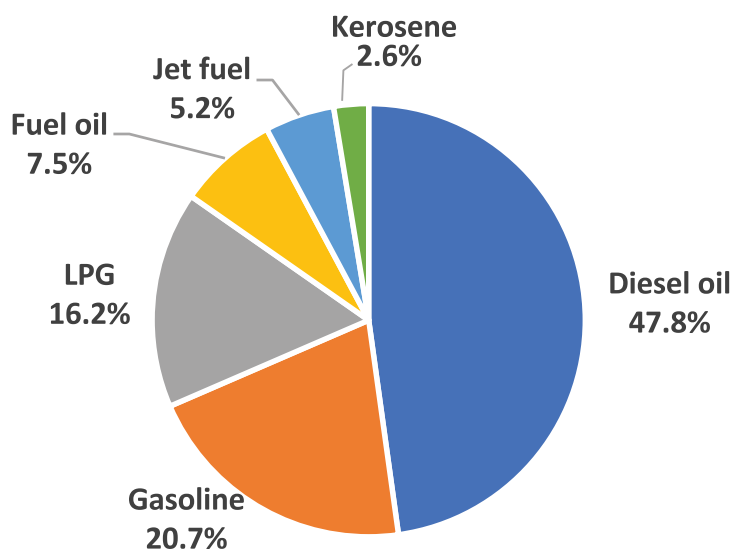
Figure 1-8: Proportion of petroleum products production, 2020

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

Total energy import in 2020 was 77,199 ktoe, a decrease of 0.6% from the previous year. Commercial energy and traditional renewable energy accounted for 99.9% and 0.1% of the total energy import, respectively. The energy import consists of crude oil 42,291 ktoe (54.8%), coal 14,908 ktoe (19.3%), petroleum products 1,862 ktoe (2.4%), the natural gas 14,064 ktoe (18.2%), condensate 1,512 ktoe (1.9%), electricity 2,518 ktoe (3.3%), and traditional renewable energy import, fuelwood, and charcoal, 44 ktoe (0.1%).

Total energy export was 10,812 ktoe in 2020, an increase of 6.2% from 2019. Commercial energy and traditional renewable energy exports accounted for 99.9% and 0.1% of the total energy export, respectively. The energy export consisted of petroleum products 9,253 ktoe (85.6%), crude oil 1,230 ktoe (11.4%), electricity 222 ktoe (2.0%), natural gasoline 51 ktoe (0.5%), coal 44 ktoe (0.4%), and traditional renewable energy export, fuelwood, and charcoal 12 ktoe (0.1%).

Fuel mix in electricity generation: Natural gas is the primary fuel which energy consumed for electric generation. Its share accounted for 59.1% of the fuel mix in electricity generation in 2020. The followings are coal/lignite 17.6%, fuel oil, and diesel oil 0.1%. The rest is renewable and other energy and accounted for 23.2%.

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

1.2.3 Alternative Energy

The domestic alternative energy comprises solar energy, wind energy, hydro energy, biomass, biogas, MSW, and biofuel (ethanol and biodiesel). In 2020, the alternative energy consumption was 11,997 ktoe, a decrease of 15.13 % from 2019 (see Table 1-4). The electricity consumption produced from alternative energy was 2,903 ktoe, and heat consumption was 6,717 ktoe. The ethanol consumed as a part of biofuel was 765 ktoe, and biodiesel was 1,612 ktoe.

Table 1-4: Alternative energy consumption

Alternative Energy Consumption	Quantity (ktoe)			Growth (%)
	2018	2019	2020	2020
1. Electricity (solar, wind, hydroelectricity, biomass, MSW and biogas)	2,960	3,239	2,903	-10.37
2. Heat (solar, biomass, MSW and biogas)	7,919	8,525	6,717	-21.21
3. Biofuel				
• Ethanol	781	829	765	-7.72
• Biodiesel	1,336	1,543	1,612	4.47
Total	12,996	14,136	11,997	-15.13

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

1.2.4 Energy Efficiency Situation:

In 2020, energy intensity significantly improved, with a decrease to 7.53 ktoe per thousand million Baht (see Figure 1-9). It is a result of the Government's energy-efficient policy, particularly the Energy Efficiency Plan 2018-2037 targeting Energy Intensity reduction of 30% by 2037, compared to the base year 2010.
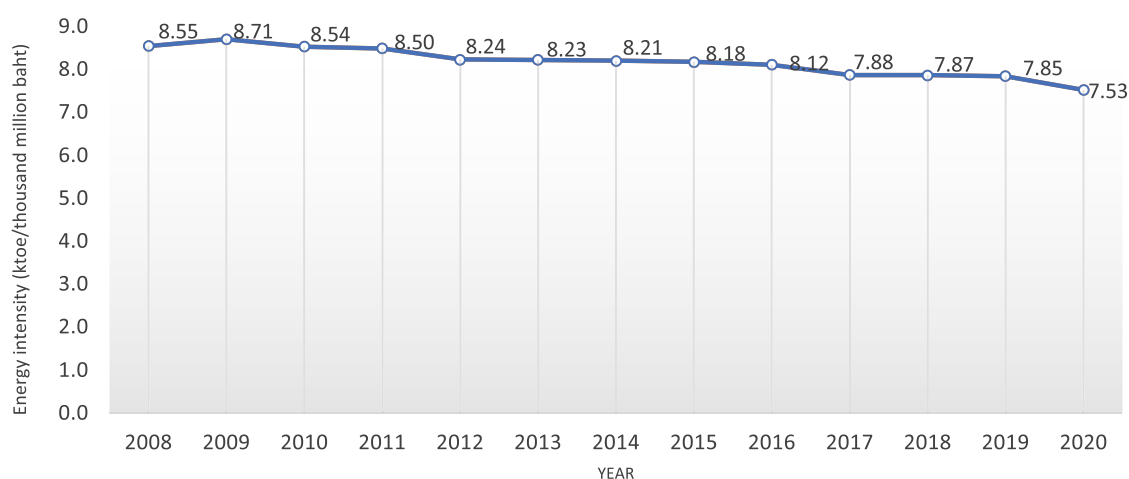
Figure 1-9: Energy efficiency trend: 2008-2020

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

The main achievements of energy development targeting indicators for SDG 7 – Ensure access to affordable, reliable, sustainable, and modern energy for all, focused on three areas:

• Access to energy: The access to electricity increased from 82.1% in 2000 to 99.21% in 2020.
• Uptake in renewable energies: In 2020, renewable energy constituted 15.99% of final energy consumption, an increase of 10.9 % in 2011.

• Improve energy efficiency: Thailand's Government aims to reduce Energy Intensity (EI) by 30% by 2036 compared to levels from 2010. In 2019, EI stood at 7.85 %, which was an 8.08% decrease and equaled the saving of 7,541 ktoe.

Source: Thailand's Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development 2021, Ministry of Foreign Affairs

1.3 Natural Resources

1.3.1 Land Resources and Forestry

Thailand's total land area is approximately 513,115 km². Forest land and non-agricultural land comprised 163,975 km² and 110,337 km² or 31.95% and 21.51%. (see Figure 1-10). Agricultural land accounted for 238,803 km² or 46.54% of the total land area.

Bamboo Forest, Teak Plantation, Other Plantations, Secondary Forest, Savanna, Vegetation on Pen Rock Platform Areas.

The forest area deteriorates from deforestation and forest fire, which occur from extreme heat and drought as part of the climate change impacts and agricultural burning. Striving to tackle the problems and achieve SDG goal 15—Protect, restore, and promote sustainable use of
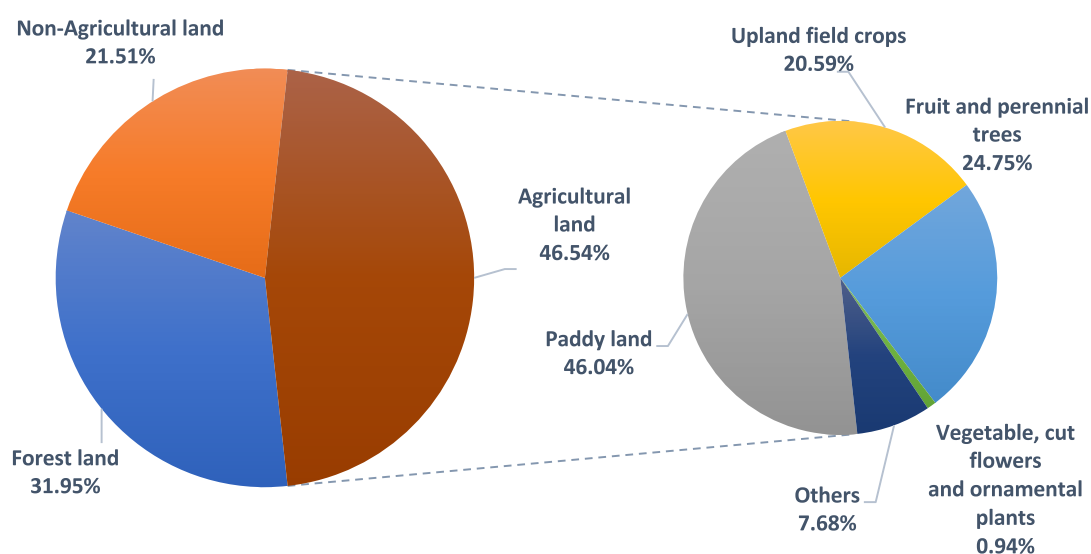
Figure 1-10: Land resources and forestry, 2020

Source: Agricultural Statistics of Thailand 2020, Office of Agricultural Economics

The attribution of agricultural land cosists of paddy land 46.04%, fruit and perennial trees 24.75%, upland field crops 20.59%, and vegetable, cut flowers, and ornamental plants 0.94%.

From the 2018-2020 statistic record of the Royal Forest Department, the forest area in Thailand is stable, at an average of 31% of the total land area, respectively. The forest types in Thailand can be categorized as follows: Moist Evergreen Forest, Dry Evergreen Forest, Montane Forest, Pine Forest, Peat Swamp Forest, Mangrove Forest, Freshwater Swamp Forest, Beach Forest, Mixed Deciduous Forest, Dry Dipterocarp Forest,

terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss, Thailand has taken the following steps:

• Legal instruments: Thailand enacted laws, regulations, and measures to manage and maintain the richness of the forest and its ecosystem. Key legal instruments include the Forest Act (1941), National Park Act (1961), National Reserved Forest Act (1964), Wild Animal Reservation and Protection Act (1992), Commercial Forest Plantation Act (1992), Chain Saws Act (2002), National Park Act (2019) and the Community Forest Act (2019).

• Strategic plan: The 5th strategy of the 20-Year National Strategy (2018-2037) environmentally growth for sustainable development—aims to prevent deforestation and increase forest areas to 55% by 2037. The 20-Year Strategic Plan for the Ministry of Natural Resources and Environment (2017-2036) further elaborates in the first strategy that the goal is to protect and conserve forest areas for sustainable development of natural resources and biodiversity, including monitoring and preventing forest fires.

Forest conservation: In 2020, Thailand expanded forest conservation from 105,696 km^2 in 2006 to 116,304 km^2. This is equivalent to 23% of the total land area, including 22 national parks extending across 6,416 km^2.

Source: 1) Office of Agricultural Economics 2) Forest Land Management Office, Royal Forest Department 3) Department of National Parks, Wildlife, and Plant Conservation 4) Thailand's Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development 2021, Ministry of Foreign Affairs 5) Office of Natural Resources and Environmental Policy and Planning

1.3.2 Water Resources

Thailand has 22 major river basins and 27 ground-water sources. In 2020, the natural surface flow was about 199 billion m^3, an increase of 31.4% from 2019. In 2021, the total water demand was about 100 billion m^3, mainly for agriculture, accounted for 82.50%, followed by the demand for ecosystem conservation, consumption, and industry at 12.81%, 3.73%, and 0.98%, respectively.

Thailand has experienced problems with water resources such as water shortage, drought, floods, decreased groundwater levels, and saltwater intrusion in groundwater sources. Severe droughts that occurred in 1979, 1994, and 1999 affected every part of the country. There have been an increasing number of recurring droughts over the

last 10 years, which have affected a total area of 42,280 km^2.

Therefore, aiming to manage the country's water resources effectively and align with SDG 6— Ensure availability and sustainable management of water and sanitation for all, Thailand has set the 20-Year National Strategy (2018-2037) and formulated the 20-Year Master Plan on Water Resources Management (2018-2037) with 6 key focus areas: management of water use, security of water production, inundation control, water quality conservation, afforestation in watershed areas and soil protection, and managing approach. Thailand has made overall achievements as follows:

• Access to clean water: The proportion of household members able to access clean drinking water increased from 97% in 2012 to 98% in 2016, and 99.5% in 2019.

• Water quantity: In 2019, the Royal Irrigation Department increased water storage capacity by 16.7 million m^2 and increased the amount of irrigated land. The Department of Water Resources and the Department of Groundwater Resources set a target to reduce the amount of water lost from 25 to 20%.

• Water quality: In 2019, the Ministry of Interior, as the responsible agency for developing the water consumption system, expanded water systems in all provinces and the Bangkok Metropolis to over 26,000 additional households.

• Ecosystem: From 2018-2019, Thailand implemented measures to revive 177.5 km^2 of up water forest areas, which represents 15% of the target set in the Water Management Masterplan.

Source: 1) 22 Basins and Designated River Basin Decree 2021, Report on Water Resource Management Plan 2021, and the 20-Year Master plan on Water Resources Management 2018-2037, Office of National Water Resources 2) Department of Groundwater Resources 4) Department of Water Resources 5) Thailand's Environmental Circumstance 2021, Office of Natural Resources and Environmental Policy and Planning 6) Thailand's Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development 2021, Ministry of Foreign Affairs

1.3.3   Marine Resources

Thailand has 24 coastal provinces, with a total area of 101,678 km^2 and a coastal length of 3,151 km. The total maritime territory is 321,247 km^2, consisting of internal waters 61,023 km^2, territorial sea 52,216 km^2, contiguous zone 37,185 km^2, exclusive economic zone 163,644 km^2, and Thai-Malaysia joint development area 7,179 km^2.

Marine and coastal resources entail 2,779 km^2 of mangroves, 256 km^2 of seagrass, 238 km^2 of coral reefs, 971 islands, and 609 beaches. The coastal area and marine resources have been adversely affected by climate change impacts and the expanding economic activities, causing many critical problems such as coastal erosion, coral bleaching, acidification of seawater, degradation of coral reefs and seagrass, depletion of marine animals, and increased marine plastic litter.

Thailand has acknowledged the degradation of marine environmental resources and the severe impacts of climate change; thus, it seeks to address the problems and implement SDG 14— Conserve and sustainably use the oceans, seas, and marine resources for sustainable development. Thailand has accomplished the following:

• Legal ground: The Department of Marine and Coastal Resources (DMCR) is the key government agency in enforcing management and conservation measures under the Marine and Coastal Resource Management Promotion Act 2015.

• Implementations: From 2017 to 2020, key initiatives and implementations for resources conservation and restoration include research on coral bleaching and acidification of seawater, planting coral and seagrass, establishing a marine life rescue center for rare species, and enforcing preventive measures for Illegal, Unreported, and Unregulated fishing (IUU). Spatial ecosystem management has been promoted by growing and restoring over 263,008 m^2 of coral reefs and

96,000 m^2 of seagrass and installing 4,710 artificial reefs in eight sites across seven provinces.

• Protected areas: Thailand has designated 35 marine protected areas extending across 15,336 km^2, or 4.74% of the country's total maritime zone. Six other areas totaling 11,865.29 km^2, or 3.67% of the total maritime zone, are currently being reviewed. By 2030, Thailand aims to declare 10 % of its total maritime zone as marine protected areas according to the National Reform Plan.

• Marine plastic pollution: Thailand set out its policies and measures to reduce single-use plastic consumption, particularly to address plastic pollution in coastal and marine areas. Aligning with Waste Management Master Plan (2016-2022) and Plastic Waste Management Road Map (2018-2030), DMCR has implemented many projects and activities with the Marine and Coastal Resources Research & Development Institute to reduce plastic marine litter. The activities include researching the effects of marine plastic litter on the marine environment and animals, collecting marine plastic litter data, analyzing micro plastics in the marine environment, organizing International Coastal Cleanup (ICC), collecting plastic litters using SCG-DMCR Litter Trap and the Ocean Cleanup Interception BV (on-going importation process). As a result, Thailand eliminated 199 tons of marine plastic litter in 2020.

• Technology: The government advanced the application of satellite remote sensing for marine pollution and ships investigations using satellite images from TERRA/AQUA, which allows for seawater quality monitoring, the development of a seawater quality database through the SNAPP and NOAA-20 satellites, and the development of PyGNOME, a system to provide area-specific water direction and speed forecasts.

1.3.4 Biodiversity

Thailand is one of the most biodiverse countries in Southeast Asia. According to the ONEP's report on Thailand's biodiversity status in 2020, national biodiversity can be classified into four groups:

1) Ecosystems: Seven types of Thailand's ecosystems are forest, mountain, agriculture, marine and coastal, island, inland water, and dry and semi-humid.

2) Plant species: From the publication of Flora of Thailand in 2015, Thailand hosted around 12,050 plant species. Later, various national and international botany journals on plant taxonomy published from 2014 to 2020 revealed 239 new plant species in Thailand.

3) Animal species: There are more than classifiable 6,928 invertebrate species and 5005 vertebrate species in 2021, an increase of 274 species from 2015. Of all the vertebrate species, 676 are listed as threatened species, with 141 critically endangered, 191 endangered, and 344 vulnerable.

4) Microorganism species: There are over 200,000 species that are diverse in terms of species, genetic, and ecological contexts.

Biodiversity condition in Thailand is threatened by the increased socio-economic activities and climate change impacts which may cause severe biodiversity loss and degraded ecosystems. ONEP, as a national focal point of the Convention on Biological Diversity (CBD), has initiated many implementations to fulfill the commitments under the CBD, such as developing the World Biodiversity Framework 2020, organizing activities for the International Day for Biological Diversity 2020, formulating the Fifth Global Biodiversity Outlook: GBO5, and organizing the Summit on Biodiversity and other related meetings.

For domestic operations, ONEP has worked as a secretary in the National Biodiversity Conservation and Exploitation Committee, responsible for proposing guidelines, policies, measures, and plans for the conservation and exploitation of the country's biodiversity to the Cabinet, including providing policy recommendations for integrating and linking strategic operations under the plan to achieve goals and maneuvering the Integrated Biodiversity Management Master Plan 2015-2021. The Master Plan adopted the Strategic Plan for Biodiversity 2011-2020 (2011-2020) as a framework for the operation's direction, focusing on conservation, restoration, protection, and exploitation of biodiversity and ecosystem services. The implementation of the Master Plan is in line with the Sustainable Development Goals 2, 6, 14, and 15, which focus on 1) maintaining, protecting, and restoring biodiversity, 2) stopping biodiversity threats, 3) promoting access and benefit-sharing of genetic resources and local wisdom in an equitable and justifiable manner, and 4) promoting the sustainable management and exploitation of terrestrial and marine ecosystems. In addition, ONEP has drafted the Biodiversity Bill, a harmonized law for unifying biodiversity management that promotes and supports the conservation and sustainable exploitation of biodiversity. The Bill aims to eliminate the disparities of legal enforcement on biodiversity issues and serves as an effective mechanism for integrating biodiversity into policies of relevant sectors.

According to the 2030 Agenda for Sustainable Development, maintaining biodiversity richness by supporting sustainable use within regenerating capacity of its components is the key mission to ensure the equilibrium between economic development and environmental protection, as indicated in SDG 15 —Protect, restore and

promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss. Thailand's overall achievements include:

•   Financial support: the Government has increased environmental budgets every year. In 2021, the budget increased from 2019 by 88.32% (from 8.572 billion THB in 2019 to 16.143 billion THB in 2021). An additional 13.267 billion THB has been allocated to conserve biodiversity from 2017 to 2022.

•   Conservation: Thailand has designated wetlands of importance to natural ecosystems, registered under the Ramsar Convention on Wetlands of International Importance. Thailand also designated biosphere reserves (limited to terrestrial ecosystem) extending across 2,672 km^2 in 2020.

•   Operation center: The Government has preserved and promoted a healthy forest ecosystem by establishing Forest Protecting Operation Centers. The Centers provide an integrated platform and serve as the headquarters for anti-deforestation operations, the reclamation of forest areas from illegal ownership, the management of national parks in accordance with IUCN Green List Standards, and efforts to promote patrolling standards reform in reserved forest areas.

•   Biodiversity loss prevention: Natural habitat loss, including forest and coastal ecosystems, has decreased. In 2019, forest areas in the country extended over 163,984 km^2, or 31.68% of the country's total land area. This amount increased slightly from 2017. In 2018, the mangrove area extended 4,576 km^2, increasing by 86.37% from 2014. Overall, grass resource areas remain at the same level and are in better health. Coral reefs now extend across 238.44 km^2, increasing by 0.05% from 2015. Compared to 2015, the growth rate for coral reefs

looks set to continue at the same rate. From 2017-2018, the wetlands area extended to 5,792.3296 km^2, increasing from 2015-2016 by 5.06%.

Source: 1) Report on Thailand's Biodiversity Status in 2020 and Thailand's Environmental Circumstance 2021, Office of Natural Resources and Environmental Policy and Planning 2) Thailand's Voluntary National

1.4 State of the Environment

1.4.1 Air Quality

Six major air pollutants in Thailand are Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Ozone (O_3), Volatile Organic Compounds (VOCs), and particulate matters (i.e., particulate matter <10 microns: PM_{10}, and <2.5 microns: $PM_{2.5}$). Overall air quality in 2020 is improved compared to 2019. In particular, the annual average amount of $PM_{2.5}$ was 23 micrograms per cubic meter ($\mu g/m^3$), 8% decreased from 2019, and PM_{10} was 43 $\mu g/m^3$, a decrease of 9% from 2019. The highest 8-hour average amount of ozone was 81 $\mu g/m^3$, 11% decreased from 2019.

Critical areas Bangkok and its vicinity: The $PM_{2.5}$ problem situation in 2020 was around 20-25 $\mu g/m^3$ (decreased from 2019). The decreased pollution was due to the implementation of the Action Plan for Driving National Agenda "Addressing Pollution Problem (Particulate Matter)" of Pollution Control Department under the Ministry of Natural Resources and Environment and the COVID-19 pandemic causing less industrial production capacities, travel activities, and energy consumption.

Haze in Northern provinces: The situation was slightly more violent than in 2019. There were 112 days in which particulate matter exceeded the standard. The accumulated number of hotspots was 88,855 (a decrease of 2% from 2019). The highest 24-hour average amount of $PM_{2.5}$ was 366 $\mu g/m^3$ (an increase of 4% from

2019). The primary cause was agricultural burning in combination with dry weather, which caused the rapid spread of forest fires. Measures addressing the Northern haze problem were implemented under the mechanism of the Disaster Prevention and Mitigation Act 2007 by determining four areas (forest, agricultural, roadside, and community areas) and five measures (command system, fuel reduction, awareness/ network/volunteer building, and law enforcement). These included the measures set up of the Forest Fire Mitigation Center.

Na Phra Lan Subdistrict, Saraburi Province:

There were 92 days in which PM_{10} exceeded the standard (39% decreased from 2019). The yearly average amount of PM_{10} was 107 µg/m^3 (9% decreased from 2019). In collaboration with the Committee on Prevention and Mitigation of Particulate Matter Problem in the Pollution Control Area, various action plans and public participation are implemented such as monitoring of PM_{10} both in ambient air and from pollution release from sources, spot checking at random areas by PM meter identifying vehicles that do not comply with the law, as well as cleaning road.

The area of Map Ta Phut, Rayong Province:

Benzene and 1,3-butadiene increased, while 1,2-dichloroethane decreased from the previous year. The objectives of measures addressing volatile organic compounds (VOCs) are as follows: 1) to find causes and control the leakage, 2) to prepare the industrial plants related organizations to implement new regulations on the standard for controlling exhaust ventilation from petroleum refineries to control benzene ventilation in terms of surveillance around the fence, and 3) to monitor the situation by various committees in Rayong Province as resolving mechanism.

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

1.4.2 Water Quality

Surface water: In 2020, the water quality of 59 water sources and six still water resources 39% was in good quality, 43% was in fair quality, and 18% was in poor quality. None was in very poor quality (see Figure 1-11).
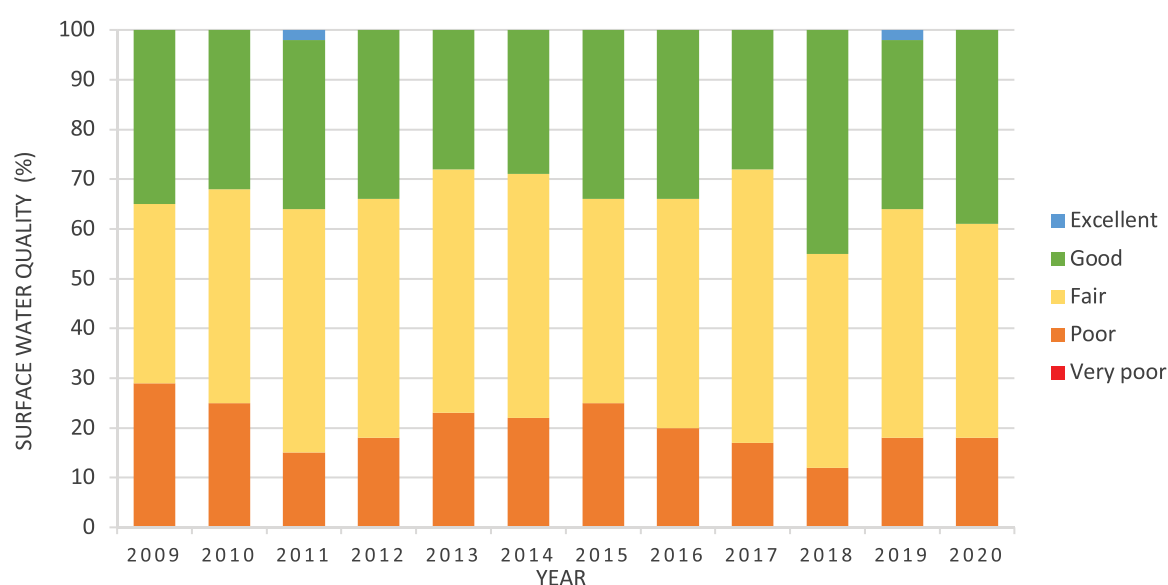
Figure 1-11: State of surface water quality: 2009-2020

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

Coastal water: In 2020, the coastal water quality: 4% was in excellent quality, 60% was in good quality, 27% was in fair quality, 7% was in poor quality, and 2% was in very poor quality (see Figure 1-12). The trend of coastal water quality in the Gulf of Thailand remains in poor quality.
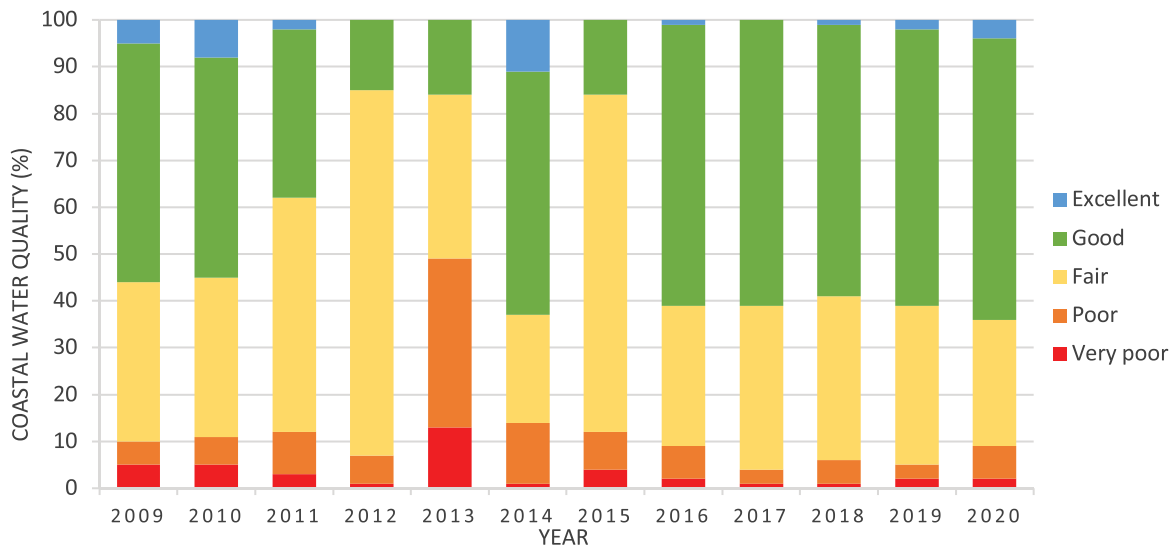
Figure 1-12: State of coastal water quality: 2009-2020

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

Groundwater: According to the monitoring system of groundwater quality and groundwater level from 2,716 observation wells, and 1,724 stations scattered in 27 groundwater basins, the groundwater was of good quality. A under the groundwater standards for consumption according to the Groundwater Act 1977. Some areas had high iron and manganese, resulting from geological and hydrogeological conditions. In 2020, some sites of shallow groundwater layers were contaminated with heavy metals and volatile organic compounds from landfills and waste disposal sites of industries and some industrial estates.

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

1.4.3 Waste Management

Solid waste: In 2020 the amount of solid waste was 25.37 million tons (12% decreased from 2019) (see Figure 1-13). The municipal solid waste was sorted at the sources and recycled as 8.36 million tons (33% decreased from 2019), were properly disposed of as 9.13 million tons (7% decreased from 2019) and improperly disposed of as 7.88 million tons (24% increased from 2019). The top five clean cities in 2020 were Bangkok, Phuket, Lamphun, Rayong, and Nonthaburi, respectively. In 2020 the amount of municipal solid waste in Bangkok and its vicinity and some Local Administration Organizations was reduced, partly due to the COVID-19 pandemic. However, the "Work from Home" measure led to the increased amount of Single-Use plastic, especially in urban areas, due to product and food purchase services via an online system.

The amount of plastic waste generated during the pandemic was approximately 6,300 tons per day, which was a 15% increase from the normal period of approximately 5,500 tons per day. Since 1 January 2020, Thailand has implemented "Everyday Say No to Plastic Bags" policy with the announcement
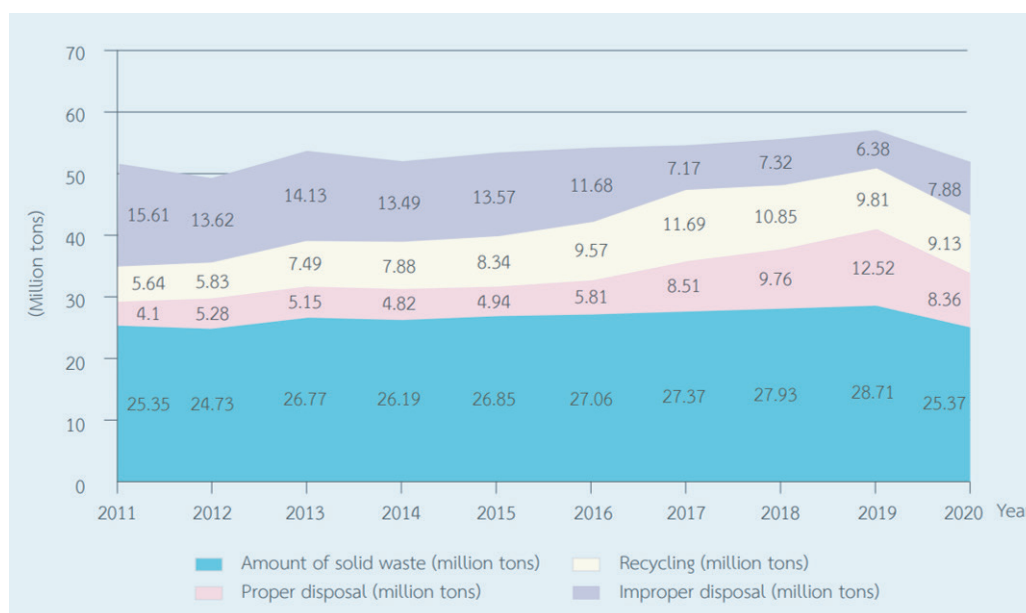
Figure 1-13: The amount of solid waste generated, the recycling, proper and improper disposal for the year 2011-2020

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

Household hazardous waste: In 2020, household hazardous waste was approximately 658,651 tons (an increase of 1.6% from 2019). Most of them were wastes from electrical and electronic equipment, with 428,113 tons (65%). Other types of hazardous wastes were batteries, dry cell batteries, chemical containers, and aerosol spray cans with 230,538 tons (35%). From the government policies on supporting the household hazardous waste management system, Local Administration Organizations and related organizations had to provide the collection points of household hazardous wastes in the community and their collection centers at provincial levels. As a result, the household hazardous wastes were managed properly 121,695 tons (18.48% of generated household hazardous wastes), which increased from the previous year but is still an insignificant proportion. The mismanagement of household hazardous waste is caused by the lack of awareness, non-separation of hazardous wastes from general wastes, no regulations to enforce household

hazardous wastes management, and no law to oversee the management of wastes from electric and electronic equipment.

Infectious Waste: In 2020, the amount of infectious waste was 47,962 tons (10% decreased from 2019). However, in 2021, the amount of infectious waste increased to 90,009.23 tons (87% increased from 2020) caused by hospitals under the Ministry of Public Health, hospitals under the Department of Academic Affairs under the Ministry of Public Health, Sub-district Health promotion hospital, hospitals affiliated with other ministries, private hospital, private clinic, animal hospital, dangerous infection laboratories and other sources of COVID-19 infected wastes such as field hospitals, state quarantine facilities, community isolation, and home isolation. The infected waste of 81,774.67 tons, 90.85% of total infected waste, was properly disposed.

Source: 1) Thailand State of Pollution Report 2020, Pollution Control Department 2) Department of Health

1.5 State of National Economic and Social Development

1.5.1 Development Objectives and Priorities

Thailand's past development followed the 12th National Economic and Social Development Plan (2017-2021) with its core principles of sustainable development, sufficient economy, and people centered development. The plan adhered to the 20-Year National Strategy Framework (2017-2036) and commitment to the Sustainable Development Goals (SDGs). The 13th National Economic and Social Development Plan (2023-2027) is going to be implemented. Its objective is to transform Thailand into a progressive society with a high-valued and sustainable economy. Five key targets are prioritized: 1) transforming the production structure toward innovation to enhance competition capacity in production and service sectors and respond to modern environmental-friendly technology development; 2) equipping Thai people with skills and capacities adjusting to the modern world norms and market; 3) reducing poverty and inequality gaps by providing opportunities for business competition, enabling social mobility for vulnerable and underprivileged groups, and providing impartial and high-quality public service; 4) moving toward sustainable production and consumption aligning with the absorptive level of the ecosystem and mitigating climate change impacts by reaching carbon neutrality; 5) building Thailand's capacity to handle risk and change in the modern world context such as climate change impacts, pandemics, and cyber threats.

Source: 12th National Economic and Social Development Plan (2017-2021) and draft 13th National Economic and Social Development Plan (2023-2027), Office of the National Economic and Social Development Council

1.5.2 Profile and Outlook

Economic Profile and Outlook

Thailand has a mixed economic system, consisting of resource-based, service-based, and industrial-based economic activities. In 2021, the Thai economy grew by 1.6%, recovering from a decline of 6.2% in 2020 (see Table 1-5). GDP value at current prices was 505.6 billion USD. GDP per capita was 7,255.5 USD per person. For economic stability, the headline inflation was at 1.2%, and the current account registered a deficit of 2.2% of GDP. On the production side, agriculture, forestry production, fishery, manufacturing, and wholesale and retail trade sectors grew by 1.4%, 4.9%, and 1.7%, respectively. On the other hand, the accommodation and food services sector and transport and storage services sector declined by 14.4% and 2.9%, respectively. On the expenditure side, the export of goods, private consumption, and investments expanded by 18.8%, 0.3%, and 3.4 %, respectively. Export value was recorded at 70.5 billion USD, significantly increasing by 21.3%, continuing from the previous 15.7%. The export volume and price indices expanded by 16.8% and 3.8%, respectively.

The Thai economy in 2022 is projected to expand in the range of 3.5 – 4.5%, supported by; (i) the regaining in domestic demand; (ii) the recovery of domestic tourism; (iii) the continual expansion of the export of goods; and (iv) the support from public investment. The export value of goods in US dollar terms is anticipated to expand by 4.9 %. Meanwhile, private consumption expenditure and private investment are expected to increase by 4.5% and 3.8%, respectively. Public investment is projected to increase by 4.6%. Headline inflation is estimated to be in the range of 1.5 – 2.5%, and the current account is projected to record a surplus of 1.5 % of GDP

Table 1 5: Thailand's economic projection, 2022

Indicators	Historical data			Projection for 2022
	2019	2020	2021	2022
Growth in real GDP (CVM, %)	2.2	-6.2	1.6	3.5-4.5
Investment (CVM, %)	2.0	-4.8	3.4	4.0
• Private	2.6	-8.2	3.2	3.8
• Public	0.1	5.1	3.8	4.6
Private Consumption	4.0	-1.0	0.3	4.5
Government Consumption	1.6	1.4	3.2	-0.2
Export of Goods	-3.0	-19.7	10.4	8.9
Volume	-3.7	-5.8	15.0	3.9
Import of Goods	-5.2	-14.4	17.9	4.0
Volume	-5.8	-10.5	18.3	4.4
Current Account to GDP (%)	7.0	4.2	-2.2	1.5
Inflation (%)	1.0	-1.3	1.9	1.2-2.2

Source: NESDC Report on Economic and Social Profile and Outlook 2019-2021, Office of the National Economic and Social Development Council

Social Profile and Outlook

National Economic and Social Development Council analyzed five key social indicators for assessing Thailand's social situation and movement employment, household debt, health and illness, the safety of life and property, and consumer protection. The 2021 report reveals that measures to control the spread of COVID-19 had a significant impact on the labor market. As a result, the number of unemployed persons and the unemployment rate reached their highest levels in the third quarter of 2021 but began to recover in the fourth quarter of 2021. Prime issues to be followed include the implementation of economic measures supporting an economic recovery while containing the outbreak, the significant increase of the informal workforce, the increased cost of living, and the promotion of skill development and modification in response to enterprise and local needs.

Source: NESDC Report on Economic and Social Profile and Outlook 2019-2021, Office of the National Economic and Social Development Council

1.5.3 Agricultural Sector

In 2021, total agricultural production increased by 1.4%, recovering from a decline of 3.5% in 2020. The agricultural sector is highly vulnerable to climate change impacts causing temperature rise and rainfall fluctuation. Thus, Thailand aims to strengthen sustainable farming and agricultural management, employing both mitigation and adaptation measures to increase resilience, minimize economic-environment loss, and secure sufficient food production for the increased population growth and quality of life. These goals are aligned with SDG 2—End hunger, achieve food security and improved nutrition, and promote sustainable agriculture. Thailand's primary achievements include:

• Food poverty reduction: Thailand has reduced the number of people living in food poverty. This is in line with Thailand's improved standing in the World Food Security Index and the overall reduction in the number of people per capita who have been unable to access sufficient food in the last 3-5 years. Moreover, Thais have enjoyed greater access to food, in 2019, the number of those under the food poverty line was 0.37%, a reduction from 0.54% in 2016.

Furthermore, Thailand's ranking in the Global Food Security Index (GFSI) has improved, with an average score of 65.1 out of 100 in 2019, compared to 58.3 in 2017 and 58.9 in 2018.

• Increasing agricultural productivity: Thailand has experienced substantial progress in increasing the value of productivity per labor unit and the gross income of small-scale agricultural producers. In 2019, the gross agricultural product was valued at 21.68 billion USD, compared to 17.25 billion USD in 2016. Employment in the agricultural sector increased from 12.57 million people in 2016 to 12.69 million people in 2019.

• Increasing sustainable agriculture: Thailand has increased the amount of sustainable agricultural land in the past 3-4 years, with increased investment in the sector from the Government. This aims to support mixed agriculture, New Theory Agriculture, organic

Source: 1) Thailand's Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development 2021, Ministry of Foreign Affairs 2) NESDC Report on Economic and Social Profile and Outlook 2019-2021, Office of the National Economic and Social Development Council

1.5.4 Tourism Sector

Tourism has always been a significant part of Thailand's economic growth, generating 20-22% of GDP. In 2019, though affected by global economic stagnation, the number of tourist visitors slightly increased by 1.36% (307,141,990 persons). The annual revenue from the tourism sector increased by 1.10% (87,863 million USD) from the previous year. The expansion was partly supported by the Government's continual measures to promote the tourism sector.

However, this sector suffered from a drastic decline in 2020 due to the COVID-19 pandemic and a nationwide lock-down measure, resulting in decreased tourists by 54.72% (139,067,291 persons) and a revenue of 69.85% (26,284.25 million USD). In 2021, the situation began to improve in the fourth quarter because of the subsided domestic outbreak situation, the relaxation of control

measures, the progress on vaccine distribution, and the domestic traveling stimulus scheme. The number of foreign tourists increased from the low base last year, owing to the implementation of the Test and Go program for international visitors and the easing of international travel restrictions in tourist-origin countries.

In contrast with the economic decline during the pandemic, Thailand's natural resources and ecosystems have recovered from degrading conditions caused by intensive tourism-related activities and swarming tourists in major ecological visiting sights exceeding the environment's carrying capacity. Particularly in the coastal and marine areas, the study shows that seawater condition has improved, and coral bleaching has decreased. Keystone species indicating the abundance of marine ecosystems have also increased, such as Irrawaddy dolphins (Orcaella brevirostris), leatherback sea turtle (Dermochelys coriacea), sea cows (Dugong dugon), false killer whales (Pseudorca crassidens), and blacktip reef sharks (Carcharhinus melanopterus). Similarly, after the natural parks were closed with no tourism activities, plant species flourished, and rarely appeared animal species were frequently detected.

With the lesson learned from the pandemic and aligning with SDG8—Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all—Thailand seeks to strengthen sustainable tourism and enhance diverse socio-cultural identities as cultures, traditions, and community livelihood. Thailand aims for quality and green tourism, environmental-friendly tourism that enhances natural conservation and sustainable exploitation of natural resources.

Sources: 1) NESDC Report on Economic and Social Profile and Outlook 2019-2021, Office of the National Economic and Social Development Council 2) Analysis Report on Thailand Tourism 2019-2021, Department of Tourism 3) Thailand's Voluntary National Review

1.5.5 Health

Since 2020, Thailand has suffered from the COVID-19 epidemic. In contrast, the NESDC report shows a general decline of 67.9% across all other diseases. Surveillance diseases (i.e., Measles, Meningococcal Fever, Encephalitis, Cholera, Hands, Feet, and Mouth, Dysentery, Pneumonia, Leptospirosis, Dengue Fever, Influenza, and Rabies) decreased by 54.5% from 2020. The most significant fall was the Hands, Feet, and Mouth disease, with a drop of more than 95.8%. The decline in other diseases was due to social distancing measures.

To cope with and adapt to climate change's impacts on health, the Department of Health (DOH) initiates Health National Adaptation Plan (HNAP), Phase 1 (2021 – 2030). The objective is to reduce illness, lessen health impacts, and become a center for health and climate change in Asia. HNAP focuses on four strategies: strengthening the community and their skills in adaptation and health literacy to cope with health risks from climate change; integrating the resources to drive public health implementation of climate change proficiently; strengthening public health preparedness for climate change to support economic and social development and security; developing the national public health

system in response to climate change. The DOH develops monitoring standard and publication on health risks from the heat wave with the support from WHO Thailand. In 2022 the health care system is strengthened to reach the standard of "Green and Clean Hospital" and "Low Carbon and Resilient Smart Health Care." Thailand has also made progress with Sustainable Development Goal 3 (SDG3) – Ensure healthy lives and promote well-being for all at all ages. Lesson learned from the COVID-19 pandemic: The Ministry of Public Health strengthens the readiness and capacity of health service systems to monitor and evaluate the situation and infection risk and provide early warning and control transmissions through sufficient diagnostic and investigation tracking and quarantine systems.

1.5.6 Poverty and Inequality

Poverty

Thailand's poverty line increased from 79.14 USD per person per month in 2017 to 88.25 USD per person per month in 2020 (see Figure 1-14). The strict measures to control the outbreak of COVID-19 have led to an economic contraction. The number of poor people in 2020 totaled 4.8 million, representing a poverty rate of 6.84%, increasing from 6.24% in 2019.
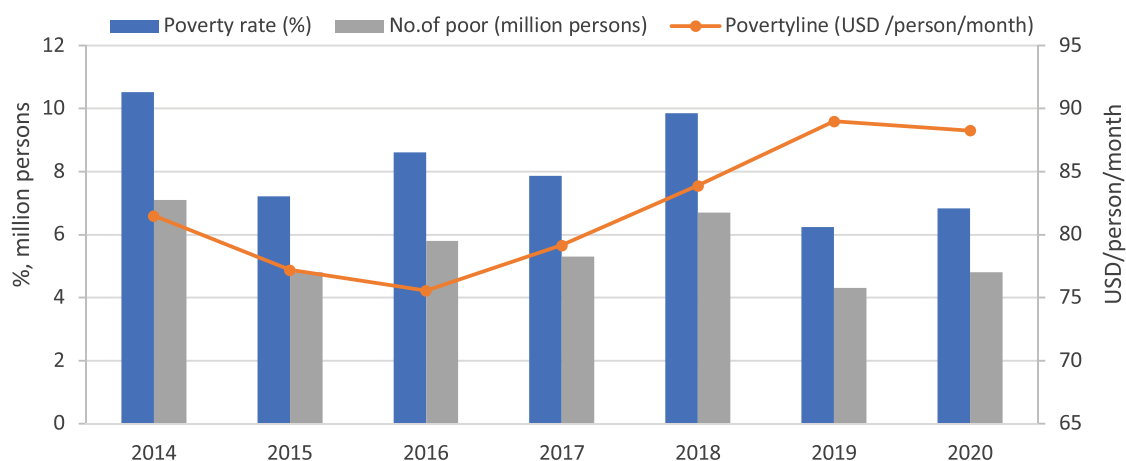
Figure 1-14: Poverty line, poverty rate and number of poor: 2014-2020

Source: Office of the National Economic and Social Development Council

Inequality

In 2020, inequality slightly increased from the previous year. The Gini coefficient on consumption expenditure in 2020 was 0.350, up from 0.348 in 2019 (see Figure 1-15). As the Government maintains an average income of 430.51 USD per person per year or about 35.88 USD per month, low-income earners can temporarily maintain their living costs.
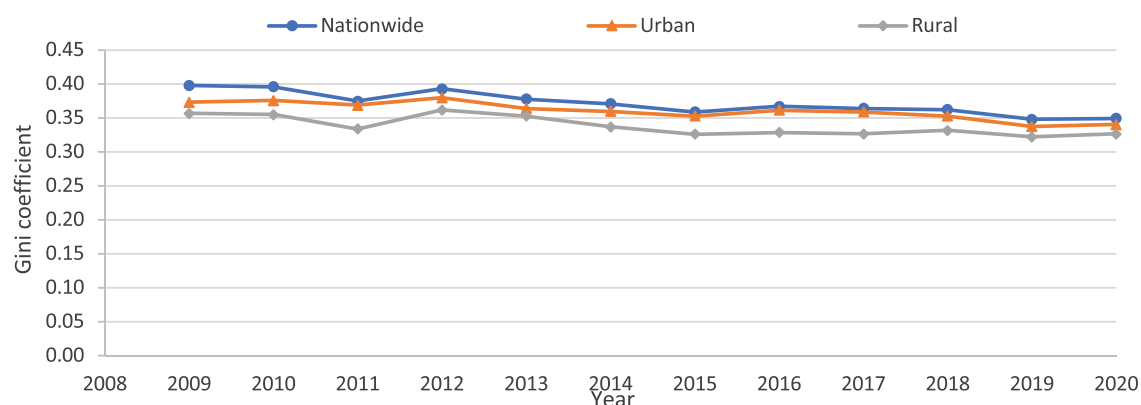
Figure 1-15: Gini coefficient in Thailand, showing urban, rural, and national levels: 2009-2020

Remark: The Gini coefficient is a tool for measuring inequality, where the value is between 0 and 1. The closer the value is to 1, the greater the income inequality.

Source: Office of the National Economic and Social Development Council

Although poverty and inequality did not drastically increase, the problem of poverty and inequality is still an issue that needs to be realized and given importance. In the case of poverty, it is estimated that without assistance, the number of poor people in 2020 will be 11.02 million, representing 15.9 % of the country's population, meaning that there will be six million more poor people.

Thailand has made progress with SDG1 – End poverty in all its forms everywhere and SDG 10—Reduce inequalities within and among countries, with the following improvements:

• Worker's vulnerability reduction: Thailand amended relevant legislation to provide increased benefits and rights to assistance for social protection covering workers in the informal sector, self-employed persons, agricultural producers, informal sellers, and freelance workers.

• Social welfare: In 2019, 46.05% of all persons eligible were given a state welfare card to support consumption costs for low-income groups, including transport costs, rent, and household internet costs. In 2018, 84.5% of children from poor backgrounds and disabled persons received financial assistance. In 2019, 81.7% of elderly persons received state financial assistance.

• Multi-Dimension Poverty Index (MPI): The MPI for Thailand which covers education, healthy lifestyle, quality of life, and financial security in 2019 was 0.051, improved from 0.068 in 2017.

Source: 1) Poverty and Inequality Report 2020, Office of the National Economic and Social Development Council 2) Thailand's Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development 2021, Ministry of Foreign Affairs

1.5.7 Gender Equality

Gender equality is a fundamental human right and a necessary foundation for a peaceful, prosperous, and sustainable world, according to the UN Sustainable Development Goals (SDG 5). Thailand has performed well in SDG achievements. In July 2019, the Sustainable Development Solutions Network (SDSN) and Bertelsmann Stiftung Foundation placed Thailand as the top country among ASEAN members for its overall SDG achievements and the 40th rank in the world. The Gender Equality Act was passed in 2015 after a legislative process that included a comprehensive consultative process between officials from the

Department of Women's Affairs and Family Development, women's civil society organizations, and LGBTI civil society organizations before the National Legislative Assembly approved it. It is currently the most robust legal instrument advocating for legal gender recognition in Thailand. This law intends to protect people from unjust discrimination and provide access to legal processes equally whether the person is male, female, or a member of a "sexual diversity group." Thailand seeks to integrate the concept of Gender and Social Inclusion (GSI) into the climate change context to ensure equitable benefits to all groups of people, and opportunities to participate in decision-making and implementation at the national, regional, and local levels.

The GSI integration in Thailand is at the initial stage. Notable initiatives can be illustrated as follows:

• The Department of Women's Affairs and Family Development (DWF), as a principal national mechanism for the promotion of gender equality and women's empowerment in Thailand, ONEP, and the Sustainable Development Foundation jointly organize a gender equality course for executive administrators to build capacity for Chief Gender Equality Officers (CGEOs) and Gender Focal Points (GFPs) on a gender approach to climate change adaptation.

• The DWF conducts a study, formulates a report, and holds workshop sessions on GSI integration in climate change mitigation, focusing on the connection between the commitments under the UNFCCC and gender dimensions and Thailand's policies related to climate change and gender. The objective is to provide guidelines and recommendations on climate change implementation equitable for all and social and gender inclusive.

• The Office of Natural Resources and Environmental Policy and Planning (ONEP) and the Office of Agriculture Economics (OAE) has initiated pilot activities to conduct and collaborate on GSI-climate vulnerability and impact assessment on a small scale and to develop an effective model to integrate GSI into

climate-related project formulation, management, and budgeting. These projects were conducted in two provinces, Maha Sarakham and Uthai Thani which are vulnerable to repeated droughts and floods, rely on agriculture as the only source of income, and diverse in terms of demography. The projects aimed to conduct participatory action research and GSI-CC data collection with community engagement and multi-stakeholder consultations. The projects revealed critical challenges in three areas: 1) improve researchers' understanding of GSI perspective to conduct participatory action research and data collection; 2) enhance institutional capacity building to improve government officials' understanding of how GSI relates to climate change impacts and actions; 3) obtain leadership support to mobilize various governmental agencies and key stakeholders.

Source: 1) Policy Brief: Gender Responsive and Socially Inclusive Public Climate Finance, Office of Natural Resources and Environmental Policy and Planning and UNDP Thailand 2) Legal Gender Recognition in Thailand a Legal and Policy Review 2018, Office of the National and Social Development Council and UNDP Thailand 3) Training Module on Gender and Climate Change: Overview of linkages between gender and climate change, UNDP 4) Department of Women's Affairs and Family Development

1.6 Institutional Arrangement

1.6.1 National Committee on Climate Change Policy (NCCC)

Thailand's National Committee on Climate Change Policy (NCCC) is chaired by the Prime Minister and has members from both the public and private sectors, including experts from relevant agencies (see Figure 1-16). The NCCC has the mandate to define national climate policies and establish guidelines and mechanisms for international collaboration regarding conventions and protocols on climate change, including supporting and evaluating domestic relevant agencies to be in accordance with the national established policies and plans.

The NCCC is composed of seven subcommittees: 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 5) Subcommittee on Climate Law, 6) The Subcommittee on the Mobilization of GHG Mitigation with Carbon Sequestration in LULUCF Sector, and 7) The Subcommittee on the Mobilization of GHG Mitigation with CCUS Technology Implication.

National Committee on Climate Change Policy (NCCC)	
Chairperson	Prime Minister
1st Vice Chairperson	Minister of Natural Resources and Environment
2nd Vice Chairperson	Minister of Foreign Affairs

Committee members:

Permanent Secretary of;

1. Prime Minister's Office	12. Ministry of Public Health
2. Ministry of Finance	13. Ministry of Industry
3. Ministry of Foreign Affairs	14. Ministry of Agriculture and Cooperatives
4. Ministry of Tourism and Sports	15. Ministry of Higher Education, Science, Research, and Innovation
5. Ministry of Transport	16. Bangkok Metropolitan Administration
6. Ministry of Digital Economy and Society	17. Office of the National Economic and Social Development Council
7. Ministry of Energy	18. Office of the National Water Resources
8. Ministry of Commerce	19. Bureau of Budget
9. Ministry of Interior	20. 5-9 Experts on law, economics, environment, science and technology, energy, or climate change
10. Ministry of Labor	
11. Ministry of Education	21. One expert from the private sector

Secretariat: Permanent Secretary, MONRE

Assistant secretary: Secretary-General of ONEP

Assistant secretary: Director of Thailand Greenhouse Gas Management Organization (TGO)

Subcommittee on Climate Change Policy and Planning Integration	Subcommittee on Climate Change Knowledge and Database	Subcommittee on Climate Change Negotiation and International Cooperation	Subcommittee on Action for Climate Empowerments and Public Relations	Subcommittee on Climate Law	Subcommittee on the Mobilization of GHG Mitigation with Carbon Sequestration in LULUCF Sector	Subcommittee on the Mobilization of GHG Mitigation with CCUS Technology Implication
Working Group on GHG Mitigation Policy and Planning	Working Group on GHG Inventory and Mitigation Measures	Working Group on Climate Change Convention Conference and Negotiation				
Working Group on National Climate Change Adaptation Implementation Integration	Working Group on Climate Change Data and Modeling					
Ad-Hoc Working Group on REDD-Plus						

Figure 1 16: Structure of the National Committee on Climate Change Policy

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

The Subcommittee on Climate Change Policy and Planning Integration is responsible for providing input on policy integration, strategy, and planning linked with climate mitigation and adaptation; providing suggestions on mechanisms and measures, such legal regulations, and financial measures; and pushing forward an integrated budget allocation system on climate change. Recently, three working groups were assembled within the subcommittee: 1) Working Group on GHG Mitigation Policy and Planning to provide comments on and recommendations for making and integrating mitigation policy, strategy, and plans, aligning with national targets, and mobilizing and advancing GHG mitigation actions to achieve the targets; 2) Working Group on National Climate Change Adaptation Implementation Integration to provide comments on and recommendations for forming national adaptation plan and supporting the integration of the adaptation plan into sectoral plans in all areas; 3) Ad-Hoc Working Group on REDD-Plus to form a strategy, action plan, and implementation

measures on climate actions in the forest sector and REDD-Plus and to establish mitigation and carbon storage targets for the forest sector in Thailand.

The Subcommittee on Climate Change Knowledge and Database is responsible for providing comments on the country report under the agreement of UNFCCC; supporting the development of the GHG inventory; providing suggestions on the development of databases and climate change knowledge in the areas of mitigation, adaptation, and Measurement, Reporting and Verification (MRV) systems. Recently, two working groups were assembled within the subcommittee: 1) Working Group on GHG Inventory and Mitigation Measures to provide recommendations on the data used for the preparation of GHG inventory in each sector, MRV direction, and assessment of GHG reduction from the mitigation measures; 2) Working Group on Climate Change Data and Modeling to build networks for collecting, sharing, processing, and analyzing data and mobilizing and coordinating the operation relating to climate change data and modeling.

The Subcommittee on Climate Change Negotiation and International Cooperation is responsible for providing recommendations on Thailand's positions for negotiations on climate change under multilateral agreements and other international frameworks; preparing and developing knowledge and data concerning international negotiations on climate change; providing guidance in international aspects of climate change implementation and the composition of Thailand's delegation for international negotiation on climate change. The Working Group on Climate Change Convention Conference and Negotiation was recently assembled to analyze, suggest, and prepare

detailed information for the negotiation and conference under UNFCCC.

The Subcommittee on Action for Climate Empowerments and Public Relations is responsible for publicizing news and knowledge on the causes, impacts, and solutions related to climate change under the Paris Agreement, Thailand's NDC targets, and the SDGs.
This committee also promotes and supports activities related to climate change by conducting training, raising awareness, and implementing capacity building across all sectors.

The Subcommittee on Climate Law is responsible for providing comments on policies for the development, improvement, cancellation, or amendment of laws related to climate change according to the NCCC; arranging and proposing draft laws, rules, regulations, or notifications; provide legal opinions on tackling issues related to climate change; and finally, to provide advice on the enforcement of laws related to national climate change.

The Subcommittee on the Mobilization of GHG Mitigation with Carbon Sequestration in LULUCF Sector is responsible for providing suggestions and recommendations on guidelines, mechanisms, and measures supporting reforestation and conservation and expansion of green areas for public and private stakeholders to push forward long-term strategy for GHG removal. The subcommittee has the Minister of Natural Resources and Environment as the president and consists of representatives from public and private sectors such as the Office of the National Land Policy Board (ONLB), Land Development Department (LDD), Department of Lands, Royal Forest Department (RFD),

Department of Natural Parks, Wildlife and Plant Conservation (DNP), Thai Banker's Association (TBA), and Bank for Agriculture and Agriculture Cooperatives (BAAC).

The Subcommittee on the Mobilization of GHG Mitigation with CCUS Technology

Implication is responsible for providing suggestions and recommendations on GHG mitigating capacity of Carbon Capture and Storage technology and carbon storage and utilization. The subcommittee also has the authority to suggest mechanisms or measures (e.g., legal, economic, and other related measures) for incentivizing, developing, and applying such technology. The subcommittee has the Minister of Energy as the president and consists of representatives from public and private sectors such as the Department of Alternative Energy Development and Efficiency (DEDE), Department of Mineral Resources (DMR), Department of Mineral Fuels (DMF), Department of Industrial

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

1.6.2 Institutional Arrangements of National Greenhouse Gas Inventory

Calculations of the national GHG inventory to report in the Fourth National Communication (NC4) have been made in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The key components in estimating GHG emissions are activity data and emission factors. Activity data are obtained from the collaboration between ONEP and the lead agencies of the following five sectors.

1) Energy: led by the Energy Policy and Planning Office (EPPO) and the Office of Transport and Traffic Policy and Planning (OTP)

2) IPPU: led by the Department of Industrial Works (DIW)

3) Agriculture: led by the Office of Agricultural Economics (OAE)

4) LULUCF: led by the Department of National Parks, Wildlife and Plant Conservation (DNP)

5) Waste: led by the Pollution Control Department (PCD).

After these lead agencies have collected activity data according to ONEP's required template from relevant agencies responsible for data collection (e.g., agencies under their supervisors, local Government, and the private sector), The GHG emission is calculated by the Thailand Greenhouse Gas Emission Inventory System (TGEIS). Results are interpreted into graphs and tables according to reporting format laid out by UNFCCC. Then, results from TGEIS are submitted to five working groups, comprising appointed representatives of the five sectors outlined above. Each working group then reviews the methodology of the GHG emission estimation as part of quality control (QC) to ensure that GHG emission estimates for their sectors are valid, accurate, and complete. Following this, the GHG inventories of the five sectors are submitted to the Climate Change Knowledge and Database Subcommittee for verification.

Finally, as the Secretariat of the NCCC, ONEP will submit the final GHG inventories as part of the BUR to the NCCC for approval before submission to UNFCCC. For a complete list of the sub-sectoral support agencies under each leading sector. (see Figure 1-17)

The lead agencies and their responsibility in reporting data activity are as follows:

Energy: EPPO and OTP are the two leading agencies responsible for gathering the data from relevant agencies within the Ministry of Energy,

the Ministry of Transport, and others. The activity data used for GHG emissions calculations are derived from fossil fuel/electricity consumption used in different activities.

Industrial Processes and Product Use (IPPU): DIW is the lead agency responsible for gathering the data from relevant agencies within the Ministry of Industry and others. The activity data used for GHG emissions calculations are each industry group's production volume, import volume, and export volume.

Agriculture: OAE is the lead agency responsible for gathering the data from relevant agencies within the Ministry of Agriculture and Cooperatives and others. The activity data used for GHG emissions calculations are derived from livestock farming, rice cultivation, agricultural soils, field burning, and the open burning of agricultural residues.

Land Use, Land-Use Change, and Forestry (LULUCF): DNP is the lead agency responsible for gathering the data from relevant agencies within the Ministry of Natural Resources and Environment (MONRE) and others. The activity data used for GHG emissions calculations are derived from land use, land-use change, and wood product.

Waste: PCD is the lead agency responsible for gathering the data from relevant agencies within the MONRE and others. The activity data used for GHG emissions calculations are derived from sources of waste, waste production rate, waste composition, and wastewater volume, including Emission Factors.

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

Figure 1-17: Structure of Thailand's Greenhouse Gas Inventory process

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

ALRO	= Agricultural Land Reform Office
BMA	= Bangkok Metropolitan Administration
CAAT	= The Civil Aviation Authority of Thailand
DEDE	= Department of Alternative Energy Development and Efficiency
DEQP	= Department of Environmental Quality Promotion
DIW	= Department of Industrial Works
DLD	= Department of Livestock Development
DLA	= Department of Local Administration
DLT	= Department of Land Transport
DMCR	= Department of Marine and Coastal Resources
DMF	= Department of Mineral Fuels
DNP	= Department of National Parks, Wildlife and Plant Conservation
DOA	= Department of Agriculture
DOC	= Department of Customs
DOAE	= Department of Agricultural Extension
DOEB	= Department of Energy Business
DOH	= Department of Health
ED	= The Excise Department
EGAT	= Electricity Generating Authority of Thailand
EPPO	= Energy Policy and Planning Office
ERC	= Energy Regulatory Commission
FIO	= Forest Industry Organization
FTI	= The Federation of Thai Industries

GISTDA	= Geo-Informatics and Space Technology Development Agency
ISIT	= Iron and Steel Institute of Thailand
LDD	= Land Development Department
MD	= Marine Department
MEA	= Metropolitan Electricity Authority
OAE	= Office of Agricultural Economics
OCSB	= Office of the Cane and Sugar Board
OIE	= The Office of Industrial Economics
OTP	= The Office of Transport and Traffic Policy and Planning
PAT	= Port Authority of Thailand
PCD	= Pollution Control Department
PEA	= Provincial Electricity Authority
PONRE	= Provincial Offices of Natural Resources and Environment
PTIT	= Petroleum Institute of Thailand
RAOT	= Rubber Authority of Thailand
RD	= Rice Department
REO	= Regional Environment Office
RID	= Royal Irrigation Department
RFD	= Royal Forest Department
SRT	= State Railway of Thailand
TCMA	= Thai Cement Manufacturers Association
WMA	= Wastewater Management Authority

1.6.3 Institutional Arrangements of Domestic Measurement Reporting and Verification (MRV) System

To monitor the implementation progress of the NAMA Roadmap, Thailand has developed a domestic MRV system, which operates according to the following structure:

National level:

- The Working Group on GHG Inventory and Mitigation Measures is responsible for 1) selecting appropriate measures/policies for monitoring and evaluation (M&E) of GHG emissions reduction, identifying Coefficient/Emission Factors, and implementing MRV processes for activity data, and 2) reviewing and providing feedback on the GHG emissions reduction report.
- Subcommittee on Climate Change Knowledge and Database is responsible for further approval on the pre-approved report submitted from sectoral level.
- The National Committee on Climate Change Policy (NCCC) is responsible for the final approval of the GHG emissions reduction report which will later be included in national reports, the Biennial Update Report (BUR) and National Communication (NC).

Sectoral level:

- The main agency at the sectoral level is responsible for the verification of the following key data and approaches after the finalization by the working groups on GHG inventory and mitigation measures as follows: 1) the appropriate measures/policies for M&E of GHG emissions reduction, 2) the methodology for calculation GHG emissions reduction, 3) MRV process for activity data, and 4) the results and GHG emissions reduction report.

The structure of the domestic MRV system is shown in Figure 1-18.
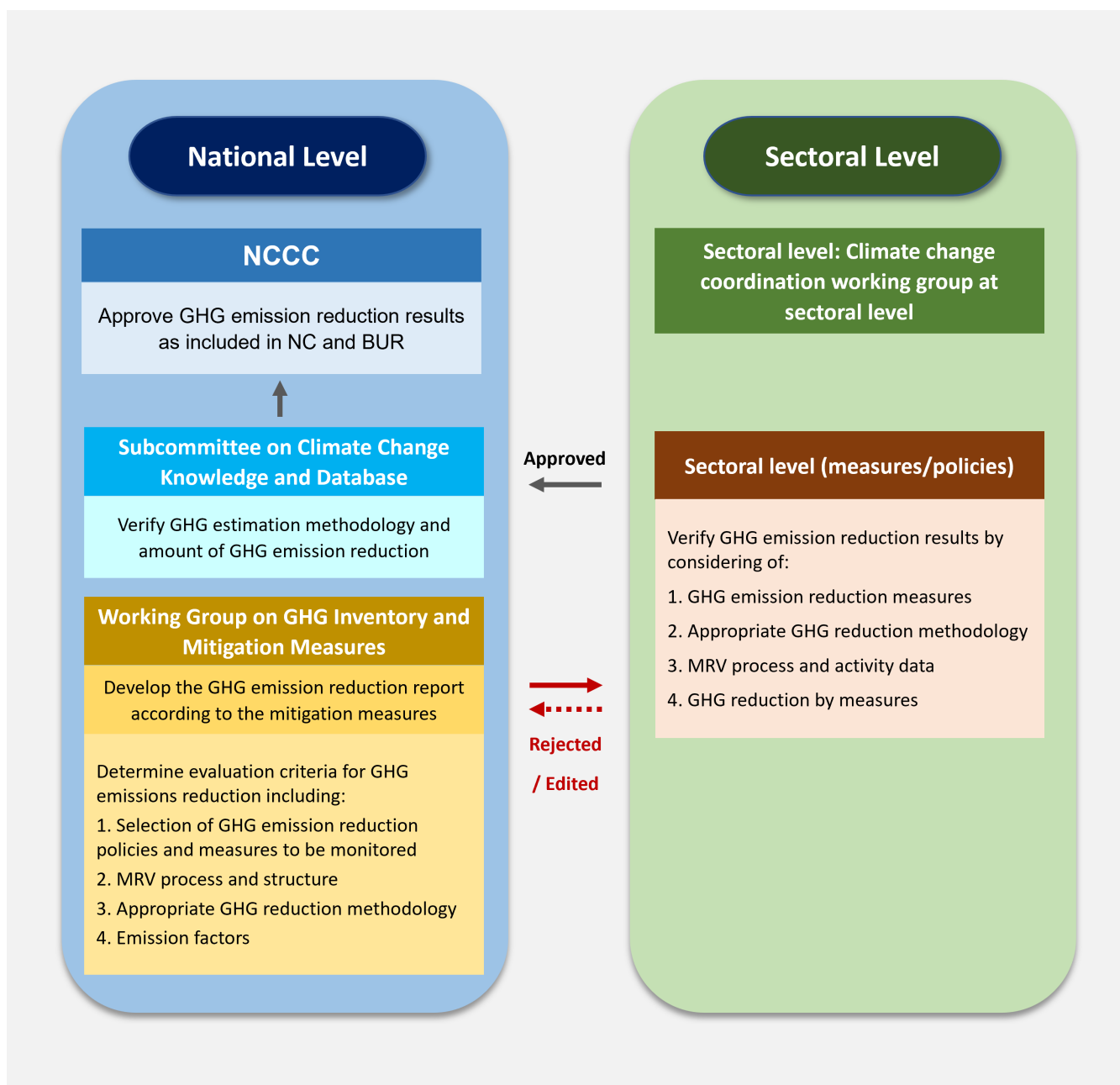
Figure 1-18: The structure of domestic MRV system

CHAPTER 2 :
N A T I O N A L
GREENHOUSE GAS INVENTORY

CO$_2$

HFCs PFCs SF$_6$ NF$_3$

CH$_4$

N$_2$O

CO$_2$
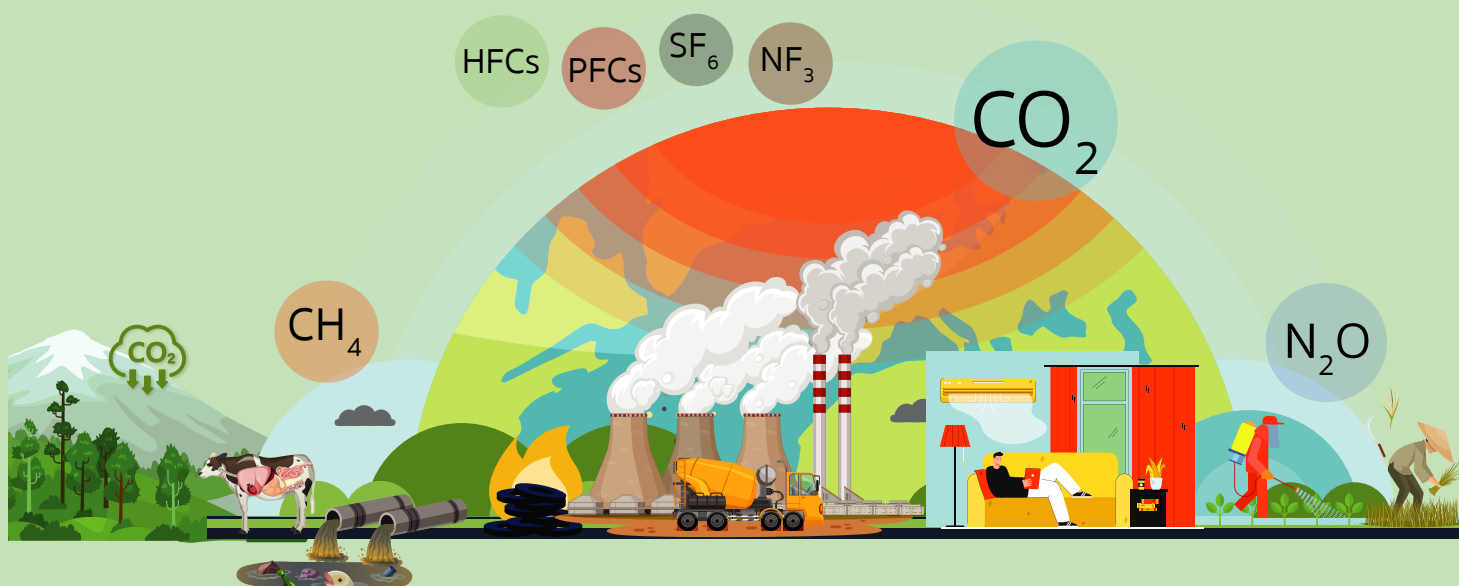
CHAPTER 2 :
NATIONAL
GREENHOUSE GAS INVENTORY

Thailand National Greenhouse Gas Inventory reported in this BUR was prepared using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

In 2019, total GHG emissions (excluding those from LULUCF) were 372,716.86 GgCO$_2$eq and Net GHG emissions were 280,728.34 GgCO$_2$eq (including those from LULUCF). The Energy sector remained the most significant contributor to Thailand's GHG emissions, accounting for 69.96% of the total GHG emissions. The share of emissions from the Agriculture, IPPU, and Waste sectors were 15.23%, 10.28%, and 4.53%, respectively. LULUCF contributed to a net removal of 91,988.52 GgCO$_2$eq.

2.1 Inventory Process in Thailand

2.1.1 Scope of Thailand National Greenhouse Gas Inventory

Thailand's GHG inventory was developed and submitted according to Article 4.1(a) of the Convention that requires a party to develop, periodically update, publish, and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol.

The inventory report was prepared using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. It presents Thailand's national GHG emissions from 2000 to 2019 by sources and removals by sinks. The GHG emissions estimated by Thailand Greenhouse Gas Emission Inventory System (TGEIS) include both direct emissions Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) Hydrofluorocarbons (HFCs) and Sulphur Hexafluoride (SF_6) and indirect emissions Nitrogen Oxides (NOx), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs) and Sulphur Dioxide (SO_2).

2.1.2 Methodology for GHG Emissions and Removals Calculation

Overall, this GHG inventory report has improved on the previous submission. The methodologies and tools used for GHG inventory reporting followed the 2006 IPCC Guidelines, LULUCF Good practice guidance for Land Use, Land-Use Change, and Forestry (referred to as GPG 2003), as well as the IPCC's 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (referred to as GPG 2000).

From Table 2-1 either Tier 1 or Tier 2 methodologies were applied wherever activity data and country-specific emission factors were available. Tier 1 methodologies were employed for all activity data in the Energy sector and almost all in Industrial Processes and Product Use (IPPU) sector. Tier 2 was adopted in most categories under the Agriculture, Land Use, Land-Use Change, and Forestry, and Waste sectors and some categories under the IPPU sector. GHG emissions from the Energy and IPPU sectors were calculated using default emission factors provided in the 2006 IPCC Guidelines. When available, country-specific emission factors were used for some sub-sectors of the LULUCF, Agriculture and Waste sectors.

The Global Warming Potential (GWP), as recommended by the IPCC, was used to convert GHGs other than CO_2 to CO_2eq. The use of GWP was provided by the IPCC in its Fourth Assessment Report (AR4) based on the effects of GHGs over a 100-year time horizon. The values were applied for the five direct GHG gases: CO_2, CH_4, N_2O, HFCs and SF_6. The indirect gases, including NOx, CO, NMVOCs, and SO_2, have been calculated and reported.

Table 2-1: Summary of methods and emission factors

GHG source and sink categories	CO₂		CH₄		N₂O		HFCs		PFCs		SF₆		NOx		CO		NMVOCs		SO₂	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A Energy Combustion Activities	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A1 Energy Industries	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A2 Manufacturing Industries and Construction	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A3 Transport	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A4 Other Sectors	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1B Fugitive emissions from fuel			T1	D																
1B1 Solid Fuels			T1	D																
1B2 Oil and Natural Gas			T1	D																
2. Industrial Processes and Product Use	T1,T2	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
2A Mineral Industry	T1,T2	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
2A1 Cement Production	T1,T2	D																		
2A2 Lime Production	T1	D																		
2A3 Glass Production	T1	D																		
2A4b Other Uses of Soda Ash	T1	D																		
2A4d Other	T1	D			T1	D														
2B Chemical Industry	T1	D	T1	D																
2B2 Nitric Acid Production	T1	D			T1	D														
2B4 Caprolactam Production	T1	D			T1	D														
2B8b Ethylene	T1	D	T1	D																
2B8c Ethylene Dichloride and Vinyl Chloride Monomer	T1	D																		
2B8e Acrylonitrile	T1	D	T1	D																
2B8f Carbon Black	T1	D	T1	D																

Table 2-1: Summary of methods and emission factors

GHG source and sink categories	CO₂		CH₄		N₂O		HFCs		PFCs		SF₆		NOx		CO		NMVOCs		SO₂	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
2C Metal Production	T1	D																		
2C1 Iron and Steel Production	T1	D																		
2D Non-Energy Products from Fuels and Solvent Use	T1	D																		
2D1 Lubricant Use	T1	D																		
2F Product Uses as Substitutes for Ozone Depleting Substances																				
2F1 Refrigeration and Air Conditioning							T1	D												
2G Other Product Manufacture and Use- Industrial Processes																				
2G1 Electrical Equipment											T1	D								
2H Other													T1	D	T1	D	T1	D	T1	D
2H1 Pulp and Paper Industry													T1	D	T1	D	T1	D	T1	D
2H2 Food and Beverages Industry																	T1	D		
3. Agriculture	T1	D	T1,T2	CS,D	T1,T2	D							T1	D	T1	D				
3A Enteric Fermentation			T1,T2	CS,D																
3B Manure Management			T1,T2	CS,D	T2	D														
3C Field Burning of Agriculture Residues			T1	D	T1	D							T1	D	T1	D				
3D Liming	T1	D																		
3E Urea Fertilization	T1	D																		
3F Direct N₂O Emission from Managed Soils					T1	D														
3G Indirect N₂O Emission from Managed Soils					T1	D														
3H Indirect N₂O Emission from Manure Management					T2	D														
3I Rice Cultivation			T2	CS																

Table 2-1: Summary of methods and emission factors

GHG source and sink categories	CO₂ Method applied	CO₂ Emission factor	CH₄ Method applied	CH₄ Emission factor	N₂O Method applied	N₂O Emission factor	HFCs Method applied	HFCs Emission factor	PFCs Method applied	PFCs Emission factor	SF₆ Method applied	SF₆ Emission factor	NOx Method applied	NOx Emission factor	CO Method applied	CO Emission factor	NMVOCs Method applied	NMVOCs Emission factor	SO₂ Method applied	SO₂ Emission factor
4. Land Use, Land-Use Change and Forestry	T1,T2	CS,D	T1,T2	CS,D	T1,T2	CS,D							T1,T2	CS,D	T1,T2	CS,D				
4A Forest Land Remaining Forest Land	T1,T2	CS,D																		
4B Cropland Remaining Cropland	T1,T2	CS,D																		
4C Land Converted to Cropland	T1,T2	CS,D																		
4D Land Converted to other land	T1,T2	CS,D																		
4E Biomass Burning			T1,T2	CS,D	T1,T2	CS,D							T1,T2	CS,D	T1,T2	CS,D				
5. Waste	T1	D	T1,T2	CS,D	T1	D														
5A Solid Waste Disposal			T2	CS,D																
5B Biological Treatment of Solid Waste			T1	D	T1	D														
5C Incineration and Open Burning of Waste	T1	D	T1	D	T1	D														
5D Wastewater Treatment and Discharge			T1	D	T1	D														

Note:
T1 = Tier 1
T2 = Tier 2
CS = Country specific D = IPCC default

2.1.3 Uncertainty Analysis

The inventories are prepared in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Thus, they typically contain a wide range of emission calculations. Results of the uncertainty analysis of the data showed that the uncertainties of Thailand's national GHG inventory when including data on LULUCF for 2000 and 2019 are approximately 9.36% and 19.08%, respectively. When the LULUCF was excluded from the analysis, uncertainties are 3.67% for 2000 and 7.28% for 2019.

Table 2-2: Uncertainties of the Thailand's national GHG inventory

Unit: %

Trend uncertainty	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Included LULUCF	9.36	9.72	10.60	11.21	12.28	14.77	14.05	14.32	14.99	15.34
Excluded LULUCF	3.67	3.83	4.18	4.45	4.94	5.24	5.31	5.50	5.88	5.75

Trend uncertainty	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Included LULUCF	16.14	16.41	17.58	18.51	19.78	19.56	19.48	19.98	19.53	19.08
Excluded LULUCF	5.69	5.75	6.20	6.26	6.53	6.70	7.41	7.58	7.32	7.28

2.1.4 Key Category Analysis

Key category analysis (KCA) presents the importance of emission sources and sinks. The 'Key categories' are defined as the emission sources and sinks that constitute 95% of total annual emissions when ranked from the greatest to the lowest contribution. A 'key source' has a significant influence on the national inventory of direct GHG emissions in terms of the absolute emissions level. The KCA reported in this inventory follows the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and is estimated for both level and trend assessments. The results of the 2019 level assessment are presented in Table 2-3, and those of the 2019 trend assessment are available in Table 2-4. There are 17 key categories in the level assessment, among which main activity electricity and heat production led the KCA, followed by cropland remaining cropland, road transportation, manufacturing industries and construction, and rice cultivation. Results of the KCA changed under trend assessment, where cropland remaining cropland, land converted to cropland led the KCA, followed by forest land remaining forest land, main activity electricity and heat production, and rice cultivation.

Table 2-3: Key category analysis for the year 2019: Approach 1 – Level assessment

Category code	IPCC source category	GHG	Base year estimate 2000 (GgCO$_2$eq)	Current year estimate 2019 (GgCO$_2$eq)	Lx,t	Cumulative total of Level assessment
1A1a	Main Activity Electricity and Heat Production	CO$_2$	58,182.12	92,990.34	0.19	0.19
4B	Cropland Remaining Cropland	CO$_2$	36,665.42	75,858.62	0.16	0.35
1A3b	Road Transportation	CO$_2$	45,479.14	71,927.21	0.15	0.50
1A2	Manufacturing Industries and Construction	CO$_2$	31,940.86	52,228.44	0.11	0.61
3I	Rice Cultivation	CH$_4$	26,553.26	28,714.75	0.06	0.66
4A	Forest Land Remaining Forest Land	CO$_2$	34,311.02	25,763.10	0.05	0.72
2A1	Cement Production	CO$_2$	14,630.20	18,465.04	0.04	0.76
1A4	Other Sectors	CO$_2$	11,044.67	15,093.85	0.03	0.79
2B8	Petrochemical and Carbon Black Production	CO$_2$	5,089.85	12,365.00	0.03	0.81
3A	Enteric Fermentation	CH$_4$	9,386.19	10,765.80	0.02	0.84
1B2	Oil and Natural Gas	CH$_4$	6,186.22	9,964.21	0.02	0.86
4C	Land Converted to Cropland	CO$_2$	23,236.24	9,506.26	0.02	0.88
1A1b	Petroleum Refining	CO$_2$	6,897.35	9,451.75	0.02	0.89
5A	Solid Waste Disposal	CH$_4$	3,447.59	8,343.31	0.02	0.91
3F	Direct N$_2$O Emission from Managed Soils	N$_2$O	6,285.53	8,060.47	0.02	0.93
5D	Wastewater Treatment and Discharge	CH$_4$	6,408.21	7,494.22	0.02	0.94
3G	Indirect N$_2$O Emission from Managed Soils	N$_2$O	2,379.55	3,049.71	0.01	0.95

Table 2-4: Key category analysis for the year 2019: Approach 2 – Trend assessment

Category code	IPCC source category	GHG	Base year estimate 2000 (GgCO₂eq)	Current year estimate 2019 (GgCO₂eq)	Tx,t	% Contribution to trend	Cumulative total of % Contribution to trend
4B	Cropland Remaining Cropland	CO_2	36,665.42	75,858.62	0.07	17.76	17.76
4C	Land Converted to Cropland	CO_2	23,236.24	9,506.26	0.07	17.26	35.02
4A	Forest Land Remaining Forest Land	CO_2	34,311.02	25,793.10	0.07	16.79	51.81
1A1a	Main Activity Electricity and Heat Production	CO_2	58,182.12	92,990.34	0.03	7.94	59.75
3I	Rice Cultivation	CH_4	26,553.26	28,714.75	0.03	6.52	66.27
1A3b	Road Transportation	CO_2	45,479.14	71,927.21	0.02	5.65	71.92
1A2	Manufacturing Industries and Construction	CO_2	31,940.86	52,228.44	0.02	5.23	77.15
2B8	Petrochemical and Carbon Black Production	CO_2	5,089.85	12,365.00	0.02	3.82	80.97
5A	Solid Waste Disposal	CH_4	3,447.59	8,343.31	0.01	2.57	83.54
3A	Enteric Fermentation	CH_4	9,386.19	10,765.80	0.01	1.85	85.39
2F1	Refrigeration and Air Conditioning	HFC-125	0.70	2,377.64	0.01	1.76	87.14
2A1	Cement Production	CO_2	14,630.20	18,465.04	0.01	1.64	88.78
4E2	Biomass Burning (Cropland)	CH_4	1,408.27	4.95	0.01	1.47	90.25
5D	Wastewater Treatment and Discharge	CH_4	6,408.21	7,494.22	0.00	1.16	91.41
2F1	Refrigeration and Air Conditioning	HFC-134a	42.49	1,324.24	0.00	0.93	92.34
1B2	Oil and Natural Gas	CH_4	6,186.22	9,964.21	0.00	0.90	93.24
1A3a	Civil Aviation	CO_2	948.90	2,482.62	0.00	0.84	94.09
3F	Direct N₂O Emission from Managed Soils	N_2O	6,285.53	8,060.47	0.00	0.61	94.70
4E2	Biomass Burning (Cropland)	N_2O	493.72	1.74	0.00	0.51	95.21

2.1.5 Time Series Consistency

Activity data for each source category presented in this inventory was based on the same sources as the national statistics for all years (2000-2019). The same emission factors were also used, in line with the 2006 IPCC Guidelines. Thus, this inventory allows for consistent comparison of data points across time, with good confidence in the emission trends.

2.1.6 Quality Assurance and Quality Control

As dictated by the 2006 IPCC Guidelines, quality control (QC) and quality assurance (QA) procedures were implemented during the preparation of this inventory. In addition, Thailand has utilized its own national system for quality control of data collection among ministerial agencies (Chapter 1, Figure 1-17). Data was controlled at each stage of the data collection process by each respective institute and further underwent a final quality assurance process conducted by the lead agency for each sector.

To fulfill transparency, accuracy, comparability, consistency, and completeness of national GHG inventory, the Energy, IPPU, Agriculture, and Waste sectors have developed and implemented the Quality Control (QC) procedure for verifying activity data (AD) and activity data factor (ADF) in the recent Thailand's GHG inventory system. The developed QC procedure followed the recommendations from the 2006 IPCC Guidelines and was modified with relevant agencies' suggestions. The QC-AD list consists of 1) completeness of data,

2) data fluctuation based on historical data, 3) availability of data for entire time series, 4) comparable information from other sources, and 5) correction of data structure. The QC-ADF list contains 1) check an applicable value as recommended in IPCC 2006 Guidelines and 2) refer to international and/or national references. The QC templates, simply operated on MS Excel, are used to support the relevant agencies for inspecting the activity data.

2.1.7 Completeness Assessment

A completeness assessment of the inventory was conducted within each source category, following the 2006 IPCC Guidelines. Results of the assessment for the Energy, IPPU, Agriculture, LULUCF, and Waste sectors are presented in Table 2-5. The following notation keys are used in the assessment.

- NA   Not Applicable
- NO   Not Occurring
- NE   Not Estimated
- EE   Estimated Elsewhere

Table 2-5: National greenhouse gas inventory of Thailand, 2019

Greenhouse gas source and sink categories	CO$_2$ emissions	CO$_2$ removals	CH$_4$	N$_2$O	HFCs	PFCs	SF$_6$	NOx	CO	NMVOCs	SO$_2$
Unit	GgCO$_2$eq	GgCO$_2$eq	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
Total national emissions and removals	**329,891.41**	**-142,872.88**	**2,887.94**	**55.28**	**3.19**		**0.00**	**1,474.62**	**7,710.58**	**1,342.55**	**506.17**
1. Energy	244,993.28	NO	530.09	8.48				1,432.85	6,211.72	895.76	499.74
1A Energy Combustion Activities	244,989.61	NO	110.78	8.48				1,432.85	6,211.72	796.18	499.74
1A1 Energy Industries	102,442.08	NO	12.22	2.04				323.67	404.02	26.45	49.41
1A1a Main Activity Electricity and Heat Production	92,990.34	NO	11.84	1.96				297.88	402.09	25.81	49.41
1A1b Petroleum Refining	9,451.75	NO	0.39	0.08				25.79	1.93	0.64	NA
1A2 Manufacturing Industries and Construction	52,228.44	NO	13.69	1.90				188.67	1,465.07	25.73	403.91
1A3 Transport	75,225.23	NO	23.44	3.73				751.35	3,157.94	592.41	9.01
1A3a Civil Aviation	2,482.62	NO	0.02	0.07				10.42	3.47	1.74	NA
1A3b Road Transportation	71,927.21	NO	23.34	3.55				725.45	3,143.46	588.47	9.01
1A3c Railways	253.30	NO	0.02	0.10				4.10	3.42	0.68	NA
1A3d Water borne Navigation	562.10	NO	0.06	0.02				11.38	7.59	1.52	NA
1A4 Other Sectors	15,093.85	NO	61.43	0.81				169.16	1,184.69	151.59	37.42
1A5 Non-specified	NO	NO	NO	NO				NO	NO	NO	NO
1B Fugitive emissions from fuel	3.68	NO	419.31	NO				NO	NO	99.58	NO
1B1 Solid Fuels	NO	NO	20.74	NO				NO	NO	NO	NO
1B2 Oil and Natural Gas	3.68	NO	398.57	NO				NO	NO	99.58	NO
1B3 Other emissions from energy production	NO	NO	NO	NO				NO	NO	NO	NO
1C Carbon dioxide Transport and Storage	NO	NO	NO	NO				NO	NO	NO	NO
1C1 Transport of CO$_2$	NO	NO	NO	NO				NO	NO	NO	NO
1C2 Injection and Storage	NO	NO	NO	NO				NO	NO	NO	NO
1C3 Other	NO	NO	NO	NO				NO	NO	NO	NO
2. Industrial Processes and Product Use	32,381.94		14.70	1.72	3.19	NO	0.00	1.38	5.14	446.79	6.43
2A Mineral Industry	19,392.59		NE	NO	NO	NO	NO	NO	NO	NO	NO
2A1 Cement Production	18,465.04		NE	NO	NO	NO	NO	NO	NO	NO	NO
2A2 Lime Production	117.07		NE	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	263.92		NE	NO	NO	NO	NO	NO	NO	NO	NO
2A4b Other Uses of Soda Ash	104.50		NE	NO	NO	NO	NO	NO	NO	NO	NO
2A4d Other	442.06		NE	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry	12,365.00		14.70	1.72	NO	NO	NO	NO	NO	NO	NO
2B2 Nitric Acid Production	NO		NE	0.62	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam Production	NO		NE	1.10	NO	NO	NO	NO	NO	NO	NO
2B8b Ethylene	10,981.87		14.65	NE	NO	NO	NO	NO	NO	NO	NO
2B8c Ethylene Dichloride and Vinyl Chloride Monomer	226.37		NO	NE	NO	NO	NO	NO	NO	NO	NO

Table 2-5: National greenhouse gas inventory of Thailand, 2019

Greenhouse gas source and sink categories	CO₂ emissions	CO₂ removals	CH₄	N₂O	HFCs	PFCs	SF₆	NOx	CO	NMVOCs	SO₂
Unit	GgCO₂eq	GgCO₂eq	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2B8e Acrylontrile	181.02		0.03	NE	NO	NO	NO	NO	NO	NO	NO
2B8f Carbon Black	975.75		0.02	NE	NO	NO	NO	NO	NO	NO	NO
2C Metal Production	**339.68**		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2C1 Iron and Steel Production	339.68		NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use	**284.67**		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2D1 Lubricant Use	284.67		NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	**NO**		**NO**	**NO**	**3.19**	**NE**	**NO**	**NO**	**NO**	**NO**	**NO**
2F1 Refrigeration and Air Conditioning	NO		NO	NO	3.19	NE	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use-Industrial Processes	**NO**		**NO**	**NO**	**NO**	**NO**	**0.00**	**NO**	**NO**	**NO**	**NO**
2G1 Electrical Equipment	NO		NO	NO	NO	NO	0.00	NO	NO	NO	NO
2H Other	**NO**		**NO**	**NO**	**NO**	**NO**	**NO**	**1.38**	**5.14**	**446.79**	**6.43**
2H1 Pulp and Paper Industry	NO		NO	NO	NO	NO	NO	1.38	5.14	3.40	6.43
2H2 Food and Beverages Industry	NO		NO	NO	NO	NO	NO	NO	NO	443.39	NO
3. Agriculture	**1,509.39**		**1,705.64**	**42.34**				**40.13**	**1,476.76**		
3A Enteric Fermentation			430.63								
3B Manure Management			83.08	1.95							
3C Field Burning of Agricutural Residues	NA		43.34	1.12				40.13	1,476.76		
3D Liming	25.48										
3E Urea Fertilization	1,483.90										
3F Direct N₂O Emission from Managed Soils				27.05							
3G Indirect N₂O Emission from Managed Soils				10.23							
3H Indirect N₂O Emission from Manure Management				1.98							
3I Rice Cultivation			1,148.59								
4. Land use, land-use change and forestry	**50,846.94**	**-142,872.88**	**1.11**	**0.04**	**NO**	**NO**	**NO**	**0.26**	**16.95**	**NO**	**NO**
4A Forest Land Remaining Forest Land	**18,102.98**	**-43,896.08**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
4B Cropland Remaining Cropland	**23,118.18**	**-98,976.80**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
4C Land Converted to Cropland	**9,506.26**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
4D Land Converted to Other Land	**119.51**	**NO**	**0.00**	**0.00**	**NO**	**NO**	**NO**	**NO**	**0.03**	**NO**	**NO**
4E Biomass Burning	**NO**	**NO**	**1.11**	**0.04**	**NO**	**NO**	**NO**	**0.26**	**16.95**	**NO**	**NO**
4E1 Biomass Burning (Forest Land)	NO	NO	0.91	0.03	NO	NO	NO	0.21	13.89	NO	NO
4E2 Biomass Burning (Cropland)	NO	NO	0.20	0.01	NO	NO	NO	0.05	0.03	NO	NO
4E3 Biomass Burning (Other Land)	NO	NO	0.00	0.00	NO	NO	NO	0.00	0.03	NO	NO
5. Waste	**159.86**		**636.39**	**2.71**				**NO, NA**	**NO, NA**	**NA**	**NA**

Table 2-5: National greenhouse gas inventory of Thailand, 2019

Greenhouse gas source and sink categories	CO₂ emissions	CO₂ removals	CH₄	N₂O	HFCs	PFCs	SF₆	NOx	CO	NMVOCs	SO₂
Unit	GgCO₂eq	GgCO₂eq	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
5A Solid Waste Disposal			333.73							NA	
5A1 Managed Waste Disposal Sites			201.47							NA	
5A2 Unmanaged Waste Disposal Sites			132.26							NA	
5B Biological Treatment of Solid Waste			2.89	0.27						NA	
5C Incineration and Open Burning of Waste	159.86		0.00	0.02	NA	NA	NA	NO	NA	NA	NA
5C1 Waste Incineration	159.86		0.00	0.02				NA	NA	NA	NA
5D Wastewater Treatment and Discharge			299.77	2.42				NO	NO	NA	
5D1 Domestic Wastewater Treatment and Discharge			76.73	2.42							
5D2 Industrial Wastewater Treatment and Discharge			223.04								
6. Other (please specify)											
Memo Items (not accounted in total Emissions)	123,741.69		0.45	0.53	NA	NA	NA	139.29	71.19	20.74	NA
International Bunkers	19,329.61		0.45	0.53	NA	NA	NA	139.29	71.19	20.74	NA
Aviation International Bunkers	15,497.25		0.11	0.43	NA	NA	NA	65.02	21.67	10.84	NA
Marine-International Bunkers	3,832.36		0.35	0.10	NA	NA	NA	74.27	49.51	9.90	NA
CO₂ from biomass	104,412.08		NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: 0.00 means less than 0.005

2.2 Key Findings from the National Greenhouse Gas Inventory

In this report, the trends of Thailand's GHG emissions for the period 2000 to 2019, from all emission sources and removals, were conducted according to the 2006 IPCC Guidelines. The GHG emissions are estimated from the Energy, IPPU, Agriculture, LULUCF, and Waste sectors which include both direct and indirect emissions. Direct GHGs consist of Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs) and Sulphur Hexafluoride (SF_6) whereas indirect GHGs consist of Nitrogen Oxides (NOx), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs) and Sulfur Dioxide (SO_2). Table 2-6 shows Thailand's national GHG inventory from 2000 to 2019.

2.2.1 The Trend of Thailand's GHG Emissions and Removals by Sector 2000-2019

Total GHG emissions (excluding those from LULUCF) increased from 245,899.56 $GgCO_2eq$ in 2000 to 372,716.86 $GgCO_2eq$ in 2019, with an average annual increase of 2.21%. The net removal of CO_2 increased from -45,443.60 $GgCO_2eq$ in 2000 to - 91,988.52 $GgCO_2eq$ in 2019. Net GHG emissions therefore increased overall from 200,455.96 $GgCO_2eq$ in 2000 to 280,728.34 $GgCO_2eq$ in 2019, with an average annual increase of 1.79% (Table 2-6, Figure 2-1). Between 2000-2019, the main source of GHG emissions was the Energy sector, which saw an increase of 57.96% from 165,092.40 $GgCO_2eq$ in 2000 to 260,772.69 $GgCO_2eq$ in 2019. The proportion of GHG emissions in the Energy sector accounted for 67.14% of total emission sources in 2000, increasing to comprise 69.96% of total emission sources in 2019. In the same period, the share of emissions from the Agriculture sector decreased from 19.95% in 2000 to 15.23% in 2019, the IPPU sector increased from 8.65% in 2000 to 10.28% in 2019 and the shares of emissions from the Waste sectors slightly increased from 4.26% in 2000 to 4.53% in 2019. (Figure 2-2).

Table 2-6: National GHG emissions/removals by sector: 2000-2019

Unit: GgCO$_2$eq

| Year	Source category					Net emissions (Include LULUCF)	Total emissions (Exclude LULUCF)
	Energy	Industrial Processes and Product Use	Agriculture	LULUCF	Waste		
2000	165,092.40	21,274.82	49,065.40	-45,443.60	10,466.94	200,455.96	245,899.56
2001	172,906.76	22,873.13	50,019.89	-54,436.91	11,281.28	202,644.15	257,081.06
2002	182,317.06	24,944.60	48,691.69	-44,126.05	12,813.68	224,640.98	268,767.03
2003	191,305.31	24,217.55	52,265.60	-45,887.41	14,281.85	236,182.90	282,070.31
2004	208,180.48	26,041.51	51,958.87	-54,146.05	14,844.36	246,879.17	301,025.22
2005	212,318.12	27,883.81	51,413.70	-58,340.43	15,167.72	248,442.92	306,783.35
2006	213,020.12	28,771.00	53,870.52	-61,390.87	16,188.61	250,459.38	311,850.25
2007	219,378.63	30,424.56	57,161.74	-68,396.37	16,569.69	255,138.25	323,534.62
2008	221,716.62	28,897.09	59,059.43	-69,184.97	17,652.74	258,140.91	327,325.88
2009	221,351.88	28,344.22	61,137.46	-71,197.04	17,455.59	257,092.11	328,289.15
2010	233,105.75	29,961.53	60,694.70	-65,827.73	15,778.55	273,712.80	339,540.53
2011	229,859.44	31,290.10	61,220.57	-74,636.18	14,900.97	262,634.90	337,271.08
2012	242,867.49	33,484.60	64,250.78	-80,695.94	11,866.89	271,773.82	352,469.76
2013	241,717.77	33,299.85	59,080.05	-83,110.84	13,978.13	264,964.96	348,075.80
2014	239,724.21	34,819.39	57,995.56	-100,508.25	14,237.77	246,268.68	346,776.93
2015	241,918.80	35,675.42	52,324.55	-87,337.57	15,998.67	258,579.87	345,917.44
2016	254,540.07	37,189.17	52,303.38	-87,054.60	16,771.89	273,749.91	360,804.51
2017	255,244.90	38,054.69	57,052.83	-85,380.82	17,666.21	282,637.93	368,018.75
2018	257,340.89	40,118.18	58,486.02	-85,968.30	16,703.68	286,680.47	372,648.77
2019	260,772.69	38,301.21	56,766.32	-91,988.52	16,876.64	280,728.34	372,716.86
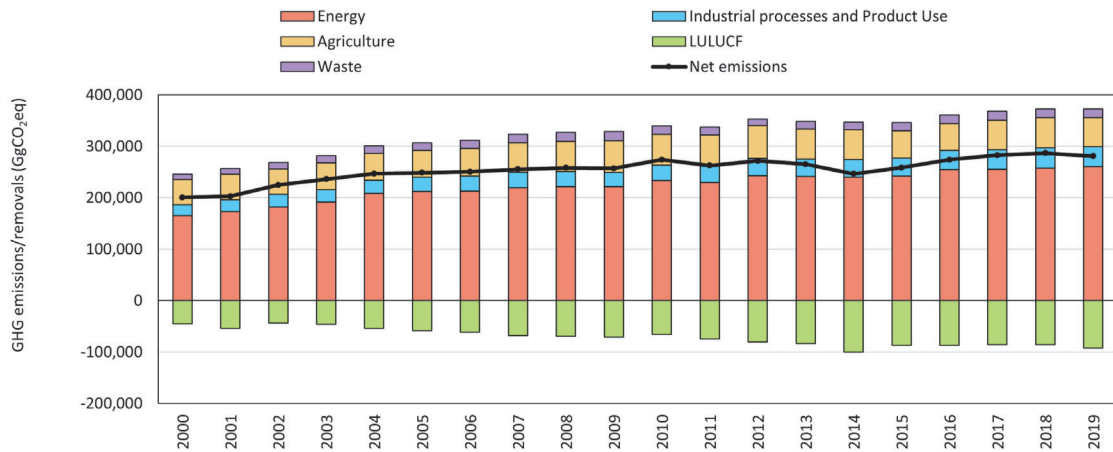
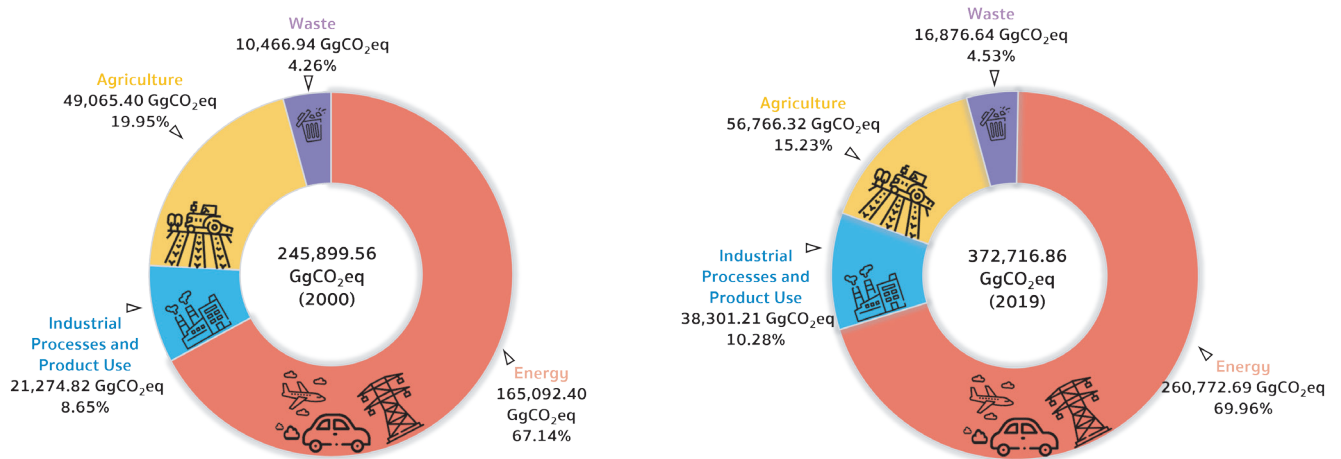**Figure 2-1:** National GHG emissions/removals by sector: 2000-2019

Figure 2-2: Total GHG emissions by sector (excluding LULUCF), 2000 and 2019

2.2.2 The Trend of Indirect GHG Emissions

The indirect GHG emissions include NOx, CO, NMVOCs, and SO_2. The trends of indirect GHG emissions for the period from 2000 to 2018 are shown in Table 2-5. The estimated indirect GHG emissions are as follows:

- NOx: 942.32 Gg (2000) to 1,474.62 Gg (2019) – an average annual increase of 2.47%
- CO: 6,022.22 Gg (2000) to 7,710.58 Gg (2019) – an average annual increase of 2.19%
- NMVOCs: 731.44 Gg (2000) to 1,342.55 Gg (2019) – an average annual increase of 3.25%
- SO_2: 594.96 Gg (2000) to 506.17 Gg (2019) – an average annual decrease of 0.85%

Table 2-7: Indirect GHG emissions by types of gases: 2000-2019

Unit: Gg

Year	Indirect Gases			
	NOx	CO	NMVOCs	SO₂
2000	942.32	6,022.22	731.44	594.96
2001	983.03	5,795.26	746.09	643.74
2002	1,037.23	6,144.15	828.22	688.52
2003	1,107.07	6,435.12	878.37	617.62
2004	1,191.62	6,347.04	895.95	719.97
2005	1,196.23	6,004.78	828.46	756.02
2006	1,190.50	6,459.84	853.77	692.78
2007	1,224.74	6,596.80	868.27	627.18
2008	1,217.36	6,736.72	834.29	631.14
2009	1,246.51	6,845.08	856.75	600.83
2010	1,282.31	6,999.10	865.80	633.92
2011	1,303.60	7,253.58	900.58	607.29
2012	1,356.38	7,408.01	896.69	564.75
2013	1,361.24	7,555.26	926.30	505.64
2014	1,330.04	7,130.69	980.53	447.45
2015	1,351.97	7,153.17	1,033.65	416.77
2016	1,383.96	7,253.94	971.01	452.08
2017	1,420.95	7,398.05	1,009.70	425.62
2018	1,451.13	7,798.65	1,057.87	497.24
2019	1,474.62	7,710.58	1,342.55	506.17
Average Annual Growth Rate (%)	2.47	2.19	3.25	-0.85

2.2.3 Recalculation of Total GHG Emissions

Previous inventories submitted in the BUR3 were calculated using the 2006 IPCC Guidelines. To provide a consistent data series, recalculations were performed for past inventories (2000-2016). As part of this current inventory submission, emissions for the period 2000-2016 were recalculated using updated activity data, revised emission factors, and subsectors according to the

Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories 2000 (GPG 2000). The method of emissions calculation in the energy sector is Tier 1.

In the energy sector, the calculation is divided into two approaches, namely 1) the sectoral approach and 2) the reference approach. Results of calculation based on the sectoral approach are presented in 1A Fuel Combustion and 1B Fugitive Emissions from Fuels, while results of a calculation
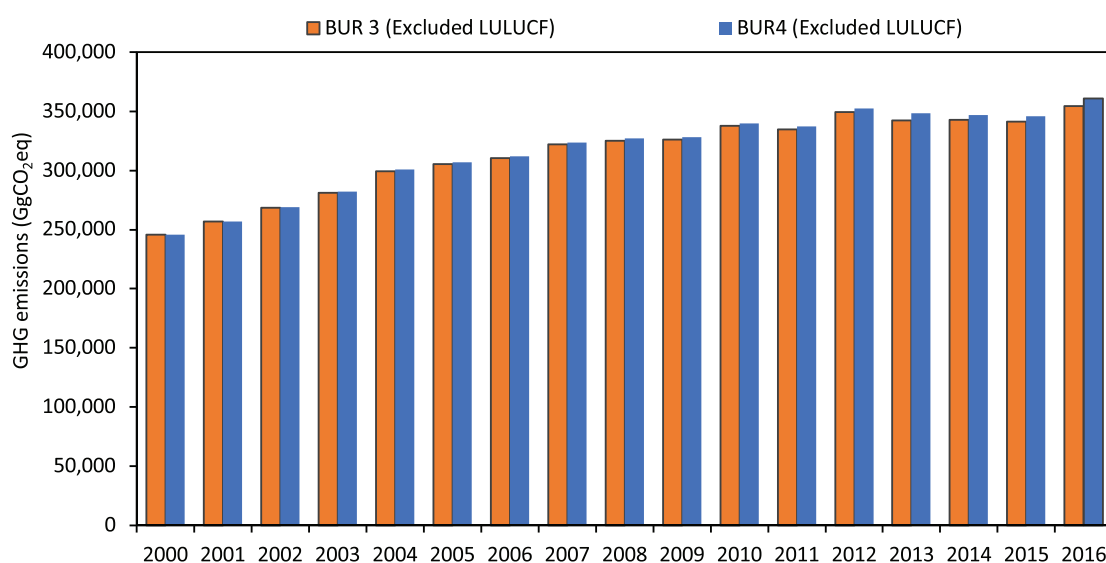

Figure 2-3: Comparison of Thailand's GHG emissions between BUR3 and BUR4

2006 IPCC Guidelines. Results of the recalculated national GHG emissions data for 2000-2016 are presented in Figure 2-3. The newly calculated emissions for 2000-2016 were slightly higher than those in the previous inventories submitted in the BUR3, in the range of an additional 0.06% to 1.82%. However, trends of emissions are the same.

2.3 Greenhouse Gas Emissions by Sector

2.3.1 Energy

2.3.1.1 Methodology
The method used in the calculation of Thailand's greenhouse gas emissions is mainly based on the 2006 IPCC Guidelines of National Greenhouse Gas Inventories in compliance with the IPCC Good

based on the reference approach presented in section 2.3.1.2

2.3.1.2 Reference and Sectoral Approaches
As a way of verifying CO_2 emissions from fuel combustion for the time series 2000–2019, Thailand also applied the top-down IPCC Reference Approach to the Inventory. The Reference Approach was applied based on relatively easily available energy supply statistics and as a way of maintaining good practice as per IPCC Reporting Guidelines. Significant differences between the reference and sectoral approaches may indicate possible problems with the activity data, net calorific values, carbon content, excluded carbon calculation etc.

The reference approach outputs were compared to the sectoral emissions for the period 2000 to

2019 and the CO_2 emissions were always higher using the reference approach. The difference in CO_2 emissions using the reference and sectoral approach was 23.92%, 14.79%, 22.67% and 21.41% for the years 2016, 2017, 2018 and 2019, respectively. The major differences were seen in the liquid and gaseous fuels, where consumption is consistently higher with the reference approach. Allocation of liquid and gaseous fuels between energy use, non-energy uses as well as use for synthetic fuels production remains one of the key drivers of the differences observed between the two datasets.

2.3.1.3 Values and Sources of Activity Data

Activity data are obtained from a collection of the official reports and documents from relevant agencies such as Energy Statistics and annual reports from the Department of Alternative Energy Development and Efficiency (DEDE), the Energy Policy and Planning Office (EPPO), the Electricity Generating Authority (EGAT), The Civil Aviation Authority of Thailand (CAAT), State Railway of Thailand (SRT), Department of Primary Industries and Mines (DPIM) and the Department of Mineral Fuels (DMF). The information obtained is analyzed, examined, and calculated for the greenhouse gas emissions in the energy sector.

2.3.1.4 Emission Factors

The emission factors employed in calculating greenhouse gas emissions in the energy sector follow the default values of the 2006 IPCC Guidelines of National Greenhouse Gas Inventories for all fuel types.

2.3.1.5 Greenhouse Gas Emissions 2019

Total direct GHG emissions from the Energy sector in 2019 were estimated to be 260,772.69 $GgCO_2$eq. The majority of GHG emissions in the Energy sector were generated by fuel combustion, consisting of 1A1 Energy industries at around 103,356.15 $GgCO_2$eq (39.63%). GHG emissions from Transport, Manufacturing Industries and Construction, and other sectors were 76,923.01 $GgCO_2$eq (29.50%), 53,137.57 $GgCO_2$eq (20.38%) and 16,869.53 $GgCO_2$eq (6.47%).

Fugitive Emissions from fuel comprised only 10,486.43 $GgCO_2$eq or 4.03% of total GHG emissions from the Energy sector. Details of GHG emissions in the Energy sector by types of gases and sources in 2019 are presented in Figure 2-4 and Table 2-8.
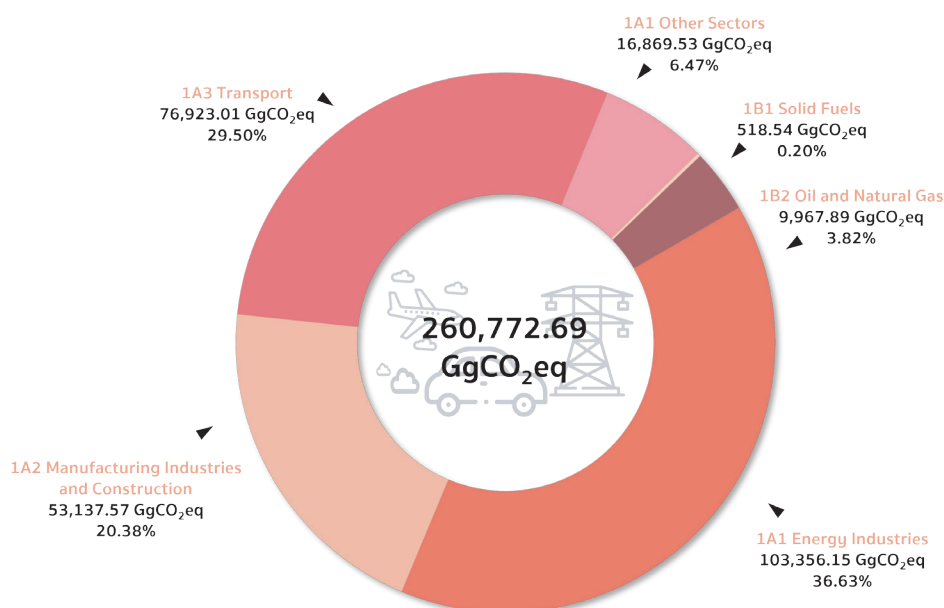

1A1 Other Sectors
16,869.53 $GgCO_2$eq
6.47%

1B1 Solid Fuels
518.54 $GgCO_2$eq
0.20%

1B2 Oil and Natural Gas
9,967.89 $GgCO_2$eq
3.82%

1A3 Transport
76,923.01 $GgCO_2$eq
29.50%

1A2 Manufacturing Industries and Construction
53,137.57 $GgCO_2$eq
20.38%

260,772.69 $GgCO_2$eq

1A1 Energy Industries
103,356.15 $GgCO_2$eq
36.63%

Figure 2-4: GHG emissions in Energy sector, 2019

Table 2-8: GHG emissions from various sources relative to total GHG emissions in the Energy sector, 2019

Greenhouse gas source and sink categories	CO₂ emissions GgCO₂eq	CO₂ removals GgCO₂eq	CH₄ Gg	CH₄ GgCO₂eq	N₂O Gg	N₂O GgCO₂eq	HFCs GgCO₂eq	PFCs GgCO₂eq	SF₆ GgCO₂eq	NOx Gg	CO Gg	NMVOCs Gg	SO₂ Gg	Total GgCO₂eq
1. Energy	244,993.28	NO	530.09	13,252.28	8.48	2,527.13				1,432.85	6,211.72	895.76	499.74	260,772.69
1A Energy Combustion Activities	244,989.61	NO	110.78	2,769.53	8.48	2,527.13				1,432.85	6,211.72	796.18	499.74	250,286.26
1A1 Energy Industries	102,442.08	NO	12.22	305.61	2.04	608.46				323.67	404.02	26.45	49.41	103,356.15
1A1a Main Activity Electricity and Heat Production	92,990.34	NO	11.84	295.94	1.96	585.40				297.88	402.09	25.81	49.41	93,871.68
1A1b Petroleum Refining	9,451.75	NO	0.39	9.67	0.08	23.06				25.79	1.93	0.64	NA	9,484.47
1A2 Manufacturing Industries and Construction	52,228.44	NO	13.69	342.35	1.90	566.78				188.67	1,465.07	25.73	403.91	53,137.57
1A3 Transport	75,225.23	NO	23.44	585.92	3.73	1,111.86				751.34	3,157.94	592.41	9.01	76,923.01
1A3a Civil Aviation	2,482.62	NO	0.02	0.43	0.07	20.69				10.42	3.47	1.74	NA	2,503.75
1A3b Road Transportation	71,927.21	NO	23.34	583.61	3.55	1,057.37				725.45	3,143.46	588.47	9.01	73,568.20
1A3c Railways	253.30	NO	0.02	0.42	0.10	29.18				4.10	3.42	0.68	NA	282.89
1A3d Water borne Navigation	562.10	NO	0.06	1.46	0.02	4.62				11.38	7.59	1.52	NA	568.17
1A4 Other Sectors	15,093.85	NO	61.43	1,535.64	0.81	240.04				169.16	1,184.69	151.59	37.42	16,869.53
1A5 Non-specified	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1B Fugitive emissions from fuel	3.68	NO	419.31	10,482.75	NO	NO				NO	NO	99.58	NO	10,486.43
1B1 Solid Fuels	NO	NO	20.74	518.54	NO	NO				NO	NO	NO	NO	518.54
1B2 Oil and Natural Gas	3.68	NO	398.57	9,964.21	NO	NO				NO	NO	99.58	NO	9,967.89
1B3 Other emissions from energy production	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	0.00
1C Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1C1 Transport of CO₂	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1C2 Injection and Storage	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1C3 Other	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO

Note: NO = Not Occurring

2.3.2 Industrial Processes and Product Use (IPPU)

2.3.2.1 Methodology

The methodologies and tools used for IPPU GHG inventory reporting followed the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), Good Practice Guidance, and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The GHG emission calculation for IPPU Sector was Tier 1 approach as the primary basis and Tier 1,2 for Cement Production.

2.3.2.2 Values and Sources of Activity Data

The agencies within the Ministry of Industry and the private sector have been providing Activity Data (AD) for GHG inventory of the IPPU sector. According to the institutional structure for reporting greenhouse gas data, approved by the National Committee on Climate Change Policy, the Department of Industrial Works (DIW) was assigned as a leading agency to collect and report the Activity Data in the IPPU sector. To retrieve the data, the DIW coordinates with relevant departments within the ministry and other ministry for example, the Office of Industrial Economics (OIE), the Electricity Generating Authority of Thailand (EGAT), the Customs Department, the Department of Energy Business (DOEB), and the Excise Department. Furthermore,

private sectors such as the Thai Cement Manufacturers Association (TCMA), the Petroleum Institute of Thailand (PTIT), the Iron and Steel Institute of Thailand (ISIT). The DIW checks the accuracy of the collected data before sending it to ONEP.

2.3.2.3 Emission Factors

The emission factors employed in calculating greenhouse gas emissions in the IPPU sector follow the default values of the 2006 IPCC Guidelines of National Greenhouse Gas Inventories.

2.3.2.4 Greenhouse Gas Emissions in 2019

Total direct GHG emissions from the IPPU sector in 2019 were estimated at 38,301.21 GgCO$_2$eq. The majority of GHG emissions in the IPPU sector were generated by the Mineral Industry (2A) at 19,392.59 GgCO$_2$eq (50.63%), mainly consisting of Cement Production at 18,465.04 GgCO$_2$eq. The followings were GHG emissions from the Chemical Industry (2B) and Product Uses as Substitutes for Ozone Depleting Substances (2F) at 13,243.74 GgCO$_2$eq (34.58%) and 4,953.92 GgCO$_2$eq (12.93%), respectively. GHG emissions from the Metal Production (2C), Non-Energy Products from Fuels (2D), and Other Product Manufacture and Use (2G) accounted for only 1.63% of total GHG emissions from the IPPU sector (see Figure 2-5 and Table 2-9).
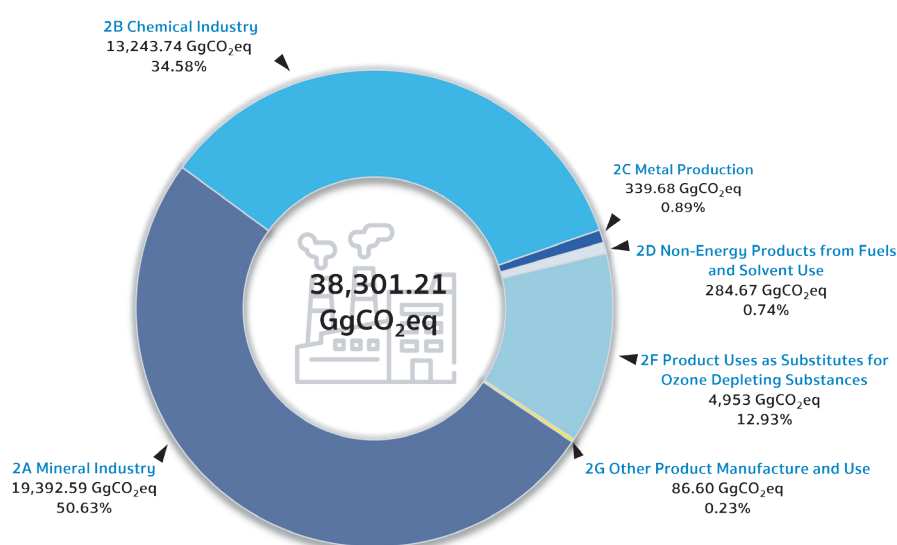

2B Chemical Industry
13,243.74 GgCO$_2$eq
34.58%

2C Metal Production
339.68 GgCO$_2$eq
0.89%

2D Non-Energy Products from Fuels and Solvent Use
284.67 GgCO$_2$eq
0.74%

38,301.21 GgCO$_2$eq

2F Product Uses as Substitutes for Ozone Depleting Substances
4,953 GgCO$_2$eq
12.93%

2A Mineral Industry
19,392.59 GgCO$_2$eq
50.63%

2G Other Product Manufacture and Use
86.60 GgCO$_2$eq
0.23%

Figure 2-5: GHG emissions in Industrial Process and Product Use Sector, 2019

Table 2-9: GHG emissions from sources relative to total GHG emissions in the Industrial Processes and Product Use Sector, 2019

Greenhouse gas source and sink categories	CO₂ emissions	CO₂ removals	CH₄		N₂O		HFCs	PFCs	SF₆	NOx	CO	NMVOCs	SO₂	Total
	GgCO₂eq	GgCO₂eq	Gg	GgCO₂eq	Gg	GgCO₂eq	GgCO₂eq	GgCO₂eq	GgCO₂eq	Gg	Gg	Gg	Gg	GgCO₂eq
2. Industrial Processes and Product Use	**32,381.94**		**14.70**	**367.60**	**1.72**	**511.14**	**4,953.93**	**NE**	**86.60**	**1.38**	**5.14**	**446.79**	**6.43**	**38,301.21**
2A Mineral Industry	**19,392.59**		**NE**	**NE**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**19,392.59**
2A1 Cement Production	18,465.04		NE	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	18,465.04
2A2 Lime Production	117.07		NE	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	117.07
2A3 Glass Production	263.92		NE	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	263.92
2A4b Other Uses of Soda Ash	104.50		NE	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	104.50
2A4d Other	442.06		NE	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	442.06
2B Chemical Industry	**12,365.00**		**14.70**	**367.60**	**1.72**	**511.14**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**13,245.74**
2B2 Nitric Acid Production	NO		NE	NE	0.62	184.00	NO	NO	NO	NO	NO	NO	NO	184.00
2B4 Caprolactam Production	NO		NE	NE	1.10	327.14	NO	NO	NO	NO	NO	NO	NO	327.14
2B8b Ethylene	10,981.87		14.65	366.23	NE	NE	NO	NO	NO	NO	NO	NO	NO	11,348.09
2B8c Ethylene Dichloride and Vinyl Chloride Monomer	226.37		NO	NO	NE	NE	NO	NO	NO	NO	NO	NO	NO	226.37
2B8e Acrylonitrile	181.02		0.03	0.81	NE	NE	NO	NO	NO	NO	NO	NO	NO	181.83
2B8f Carbon Black	975.75		0.02	0.56	NE	NE	NO	NO	NO	NO	NO	NO	NO	976.31
2C Metal Production	**339.68**		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**339.68**
2C1 Iron and Steel Production	339.68		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	339.68
2D Non-Energy Products from Fuels and Solvent Use	**284.67**		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**284.67**
2D1 Lubricant Use	284.67		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	284.67
2F Product Uses as Substitutes for Ozone Depleting Substances	**NO**		**NO**	**NO**	**NO**	**NO**	**4,953.93**	**NE**	**NO**	**NO**	**NO**	**NO**	**NO**	**4,953.93**
2F1 Refrigeration and Air Conditioning	NO		NO	NO	NO	NO	4,953.93	NE	NO	NO	NO	NO	NO	4,953.93
2G Other Product Manufacture and Use-Industrial Processes	**NO**		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**86.60**	**NO**	**NO**	**NO**	**NO**	**86.60**
2G1 Electrical Equipment	NO		NO	NO	NO	NO	NO	NO	86.60	NO	NO	NO	NO	86.60
2H Other	**NO**		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**1.38**	**5.14**	**446.79**	**6.43**	**NO**
2H1 Pulp and Paper Industry	NO		NO	NO	NO	NO	NO	NO	NO	1.38	5.14	3.40	6.43	NO
2H2 Food and Beverages Industry	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	443.39	NO	NO

Note: NE = Not Estimated, NO = Not Occurring

2.3.3 Agriculture

2.3.3.1 Methodology

In this inventory, the methodologies used for the Agriculture sector were based on the 2006 IPCC guidelines. GHG estimations were calculated for 2 sub-categories, including Livestock (3A Enteric fermentation and 3B Manure management) Aggregate sources and non-CO_2 emission sources on land (3C Field Burning of Agricultural residues, 3D Liming, 3E Urea fertilization, 3F Direct N_2O emissions from managed soils, 3G Indirect N_2O emissions from managed soils, 3H Indirect N_2O emissions from manure management, and 3I Rice cultivation). Sub-categories 3D, 3E, and 3H were estimated for the first time in BUR3. Methodology tiers were chosen according to the decision trees in the 2006 IPCC Guidelines. Tier 1 and tier 2 methods were applied to the Agriculture sector.

2.3.3.2 Values and Sources of Activity Data

Activity data (AD) were mainly obtained from the published reports. The relevant government agencies include the Land Development Department (LDD), the Department of Livestock Development (DLD), the Office of Agricultural Economics (OAE), the Department of Agriculture (DOA), and the Office of the Cane and Sugar Board (OCSB). Supporting data for Activity Data factor were also acquired from the country's published data and expert judgment and were also from the IPCC defaults.

2.3.3.3 Emission Factors

Emission factors (EFs) used were country-specific EF for some livestock and rice cultivation, while 2006 IPCC defaults were for the rest.

2.3.3.4 Greenhouse Gas Emissions 2019

Total GHG emissions from the Agriculture Sector in 2019 were 56,766.32 $GgCO_2eq$. Livestock contributed 14,013.66 $GgCO_2eq$ (24.69%), comprising 10,765.80 $GgCO_2eq$ from enteric fermentation, 2,657.52 and 590.34 $GgCO_2eq$ for direct and indirect manure management, respectively. Meanwhile, crop related-GHG emissions accounted for 42,752.64 $GgCO_2eq$ (75.31%). Rice cultivation was the main GHG contributor in Thailand's Agriculture sector, at 28,714.75 $GgCO_2eq$ (50.58%). Agricultural soils emitted 11,110.18 $GgCO_2eq$ (19.57%) with direct and indirect emissions contributing 8,060.47 and 3,049.71 $GgCO_2eq$, respectively. Field burning of agricultural residues and urea fertilizer contributed similar GHG emissions of 1,418.33 and 1,483.90 $GgCO_2eq$ (2.50 and 2.62 %), respectively. The lowest agricultural GHG emission in 2019 was from liming (25.48 $GgCO_2eq$ or 0.04%). Details of 2019 GHG emissions in the Agriculture sector by types of gases and sources are presented in Figures 2-6 and Tables 2-10.

In the Agriculture sector, field burning of agricultural residues was estimated based on the residues being burnt as residue management in croplands. This field burning was in the category of "3C1b Emissions from Biomass Burning in Cropland (Cropland Remaining Cropland)" in the 2006 IPCC Guidelines.
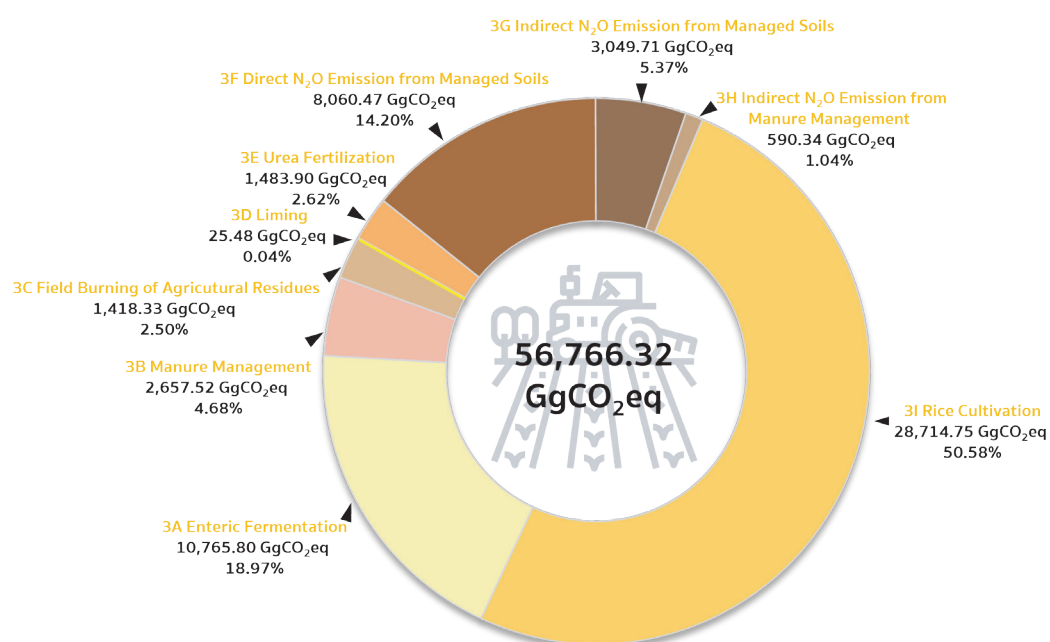

3G Indirect N_2O Emission from Managed Soils
3,049.71 $GgCO_2eq$
5.37%

3F Direct N_2O Emission from Managed Soils
8,060.47 $GgCO_2eq$
14.20%

3H Indirect N_2O Emission from Manure Management
590.34 $GgCO_2eq$
1.04%

3E Urea Fertilization
1,483.90 $GgCO_2eq$
2.62%

3D Liming
25.48 $GgCO_2eq$
0.04%

3C Field Burning of Agricultural Residues
1,418.33 $GgCO_2eq$
2.50%

3B Manure Management
2,657.52 $GgCO_2eq$
4.68%

56,766.32 $GgCO_2eq$

3I Rice Cultivation
28,714.75 $GgCO_2eq$
50.58%

3A Enteric Fermentation
10,765.80 $GgCO_2eq$
18.97%

Figure 2-6: GHG emissions in Agriculture Sector, 2019

Table 2-10: GHG emissions from sources relative to total GHG emissions in the Agriculture Sector, 2019

Greenhouse gas source and sink categories	CO₂ emissions	CO₂ removals	CH₄		N₂O		HFCs	PFCs	SF₆	NOx	CO	NMVOCs	SO₂	Total
	GgCO₂eq	GgCO₂eq	Gg	GgCO₂eq	Gg	GgCO₂eq	GgCO₂eq	GgCO₂eq	GgCO₂eq	Gg	Gg	Gg	Gg	GgCO₂eq
3. Agriculture	1,509.39		1,705.64	42,641.01	42.34	12,615.92				40.13	1,476.76			56,766.32
3A Enteric Fermentation			430.63	10,765.80										10,765.80
3B Manure Management			83.08	2,076.97	1.95	580.56								2,657.52
3C Field Burning of Agricultural Residues	NA		43.34	1,083.49	1.12	334.84				40.13	1,476.76			1,418.33
3D Liming	25.48													25.48
3E Urea Fertilization	1,483.90													1,483.90
3F Direct N₂O Emission from Managed Soils					27.05	8,060.47								8,060.47
3G Indirect N₂O Emission from Managed Soils					10.23	3,049.71								3,049.71
3H Indirect N₂O Emission from Manure Management					1.98	590.34								590.34
3I Rice Cultivation			1,148.59	28,714.75										28,714.75

Note: NA = Not Applicable

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

2.3.4.1 Methodology

All methodologies and tools used to report GHG inventories for Land Use, Land-Use Change, and Forestry (LULUCF) were consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), Good Practice Guidance for Land Use, Land-Use Change, and Forestry (IPCC, 2003), and Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The 2006 IPCC Guidelines define six land-use categories: forest land, cropland, grassland, wetlands, settlements, and other lands. GHG emissions/removals from the LULUCF sector during 2000-2018 were estimated for the three land categories (excluding grassland, wetlands, and settlements). The Tier 2 methodology was used primarily wherever activity data and country-specific emission factors were available. Approach 1 in the 2006 IPCC Guidelines was adopted for representing land-use areas of which total land-use areas in each stratification were reported without data on conversions between land uses.

2.3.4.2 Values and Sources of Activity Data

The Royal Forest Department (RFD), the Department of National Parks, Wildlife, and Plant Conservation (DNP), the Department of Marine and Coastal Resources (DMCR), the Forest Industry Organization (FIO), the Rubber Authority of Thailand (RAOT) and the Office of Agricultural Economics (OAE) provided activity data (AD) from published reports.

2.3.4.3 Emission Factors

The Tier 2 country-specific EFs acquired from published data and expert judgment were used for most LULUCF categories, except for non-CO_2 emissions from biomass burning.

2.3.4.4 Greenhouse Gas Emissions 2019

The total CO_2 emissions/removals from C stock changes for each land use category is the sum of those from these all sub-categories taking into account the three carbon pools: (i) above-ground biomass, (ii) below-ground biomass, and (iii) dead organic matter (deadwood and litter). The LULUCF sector in Thailand showed a trend of increased net removals because the total removals exceeded the total emissions. LULUCF activities contributed to a tremendous increase in net removal from the atmosphere since 2000 due to the net removal of rubber plantations. It can be observed that cropland dominates the net removals estimated for the LULUCF sector for Thailand. The net removals in the period of 2000 –2014 fluctuated due to the net removals from cropland and emissions from land conversion, but it seemed stable after 2015.

In 2019, the LULUCF sector contributed to a net removal of 91,988.52 GgCO_2eq, accounting for an increase by two folds compared with the year 2000. The net removal estimated for cropland remaining cropland was 75,858.62 GgCO_2eq, accounting for almost 80% of the overall net removals of the LULUCF sector. The forest land conversion emitted 9,506.26 and 119.51 GgCO_2eq from land converted to cropland and other lands, respectively, thereby decreasing about 60% compared with the emissions in 2000. While non-CO_2 emissions from biomass burning in the LULUCF sector emitted 37.43 GgCO_2eq. Details of GHG emissions/removals in the LULUCF sector by types of gases and sources in 2019 are presented in Figure 2-7 and Table 2-11.

In the LULUCF sector, non-CO_2 emissions were estimated from biomass burning from an uncontrolled forest fire in natural forest (4E1 Forest Land Remaining Forest Land) and forest converted to cropland (4E2 Land Converted to Cropland) and to other lands (4E3 Land Converted to other lands) in the 2006 IPCC Guidelines.
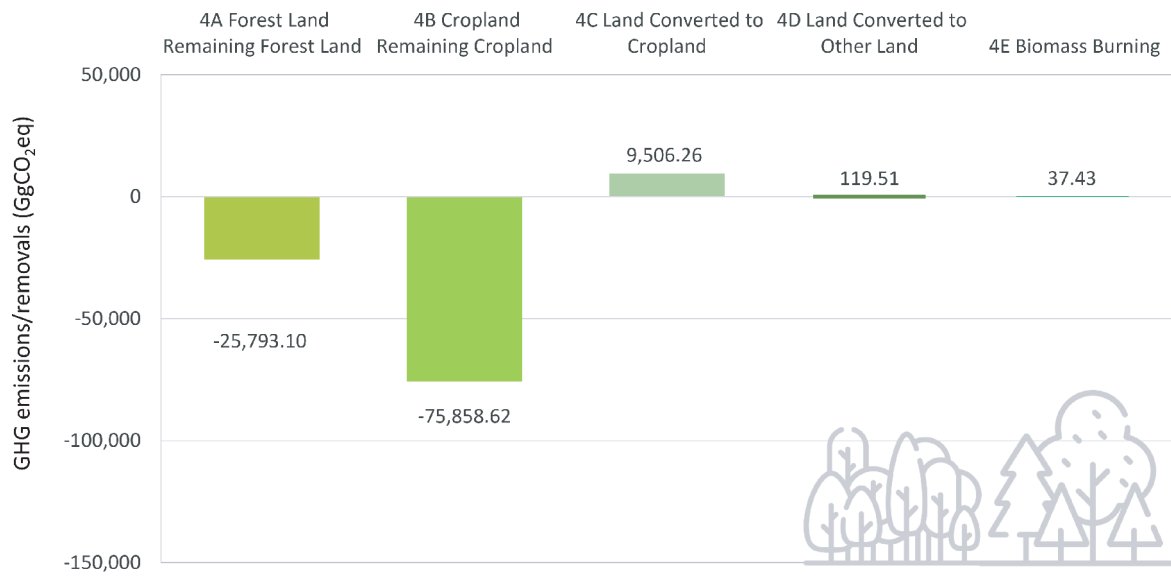
Figure 2-7: GHG emissions in the LULUCF Sector, 2019

Table 2-11: GHG emissions from sources relative to total GHG emissions in the LULUCF Sector, 2019

Greenhouse gas source and sink categories	CO$_2$ emissions GgCO$_2$eq	CO$_2$ removals GgCO$_2$eq	Net GgCO$_2$eq	CH$_4$ Gg	CH$_4$ GgCO$_2$eq	N$_2$O Gg	N$_2$O GgCO$_2$eq	HFCs GgCO2eq	PFCs GgCO2eq	SF$_6$ GgCO2eq	NOx Gg	CO Gg	NMVOCs Gg	SO$_2$ Gg	Total GgCO$_2$eq
4. Land use, land-use change and forestry	50,846.94	-142,872.88	-92,025.95	1.11	27.71	0.04	9.72	NO	NO	NO	0.26	16.95	NO	NO	-91,988.52
4A Forest Land Remaining Forest Land	18,102.98	-43,896.08	-25,793.10	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	-25,763.10
4B Cropland Remaining Cropland	23,118.18	-98,976.80	-75,858.62	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	-75,858.62
4C Land Converted to Cropland	9,506.26	NO	9,506.26	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	9,506.26
4D Land Converted to Other Land	119.51	NO	119.51	0.00	0.00	0.00	0.00	NO	NO	NO	NO	NO	NO	NO	119.51
4E Biomass Burning	NO	NO	NO	1.11	27.71	0.04	9.72	NO	NO	NO	0.26	16.95	NO	NO	37.43
4E1 Biomass Burning (Forest Land)	NO	NO	NO	0.91	22.70	0.03	7.96	NO	NO	NO	0.21	13.89	NO	NO	30.66
4E2 Biomass Burning (Cropland)	NO	NO	NO	0.20	4.95	0.01	1.74	NO	NO	NO	0.05	0.03	NO	NO	6.69
4E3 Biomass Burning (Other Land)	NO	NO	NO	0.00	0.06	0.00	0.02	NO	NO	NO	0.00	0.03	NO	NO	0.08

Note: NO = Not Occurring

2.3.5 Waste

2.3.5.1 Methodology

The methodologies and tools used for GHG inventory reporting followed the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). In the Waste sector, the methodologies used varied from Tier 1 to Tier 2, depending on types of activity data and emission factors. Tier 2 was adopted for solid waste disposal and Tier 1 for the rest.

2.3.5.2 Values and Sources of Activity Data

Activity data of the inventory were collected by relevant agencies and delivered to ONEP. Agencies involved in collecting activity data of the Waste sector are affiliated to several ministries as follows:

  • The Pollution Control Department (PCD) and Regional Environment Office (REO) under the Ministry of Natural Resources and Environment

  • The Department of Industrial Works (DIW) and the Office of Industrial Economics (OIE) under the Ministry of Industry

  • The Department of Health (DOH) under the Ministry of Public Health

  • The Department of Local Administration (DLA), Wastewater Management Authority (WMA) and Bangkok Metropolitan Administration (BMA) under the Ministry of Interior

  • The Department of Alternative Energy Development and Efficiency (DEDE) under the Ministry of Energy

The quality of data based on the principles of Transparency, Accuracy, Consistency, Completeness, and Comparability (TACCC) are considered. The data were pre-calculated, transformed, and filled in the Data Entry Template (DET), prior to processing by TGEIS. Separated Excel worksheets were developed to calculate GHG inventory in parallel and to verify the results of TGEIS. The calculation outputs from TGEIS provided by the ONEP inventory team were reviewed and analyzed. The meetings of the GHG Inventory Committee were conducted to consider and approve the results of the GHG Inventory.

2.3.5.3 Emission Factors

Country-specific emission factors were used in solid waste disposal, while 2006 IPCC defaults were for the rest.

2.3.5.4 Greenhouse Gas Emissions 2019

GHG emissions in the Waste sector were mainly from solid waste disposal, at 8,343.31 $GgCO_2eq$ (49.44%), and wastewater treatment and discharge, at 8,214.64 $GgCO_2eq$ (48.67%). Waste incineration accounted for 164.60 $GgCO_2eq$ (0.98%), while biological treatment of solid waste was the smallest proportion of total GHG emissions in this sector, with an amount of 154.10 $GgCO_2eq$ (0.91%). Details of GHG emissions in the Waste sector by types of gases and sources in 2019 are given in Figure 2-8 and Table 2-12.
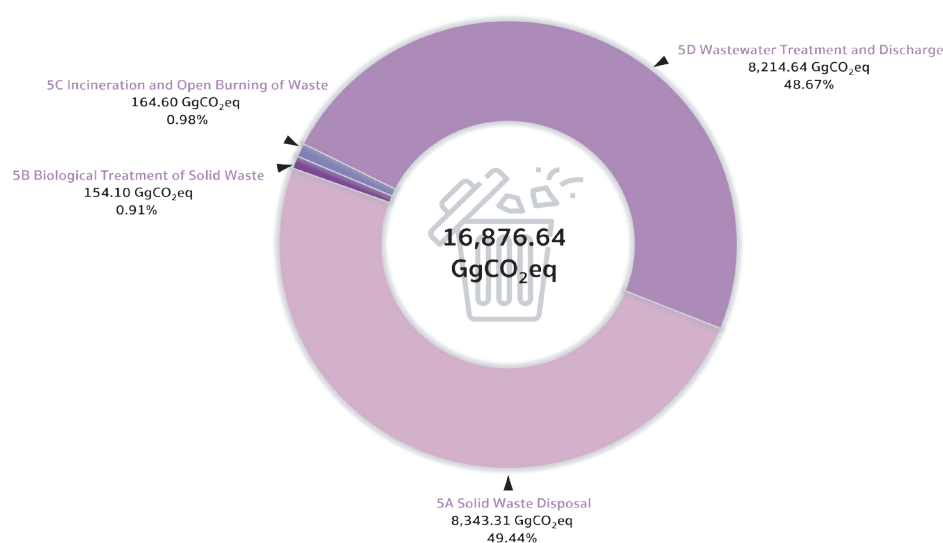

5D Wastewater Treatment and Discharge
8,214.64 $GgCO_2eq$
48.67%

5C Incineration and Open Burning of Waste
164.60 $GgCO_2eq$
0.98%

5B Biological Treatment of Solid Waste
154.10 $GgCO_2eq$
0.91%

16,876.64 $GgCO_2eq$

5A Solid Waste Disposal
8,343.31 $GgCO_2eq$
49.44%

Figure 2-8: GHG emissions in Waste Sector, 2019

Table 2-12: GHG emissions from sources relative to total GHG emissions in the Waste Sector, 2019

Greenhouse gas source and sink categories	CO$_2$ emissions GgCO$_2$eq	CO$_2$ removals GgCO$_2$eq	CH$_4$ Gg	CH$_4$ GgCO$_2$eq	N$_2$O Gg	N$_2$O GgCO$_2$eq	HFCs GgCO$_2$eq	PFCs GgCO$_2$eq	SF$_6$ GgCO$_2$eq	NO$_x$ Gg	CO Gg	NMVOCs Gg	SO$_2$ Gg	Total GgCO$_2$eq
5. Waste	**159.86**		**636.39**	**15,909.90**	**2.71**	**806.88**				**NO, NA**	**NO, NA**	**NA**	**NA**	**16,876.64**
5A Solid Waste Disposal			**333.73**	**8,343.31**								**NA**		**8,343.31**
5A1 Managed Waste Disposal Sites			201.47	5,036.83								NA		5,036.83
5A2 Unmanaged Waste Disposal Sites			132.26	3,306.48								NA		3,306.48
5B Biological Treatment of Solid Waste			**2.89**	**72.31**	**0.27**	**81.79**				**NO**		**NA**		**154.10**
5C Incineration and Open Burning of Waste	**159.86**		**0.002**	**0.06**	**0.02**	**4.68**				**NA**	**NA**	**NA**	**NA**	**164.60**
5C1 Waste Incineration	159.86		0.002	0.06	0.02	4.68				NA	NA	NA	NA	164.60
5D Wastewater Treatment and Discharge			**299.77**	**7,494.22**	**2.42**	**720.42**				**NO**	**NO**	**NA**		**8,214.64**
5D1 Domestic Wastewater Treatment and Discharge			76.73	1,918.15	2.42	720.42								2,638.57
5D2 Industrial Wastewater Treatment and Discharge			223.04	5,576.07										5,576.07

Note: NA = Not Applicable, NO = Not Occurring

2.4 Preparation for the electronic reporting of the information in common reporting tables of the BTR

According to the outcomes of COP24 in Katowice, the key elements were the modalities, procedures and guidelines (MPGs) for the Enhanced Transparency Framework (ETF) under which Parties will start reporting from 2024. The MPGs set out how, under the ETF, biennial transparency reports (BTRs) will be submitted every two years. BTRs are going to supersede the current biennial reporting requirements and the first BTR will be submitted at the latest by 31 December 2024. In addition, Parties may submit their national communication (NC) and BTR as a single report with the option of integrating their BTR into their NC submission by adding more chapters. Parties are, therefore, required to prepare their BTR and NC in accordance with the MPGs included in the annex to decision 18/CMA.1.

The key elements of the BTR for developing countries include:
(1) national greenhouse gas inventory,
(2) information necessary to track progress in implementing and achieving its NDC,
(3) information on climate change impacts and adaptation,
(4) information on financial, technology transfer and capacity building support needed and received, and
(5) information on any support provided.

Thailand, as a developing country, is preparing to complete its first BTR, and the first two elements correspond to the mandatory of the decision 18/CMA.1. In accordance with the MPGs, the national greenhouse gas inventory report consists of a national inventory document and the Common Reporting Table (CRT). Preparation of the CRT to facilitate Thailand's first BTR submitted by December 2024 is elucidated in this section.

In the intervening years, three main processes are promptly stipulated as detailed below.

2.4.1 Scrutiny of a mapping exercise between the 2006 IPCC Guidelines and the CRT template for electronic reporting

Conceptually, all emission sources and removals reported in both NCs and BURs are categorized and presented according to the 2006 IPCC Guidelines. Categories in the CRT template are, however, different from the 2006 IPCC Guidelines in two main features: (1) the categorization of source structure and (2) the reporting of emissions and removals. Examples of the differences are shown below.

1) Categorization of source structure:
• In 1A2 Manufacturing Industries and Construction, there are 13 sub-categories according to the 2006 IPCC Guidelines, but only seven sub-categories remain after grouping the last seven categories into 1A2g Other (please specify) in the CRT template.
• For fugitive emissions from oil and natural gas in the Energy sector, there are two sub-categories, including 1B2a oil and 1B2b natural gas, according to the 2006 IPCC Guidelines. Each sub-category contains three activities and emission sources, i.e., venting, flaring and all others. Alternatively, in the CRT template, emissions from venting and flaring are separated into a new sub-category, 1B2c Venting and Flaring. There are six activities and emission sources of 1B2a oil and 1B2b natural gas reclassified, in addition, containing production and upgrading, transport, refining, distribution of all products, other, and exploration.
• Source structure of the agriculture and LULUCF sectors in the CRT template differs substantially from the 2006 IPCC guidelines. For the Agriculture sector, there are two sub-sectors, comprising of 3A Livestock and 3C Aggregate sources and non-CO_2 emission

sources on land regarding the 2006 IPCC guidelines; however, they are reclassified to be 10 sub-sectors in the CRT template.

2) Reporting of emissions and removals:
- In the IPPU sector, emissions of HFCs and PFCs are reported separately in the 2006 IPCC Guidelines, however, one additional emission from unspecified mix of HFCs and PFCs can be reported in the CRT template.
- Emissions and removals from agriculture and land use, land use change and forestry are reported individually in the CRT template, which is not merged into the AFOLU sector as in the 2006 IPCC Guidelines. Emissions from agriculture are reported in Table 3 Sectoral report for agriculture, while emissions and removals from LULUCF is reported in Table 4 Sectoral report for LULUCF.
- Remarkably, recovering as well as capturing of not only carbon dioxide but also other greenhouse gases, especially Methane and Nitrous oxide, is considered significantly in all sectors. For instance, in the IPPU sector, both fossil and biogenic carbon dioxides are required to be reported in the CRT template. Long term storage of carbon in waste disposal sites is additionally required to be reported in the Memo item of the Waste sector.

Therefore, scrutiny of a mapping exercise of the categories in the 2006 IPCC Guidelines and the CRT template for the electronic reporting to identify differences in category name and to preset the findings of this mapping exercise to improve the national greenhouse gas inventory of the country should be prepared as soon as possible.

2.4.2 Improvement of reporting year and supplement methodologies to fulfil completeness of the national greenhouse gas inventory

Reporting year
According to the annex to decision 18/CMA.1, paragraph 58, the latest reporting year shall be no more than two years prior to submission of its national inventory report; however, for developing country Parties that need flexibility, their latest reporting year can be three years prior to submission of their national inventory report. The latest reporting year of this BUR, the Thailand's fourth BUR, is three years prior to the submission. However, Thailand plans to improve the reporting year as two years prior its first BTR submission in 2024.

Completeness of the national greenhouse gas inventory
Thailand plans to improve the higher tier or supplement methodologies regarding the development of local emission factors in the Energy sector as well as using tools for data collection provided to support operationalization of the web-based inventory system, specifically in the AFOLU sector, in the alignment of the Capacity-building Initiative for Transparency (CBIT), funded by the Green Environment Facility (GEF).

Presently, activity data in the AFOLU have been reported by multiple agencies with different methodologies and formats for data collection, preventing harmonization and comparison of submitted data. They need to be unified through standardized templates and guidelines. Standardized land use maps together with reporting templates for activity data are for supporting data collection processes, enhancing data consistency, transparency, and comparability. The CBIT is targeted towards institutional capacities,

specifically focusing on developing capacities in institutions and providing relevant tools, guidelines, templates, databases, and procedures; and building and enhancing adequate technical and institutional capacities to meet the provisions of the enhanced transparency framework.

In the AFOLU sector, development of aerial photography and satellite image interpretation, utilized in the web-based inventory system (TGEIS) is necessary to facilitate the Forestry sector activity data acquisition. Activities specifically focus on the critical need identified by the stakeholders in the Forestry sector to identify clearly and accurately forested vs. non-forest areas. Incidentally, to develop institutional capacities, the Geo-Informatics and Space Technology Development Agency (GISTDA), which is responsible for space technology and geo-informatics applications of Thailand is being formulated with an official mandate of undertaking satellite interpretation in relation to climate change.

Both forest and non-forest areas, which are the output from aerial photography and satellite image interpretation, are specified and exploited to fulfil the completeness the national inventory report of Thailand, especially GHG emissions from wetlands, which is a problematic estimation currently. Generally, overall land use area is classified into 23 types, i.e., 13 forest types, five plantations, rice field, savanna, settlement, freshwater and others. In Thailand, wetland, which mostly includes peat swamp and mangrove forests, accounts for around 2,914 square kilometers or less than one percent of overall land use area of Thailand. Thus, development of satellite image interpretation could enable transparent, accurate, and consistent estimation of GHG emissions in not only wetland but also other land use areas in the AFOLU sector such as plantations and rice fields.

2.4.3 Enhancement of Thailand's Greenhouse Gas Emission Inventory System according to the CRT template on electronic report

Thailand's Greenhouse Gas Emission Inventory System or TGEIS is a tool to support robust and clear national inventory system governance and institutional arrangements in the process of calculating the national GHG inventory for Thailand. TGEIS is supported by the Australian government to improve the MRV framework for climate action at the national level, which will eventually facilitate the preparation of NCs and BURs according to the UNFCCC's requirements. TGEIS is designed to produce timely, high quality and transparent GHG emission data using 2006 IPCC Guidelines. Hence, to enhance the transparency framework, TGEIS's database is required to be revised according to the CRT template in two main important issues.

Firstly, the 100-year time-horizon Global Warming Potential (GWP) database needs to be revised. Currently, variable GWP values programmed in the TGEIS are obtained from the IPCC Second and Fourth Assessment Reports. According to the annex to decision 18/CMA.1, paragraph 37, the GWP values from the IPCC Fifth Assessment Reports (AR5) are required to use and report aggregated emissions and removals of GHGs, expressed in CO_2eq.

Secondly, GHG emissions and removals exported from the TGEIS to the CRT template need to be assembled. GHG emissions and removals exported from the TGEIS currently provide information on the categories and gases used at the most disaggregated levels according to the IPCC guidelines.
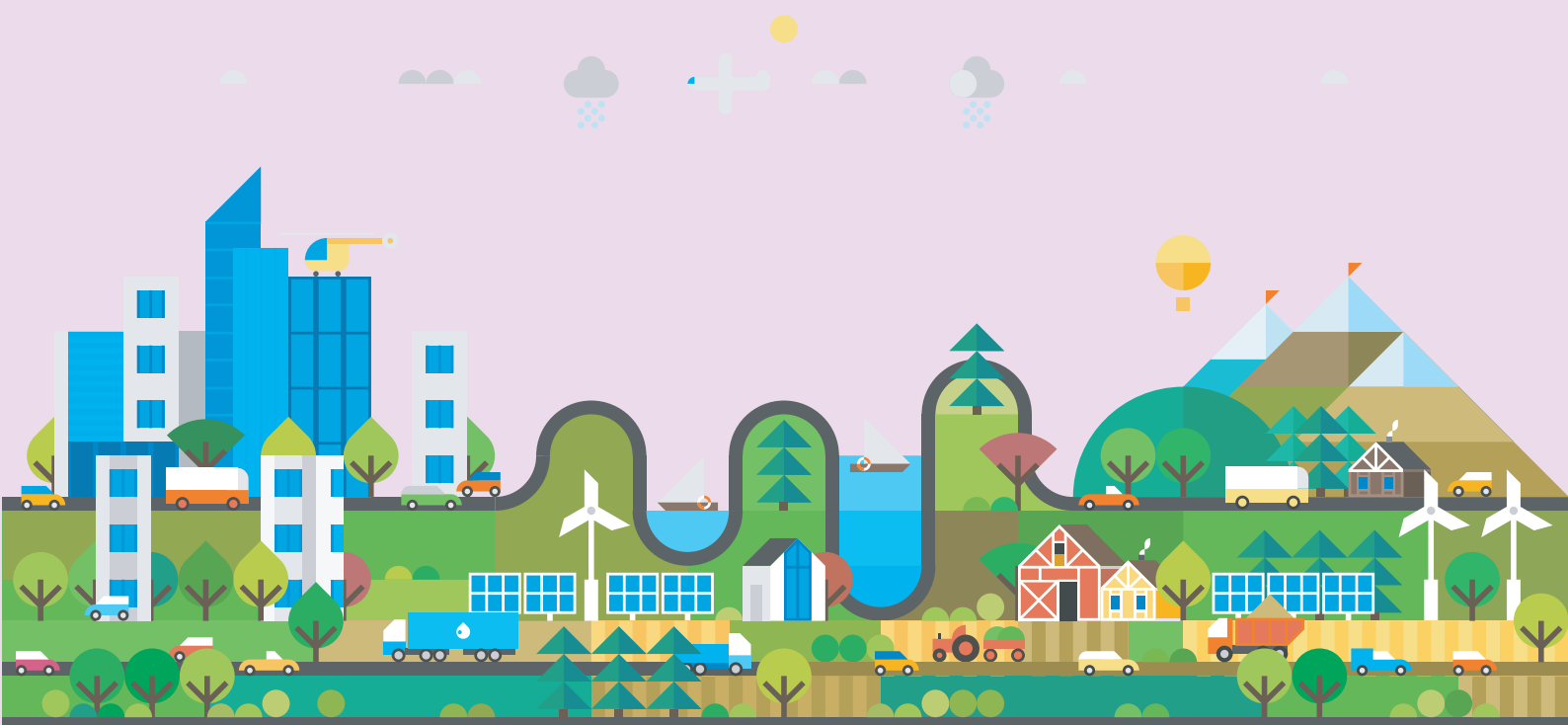
MITIGATION
MEASURES

CHAPTER 3 :
MITIGATION
MEASURES

Thailand has put all efforts within its capacity to uphold its commitment under the Convention by integrating climate change mitigation into its national and sectoral policies and plans and implementing mitigating measures to achieve the national GHG reduction targets—NAMA's target to reduce GHG emission by 7-20% from BAU by 2020 and the 1st updated NDC's target to reduce GHG emission by 20-25% from BAU by 2030. However, Thailand communicated its 2nd updated NDC to UNFCCC on 2 November 2022. The 2nd updated NDC aligns with an ambitious pledge to reduce GHG emissions by 30 % from the BAU level by 2030. The contribution level increases up to 40%, subject to adequate and enhanced access to technology development and transfer, financial resources, and capacity-building support. Furthermore, Thailand will continue efforts to meet the long-term goals of carbon neutrality by 2050 and net-zero GHG emissions by 2065.

This chapter lays out Thailand's national, sectoral, and municipal mitigation policies and plans. The national plans include the 20-Year National Strategy, 12th and 13th National Economic and Social Development Plans, Climate Change Master Plan, Nationally Appropriate Mitigation Action (NAMA), Thailand's Nationally Determined Contribution (NDC), and Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS). Aligning with the economy as a whole, the climate mitigation agenda is also incorporated into sectoral plans in emission-intensive sectors—energy, transport, IPPU, and waste sectors.

Subsequently, this chapter sums up the overall implementation of NAMA's measures, GHG reduction achievement, and the transition towards the NDC implementation. It further illustrates other mitigation actions, including voluntary actions from the carbon market and carbon label schemes which are increasingly developed.

3.1 Policies and plans

Thailand has integrated the climate change agenda into its national, sectoral, and municipal policies and plans to address the problem systematically and effectively.

3.1.1 National Plans

The climate change agenda, particularly climate mitigation, has been incorporated into national development policies, strategies, and plans, including the 20-year National Strategy, the 12th National Economic and Social Development Plan, the Climate Change Master Plan, the Nationally Appropriate Mitigation Action (NAMA), the Nationally Determined Contribution (NDC), and the Long-Term Low Greenhouse Gas Emission Development Strategy.

The 20-Year National Strategy 2018 – 2037

The 20-Year National Strategy (2018-2037) is the country's first national long-term strategy developed pursuant to Section 65 of the Constitution which stipulates that the State should develop a national strategy to be employed as the country's goal for sustainable national development in accordance with the principle of good governance. One of the key strategies is "Eco-Friendly Development and Growth," aiming to 1) conserve and preserve natural resources and environment as well as culture for the next generation's sustainability, 2) restore and reconstruct natural resources and the environment for mitigation of negative impacts that may arise from national economic and social development, 3) ensure balanced utilization of the natural resource and environmental base by balancing development with ecosystem capacity, and 4) ensure the country's paradigm shift for the determination of the country's natural resources and environment, as well as culture, based on good governance and public participation. This development strategy seeks to achieve all development aspects of the Sustainable Development Goals (SDGs), including promoting mutual growth in terms of the economy, environment, and quality of life. The focus is to create balance among these three factors to promote sustainability for future generations.

The National Strategy recognizes that climate change impacts have been anticipated to intensify concerning variability, frequency, and coverage. Such impacts will inevitably threaten lives, damage properties and necessary infrastructure, and affect agricultural production and water security. At the same time, ecological systems are likely to deteriorate. Given this recognition, greenhouse gas (GHG) emissions and values of the bio-economy are one of the key indicators for this development goal.

The strategic guideline to promote sustainable climate-friendly based society growth focuses on the following points:

• Mitigation measures: reducing greenhouse gas emissions and promoting a low-carbon society, supporting agricultural management to benefit from greenhouse gas reductions, accelerating the restoration of deteriorated forests, and expanding forest areas to function as carbon storage areas.

• Adaptation measures: improving the overall disaster management system, enhancing people's capacity to cope with and adjust to any harmful impact caused by climate change, and developing preparedness and response systems for emerging and reemerging infectious diseases caused by climate change.

• Enabling measures: developing a database system, promoting low-carbon products and services to systematically reinforce national competitiveness, developing economic measures to incentivize investments that cope with climate change, encouraging businesses to plan for climate change, and improving relevant laws to drive climate change management.

Source: The 20-Year National Strategy 2018 – 2037

The 12th National Economic and Social Development Plan 2017-2021

The 12th National Economic and Social Development Plan 2017-2021 recognizes that climate change and natural disasters have become more unpredictable and severe, particularly floods and droughts, causing impacts on the economic sectors and the domestic supply chain. Plus, international agreements on climate change and competitive trade have intensified.

Thus, the fourth strategy, "Strategy for Environmental-Friendly Growth for Sustainable Development," seeks to improve greenhouse gas reduction and adaptation capacity, lessen the impacts of climate change, and improve the response to natural disasters. For this target, key indicators include: 1) the volume of greenhouse gas emissions in the energy and transport sectors decreases by 7 % compared to the business as usual scenario for 2030, 2) the unit costs of GHG emissions reduction decrease (THB per ton of carbon dioxide equivalent), 3) there are action plans for adaptation to climate change in each of the priority sectors, such as water resources management, agriculture, health and forestry, and 4) domestic climate change mitigation mechanisms are established to provide support in terms of finance, technology, and capacity building.

The development guidelines to support greenhouse gas reduction as well as enhance adaptive capacity to climate change are as follows:

• Draft and amend laws and regulations related to climate change so that they can respond to international climate change agreements in an integrated and comprehensive manner.

• Prescribe measures and mechanisms to support greenhouse gas reduction in all sectors, emphasizing the following sectors: electricity generation, transport, industry, households, and buildings. Reduce the use of fossil fuels in generating power while promoting renewable energy, energy-saving, and waste-to-energy. Build the capacity of the workforce to excel in various forms of renewable energy. Support sustainable transport systems, and increase the efficiency of engines, machines, and instruments. Foster the establishment of financial mechanisms between the public and private sectors to support climate change actions that generate co-benefits. Moreover, encourage the private sector to invest more in greenhouse gas reduction.

• Promote the private sector, state enterprises, and local administrations to collect and report information regarding greenhouse gas emissions from energy usage.

• Enhance the capacity of R&D in science, technology, and innovation (ST&I) to support climate change adaptation.

• Create knowledge and understanding and raise awareness and public participation from all stakeholders in response to climate change impacts.

Policy and Plan for Enhancement and Conservation of National Environmental Quality 2017 – 2036

Under section 13 (1) of the Enhancement and Conservation of National Environmental Quality Act 1992, the Office of Natural Resources and Environmental Policy and Planning (ONEP) has prepared the Policy and Plan for the Enhancement and Conservation of Environmental Quality 2017 – 2036 as a framework for managing natural resources and the environment of the country in the next 20 years. The objectives are to be a policy framework and direction for integrally managing natural resources and the environment over the next 20 years; for all relevant sectors to use it as a guideline for the preparation of master plans and action plans in the medium-term

(5 years) to achieve appropriate, proactive, and efficient natural resource and environmental management; and to enhance the environmental management capacity which would enable environmental-friendly economic and social growth, promote equilibrium and sustainable development, and keep pace with global and regional changes.

The management of natural resources and the environment is based on ten principles— Sustainable Development, Ecosystem Approach, Precautionary Principle, Polluters Pay Principle (PPP), Beneficiaries Pay Principle: BPP, Public-Private Partnership, Good Governance, Extended Producer Responsibility (EPR), Resource Decoupling/Resource Efficiency, and Human Rights—translating into four main policies as follows:

1) A policy to manage natural resources based on balance, fairness, and sustainability: It focuses on maintaining national biodiversity and balance of the ecosystem, which are the sources of food, water, and energy security. It aims to create a system that enables fair access, sharing, and utilizing of natural resources within their limits of regenerating capacity.

2) A policy to generate environmental-friendly growth for wealth and prosperity: It seeks to provide people with a safe and quality environment, enhance an eco-friendly economy, and promote a production and consumption system with effective and efficient natural resource exploitation causing minimum waste and pollution.

3) A policy to enhance measures in natural resource and environmental management: It targets creation of legal, financial, technical, and technology development mechanisms that enhance the capacity of natural resource management to be efficient and proactive and support environmental-friendly development and growth.

4) A policy to create partnerships in natural resource and environmental management: It aims to involve all sectors in managing and exploiting natural resources and the environment in the form of mutual ownership by encouraging all sectors to learn and have joint responsibility with the government, including enhancing the capacity for international environmental cooperation.

Climate Change Master Plan (2015-2050)

Aligning with the 20-Year National Strategy and the 12th National Economic and Social Development Plan, Thailand's Climate Change Master Plan (CCMP) aims for Thailand to be resilient to the impacts of climate change and to achieve low carbon growth through sustainable development. The objectives of the plan are 1) to provide a long-term national framework for climate change adaptation and low carbon growth promotion according to the sustainable development principle; 2) to provide a policy framework for the development of mechanisms and tools at the sectoral and national level in order to achieve effective resolutions for climate change, 3) to provide government agencies and relevant organizations with a framework for detailed action plans; facilitating awareness and mutual understanding by means of a common framework of reference points, thereby increasing integration and reducing redundant processes, and 4) to provide budgeting agencies with a clear framework for budget allocation, thus enabling the mobilization of concrete climate change resolutions. The Master Plan also consists of three key strategies: climate change adaptation, mitigation, low carbon development, and enabling environment on climate change management. The implementation of these three strategies is divided into three phases: short-term 2016, medium-term 2020, and long-term 2050. The CCMP is subject to be revised according to the updated Nationally Determined Contribution and Long-Term Strategy Target.

The CCMP Strategy 2 "Mitigation and low carbon development" comprises actions and measures in the following eight sectors:

• Power generation and energy supply—focusing on decreasing fossil fuel consumption, increasing/developing renewable energy production, and developing infrastructure which facilitates low carbon development while simultaneously lowering GHG emissions

• Transport—focusing on increasing the efficiency of transport and logistics, developing low carbon transport infrastructure, and applying sustainable principles to manage transport demand

• Energy consumption in buildings—focusing on improving energy conservation and efficiency in buildings

• Industry—focusing on improving the performance of machinery, energy efficiency, and waste reduction through measures such as the promotion of renewable energy production and consumption, and investments in low-carbon and environmentally friendly industries

• Waste management—focusing on integrated life cycle waste management by prioritizing source reduction and the 3Rs (Reduce, Reuse, Recycle) in accordance with the waste hierarchy. Waste management efficiency will be increased by supporting waste-to-energy programs.

• Agriculture—focusing on low emission agricultural practices with environmental and financial co-benefits; increasing the capacity of farmers to accommodate GHG reduction technologies and management systems

• Forestry—focusing on creating carbon sinks via forest conservation, restoration, reforestation, and afforestation. Measures that affect communities in forested areas should be evaluated on the merits of their environmental and social impact via public hearings of sufficient duration and transparency, which will aid the decision and policy-making processes

• Urban management—focusing on increasing urban green spaces to act as carbon and pollution sinks which can also help mitigate GHG emissions from human activities in major cities.
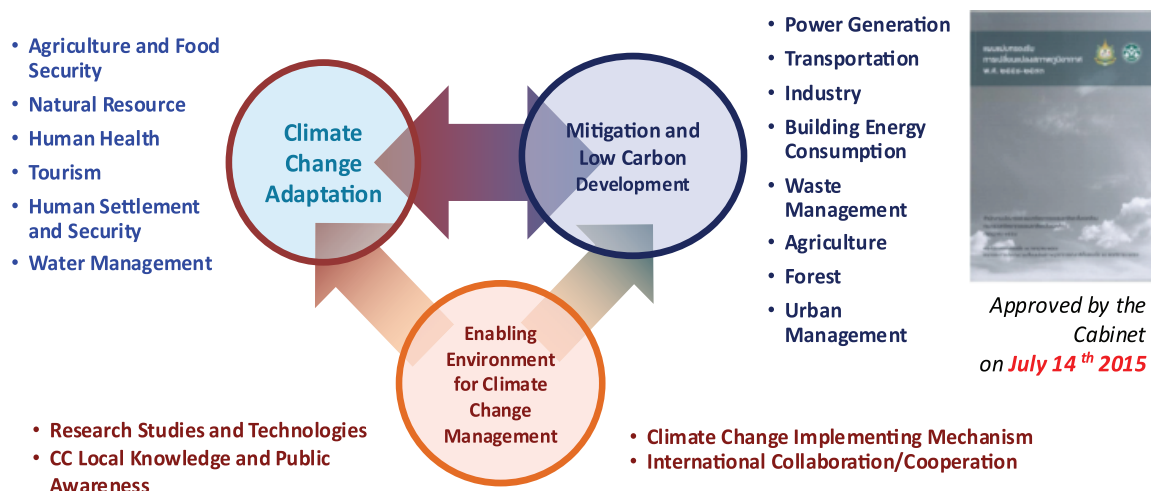
Climate Change Master Plan (2015-2050)

Figure 3-1: Overview of Climate Change Master Plan 2015-2050

Source: 1) Thailand's Climate Change Master Plan (2015-2050) 2) Office of Natural Resources and Environmental Policies and Planning (ONEP)

Nationally Appropriate Mitigation Action (NAMA)

Thailand's GHG mitigation goal committed to UNFCCC can be divided into two phases: pre-2020 and post-2020. For the pre-2020 phase, Thailand's Nationally Appropriate Mitigation Action (NAMA) pledged in 2014 to reduce national GHG emissions in the range of 7-20% under the business-as-usual (BAU) scenario in energy and transport sectors by 2020, subject to the level of

international support provided. The details of the NAMA Roadmap and its progress were reported in the BUR3. Thailand had implemented NAMA Roadmap and Action Plan and achieved a GHG emission reduction of 15.4% from BAU by 2020. The overall NAMA implementation will be illustrated in section 3.2, "Mitigation Measures" of this chapter.
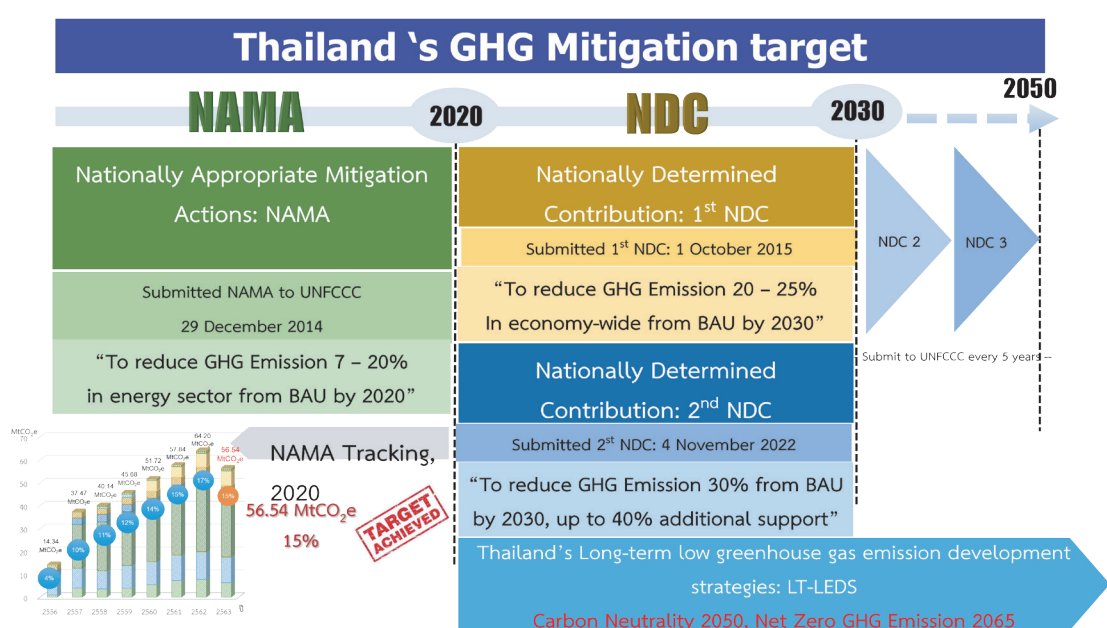
Figure 3-2: Thailand's GHG Mitigation Target

Source: 1) Thailand Third Biennial Update Report 2) Office of Natural Resources and Environmental Policies and Planning (ONEP)

Thailand's Nationally Determined Contribution (NDC)

For the post-2020 phase, on 1 October 2015, Thailand submitted its Intended Nationally Determined Contribution (INDC) to UNFCCC. It later launched Thailand's Nationally Determined Contribution (NDC) Roadmap and Action Plan in 2017 with the target to reduce its GHG emissions by 20-25% from the projected BAU level by 2030. The NDC Roadmap established a framework for

mitigation measures in Energy, Transport, IPPU, and Waste sectors. To achieve the NDC targets, key agencies have developed NDC Sectoral Action Plans on greenhouse gas mitigation corresponding to the NDC Roadmap to ensure the achievement of the pledged target of a 20% reduction from the 2030 BAU. In addition, key agencies, NDC sectoral focal points, developed the Supportive Action Plan, which aims to create an enabling environment to support the NDC implementation.
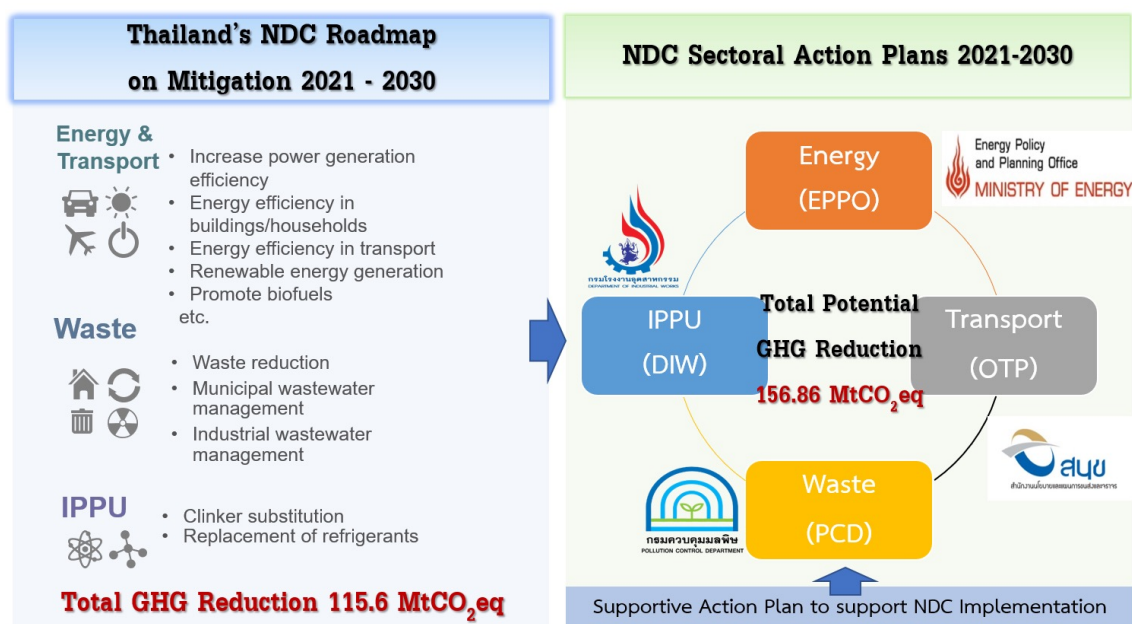
Figure 3-3: Overview of Thailand's NDC Roadmap and Action Plan

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

• NDC Sectoral Action Plan for the Energy Sector 2021 – 2030

The National Climate Change Policy Committee (NCCC) assigned the Energy Policy and Planning Office (EPPO) to be the main responsible agency for the preparation of the national greenhouse gas reduction action plan for 2021 – 2030 in the energy sector, together with the Office of Natural Resources and Environment Policy and Plan (ONEP) and Greenhouse Gas Management Organization (TGO). EPPO, ONEP, and TGO cooperate with related agencies, such as the Department of Alternative Energy Development and Efficiency (DEDE), Electricity Generating Authority of Thailand (EGAT), Office of the Energy Regulatory Commission (OEC), Office of Transport Policy and Planning, and Traffic (OTP), Chiang Mai University, and private power producers to prepare the details for the draft action plan on national GHG emissions in the energy sector, which consists of three key plans:

1) Energy Efficiency Plan (EEP2015) aims to reduce energy intensity (EI) by 30% in 2036 compared to 2010, which will be implemented in four economic sectors: industrial, business and government buildings, residential, and transportation sectors.

2) Alternative Energy Development Plan 2015 – 2036 (AEDP2015) aims to increase the share of renewable energy consumption by considering the potential for renewable energy sources that can be developed in the form of electricity, heat, and biofuels accounting for 30% of final energy consumption by 2036.

3) Power Development Plan 2018 – 2037 (Power Development Plan: PDP2018) has four main guidelines: 1) promote renewable power generation, 2) allocate main power plants for regional energy security according to the necessity and sufficiency to maintain the stability of the electricity system, 3) renewable energy has an annual purchase policy under the renewable energy generation policy, and it is purchased at a price not exceeding Grid Parity to prevent the retail electricity price from rising, and

4) energy conservation policy can prove convincing with quality and compete with prices not exceeding the Grid Parity.

The NDC Sectoral Action Plan for energy sector 2021 – 2030 aims to reduce greenhouse gases by at least 82 million tCO_2 by 2030, compared to a business-as-usual case. The plan laid down three strategies for greenhouse gas reduction operations: drive GHG reduction in the energy sector, prepare a long-term strategy for GHG reduction in the energy sector, and create a network of public, private, and public partnerships.

Source: Source: The Energy Policy and Planning Office (EPPO)

• NDC Sectoral Action Plan for the Transport Sector 2021 – 2030

The Office of Transport and Traffic Policy and Planning (OTP) has developed the NDC Sectoral Action Plan for Transport Sector 2021 – 2030, which aims to reduce GHGs by millions of tons of carbon dioxide equivalent with four key strategies: 1) supporting and promoting the implementing programs in the transport sector, 2) developing and improving laws supporting GHG reduction, 3) developing measurement, reporting and verification (MRV), and 4) engaging and strengthening the capacity of all agencies to reduce GHGs. An emphasis is on developing efficient and sustainable transportation systems to reduce energy consumption in the transportation sector, lessen traffic congestion, create livable cities, and reduce greenhouse gas emissions, which will lead to stable and sustainable economic growth. Three key measures are as follows:

1) Avoid: developing policies that encourage people to avoid travel or reduce unnecessary travel distances by integrating urban planning with appropriate transportation planning, such as developing living spaces in compact areas, the development of the area

around transit-oriented development (TOD), and work-from-home measures promotion.

2) Switch: developing policies that encourage people to switch from using private vehicles to more efficient and environmentally friendly forms of travel, including public transport and motorless travel (cycling and walking).

3) Improve: developing policies that improve energy efficiency in motor vehicles and fuel efficiencies such as automotive energy-saving technology, alternative energy consumption, promoting gasohol oil consumption, and promoting electric vehicles and bicycles.

• NDC Sectoral Action Plan for the IPPU Sector 2021 – 2030

The Department of Industrial Works (DIW) has prepared the NDC Sectoral Action Plan for IPPU Sector 2021 – 2030 to reduce greenhouse gas emissions in the IPPU sector by setting targets for implementation in 2 phases: 1) Preparation phase (2019 - 2020) is to be completed in 2020, which is a preparation to support the implementation of measures according to the NDC roadmap starting in the year 2021; 2) Action Phase (2021 - 2030) has targets for driving key measures and supporting measures to reduce GHG emissions in the IPPU sector, including wastewater from industries to achieve the goal within the year 2030 according to the NDC Roadmap and Action Plan.

The NDC Sectoral Action Plan for IPPU and industrial wastewater consists of three main measures:

1) Clinker substitution measures with two sub-activities: the use of clinker substitutes in the hydraulic cement production process and the increased use of cement substitutes in ready-mixed concrete.

2) Refrigerant replacement measures with

two sub-activities: refrigerant modification under the RAC NAMA project and the proper disposal of waste and deteriorated refrigerant.

3) Measures to manage industrial wastewater: consistent and with the potential to reduce GHG emissions according to the NDC goals guideline, such as measures to increase biogas production from industrial wastewater by reusing methane gas according to the Alternative Energy Development Plan 2015 – 2036 (AEDP2015), which sets goals for the use of biogas from industrial wastewater, agricultural waste ranches, and community waste to be utilized to generate electricity and heat.

• NDC Sectoral Action Plan for the Waste Sector 2021 – 2030

In conjunction with the relevant authorities, the Pollution Control Department (PCD) has developed the NDC Sectoral Action Plan for Waste Sector 2021-2030, targeting a reduction in GHG emissions of 2.0 million tCO_2eq from municipal solid waste and municipal and industrial wastewater. 65% of this target (1.3 million tCO_2eq) is expected to come from implementing measures in the municipal solid waste sector, while 35% (0.7 million tCO_2eq) is expected from implementing measures in wastewater management. The plan is divided into two parts: 1) the NDC Action Plan in the municipal waste management sector, prepared by the Pollution Control Department, Ministry of Natural Resources and Environment, and 2) the NDC Action Plan in the industrial processes and product use, including the industrial wastewater sector, prepared by the Department of Industrial Works, Ministry of Industry.

The prospective mitigation measures in municipal solid waste management include: 1) landfill gas utilization, 2) waste to energy, 3) composting, 4) semi-aerobic landfills, 5) anaerobic digestion,

and 6) mechanical biological treatment, whereas the potential mitigation measure in industrial wastewater management is methane recovery from industrial wastewater treatment. The MRV systems for implementation of NDC measures, including landfill gas utilization, waste to energy, composting, and methane recovery from industrial wastewater treatment, have been accomplished. Additionally, supportive mechanisms for effective implementation of the sectoral action plans in the waste sector, such as research and development, capacity building, and stakeholder engagement, are being executed.

The Second Updated Thailand's Nationally Determined Contribution (2nd Updated NDC)

At the World Leader Summit COP26 on 1 November 2021, Thailand's Prime Minister expressed Thailand's intention to fully elevate climate mitigation measures. Thailand aims to achieve carbon neutrality by 2050 and net-zero Greenhouse Gas emissions by 2065. Furthermore, Thailand aims to increase the NDC target to reduce 40 % of GHG emissions compared to BAU by 2030, given that the international community, through the mechanism of the Convention, can provide necessary financial, technical, technology, and capacity-building support. Based on a more ambitious pledge, Thailand updated the Nationally Determined Contribution (NDC) and Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDs) to reflect national targets aligned with the Prime Minister's statement. The 2nd Updated NDC was submitted to the UNFCCC on 4 November 2022.

The 2nd updated NDC framework of Thailand is similar to that of Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS). The 2nd updated NDC is conducted with reference to the planned implementation goals of

each relevant Ministry in the energy, IPPU, Agriculture, LULUCF, and waste management sectors. The plans include the Energy Efficiency Plan 2018 – 2037 (EEP2018), the Alternative Energy Development Plan 2018 – 2037 (AEDP2018), the Power Development Plan 2018 – 2037 No. 1 revised edition (PDP2018 Rev.1), and the guidelines for the promotion of electric vehicles (EV) of the country according to the 30@30 policy. Measures from the agricultural sector were incorporated into the 2nd updated NDC goal and guidelines to reduce greenhouse gas emissions. The 2nd updated NDC guidelines and measures include:

- Energy and transport sector: The energy sector is the sector with the most significant potential to reduce greenhouse gas emissions. It includes measures to increase the energy efficiency of equipment/machines in power plants and renewable energy utilization.
- IPPU sector, comprising clinker substitution measures and refrigerant replacement
- Waste management sector consists of municipal solid waste management, domestic wastewater management, and industrial wastewater management.
- Agriculture sector consists of fixed dome digester biogas production measures and improvements in rice farming to reduce methane emissions.

Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS)

The implementation of Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy is in accordance with Article 4 of the Paris Agreement, which requires all countries to develop and communicate a long-term strategy for low GHG emission development to the UNFCCC Secretariat aiming to limit global temperature from rising above 2°C or 1.5°C. Thailand has set long-term targets and guidelines for GHG reduction toward carbon neutrality by 2050 and net-zero emission in 2065 by identifying key measures in the sectors of energy, transport, IPPU,

waste, agriculture, and LULUCF, which is the GHG removal sector of the country, for relevant agencies and sectors to use as operational guidelines.

The revised and updated LT-LEDS and NDC, communicated to UNFCCC in 2022, were supported by the Deutsche Gesellshaft für Internationale Zusammenarbeit (GIZ) GmbH. The updated LT-LEDS was submitted to the UNFCCC on 7 November 2022 and sets goals and measures aligned with an increase in global average temperatures of 1.5°C and moving toward carbon neutrality by 2050. The analyses employ the end-use approach of Asia-Pacific Integrated Assessment Model (AIM) to project the long-term low-level greenhouse gas emissions, including remedial policy measures for climate change adaptation action, and use the computable general equilibrium model of AIM model to assess the economic and environmental impacts of energy policy and others in the development of LT-LEDS. The current national plans used to develop and define LT-LEDS are as follows:

- 20-Year National Strategy 2018-2037
- Climate Change Master Plan 2015-2050
- Thailand Nationally Determined Contribution (NDC) 2021-2030
- National Energy Plan 2022
- Energy Efficiency Plan 2018-2037 (EEP 2018)
- Alternative Energy Development Plan 2018-2037 (AEDP 2018)
- Power Development Plan 2018-2037 (PDP 2018 Rev.1)
- The guideline for promoting electric vehicles (EV) under policy 30@30.
- National Industrial Development Master Plan 2012-2031
- Industrial Development Strategy of Thailand 4.0 2017-2036
- Thailand Forest Reference Emission Level and Forest Reference Level REDD+ under the UNFCCC
- 20-Year Strategy of the Royal Forest Department 2017-2036
- 20-Year Agriculture and Cooperative Strategy 2017–2036

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

3.1.2 Sectoral Plans

3.1.2.1 Energy Sector

Moving towards Carbon Neutrality in 2050, the Ministry of Energy is developing details in the National Energy Plan 2022 Framework, consisting of five key plans:

1) Power Development Plan 2018-2037 (PDP): The plan includes constructing new power plants with clean energy sources; phasing out fossil-fuel power plants; enhancing CCUS technology; developing an energy management system and energy forecast system; liberalizing the energy business; creating the wheeling charge system; and promoting an EV and EV charging station production and purchasing system.

2) Alternative Energy Development Plan 2018-2037 (AEDP): It aims to increase the renewable energy generation target and investment; enhance the renewable energy (RE) management and trade; develop RE at community levels to elevate farmers' standard of living and grassroots economy; formulate a Data Platform and RE control center; research and develop hydrogen utilization; and develop a Bio Circular Economy, carbon credits mechanism and RECs, and biofuel market for energy and heat production.

3) Energy Efficiency Plan 2018-2037 (EEP): It seeks to enhance energy efficiency in buildings, industries, and households; promote green industries and Smart Energy Management; and develop digital and EV Data platforms and charging stations to promote electric vehicle utilization

4) Gas Plan 2018-2037: Its targets include enhancing LNG importation and management; promoting LNG use in industrial and transportation sectors; developing capacity assessment and management systems; and managing land-based and marine-based gas sources.

5) Oil Plan 2018-2037: It intends to improve the standard of an oil refinery to EURO 5 and 6 and LNG and NGV management; promote proper biofuel utilization in the transportation sector; develop an oil database and control system; reconstruct oil price and reduce biofuel cost; and manage oil industry to accommodate EV utilization.

The policy direction of the National Energy Plan Framework has 4 targets: increasing renewable energy to at least 50 %, transitioning the energy used in transportation to green energy by promoting electric vehicles to reduce GHG emissions and particulate matters, increasing energy efficiency by 30 % by utilizing technology and innovation to optimize energy efficiency and management, and modifying the energy business structure to embrace energy transition according to the 4D1E framework (Decarbonization, Digitalization, Decentralization, Deregulation, and Electrification).

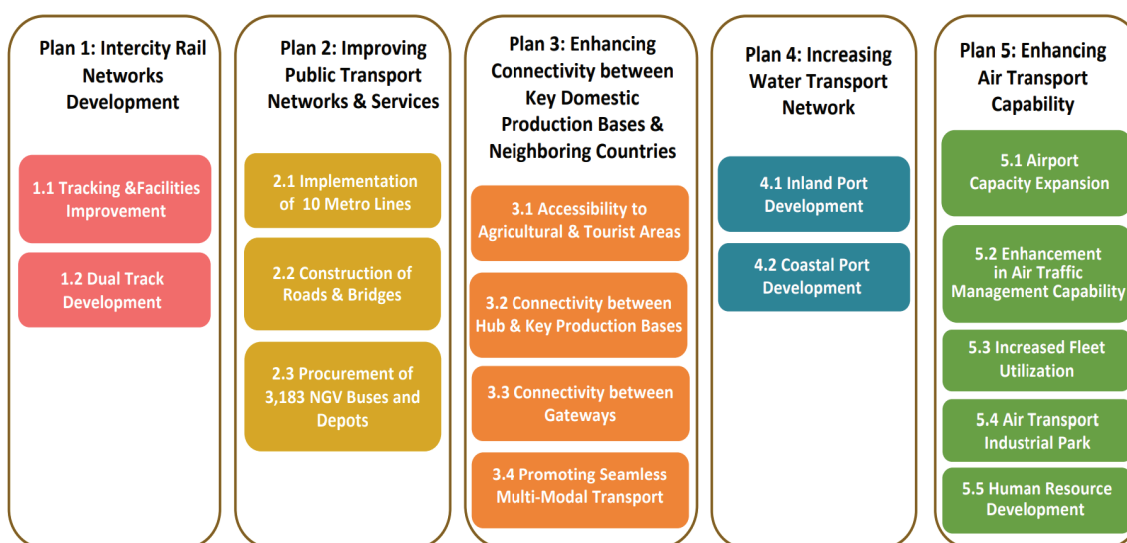**Figure 3-4:** Policy Direction of National Energy Plan 2022

Source: The Energy Policy and Planning Office (EPPO)

3.1.2.2 Transport Sector

Thailand's Transport Infrastructure Development Plan 2015-2022

Thailand's Transport Infrastructure Development Plan 2015-2022 is a development framework that seeks to improve people's quality of life by mobilizing long-term economic and social development, creating jobs, distributing income,

Development Master Plan 2012-2031 aims to achieve sustainable production that considers social and environmental considerations "Environmentally Friendly - Green and Clean." The development in the industrial sector should reflect a green growth industry, climate resilient society, and low carbon society. Therefore, the industrial development framework in the master plan aims to strike a balance between 4 dimensions: 1) Enhancing

Plan 1: Intercity Rail Networks Development	Plan 2: Improving Public Transport Networks & Services	Plan 3: Enhancing Connectivity between Key Domestic Production Bases & Neighboring Countries	Plan 4: Increasing Water Transport Network	Plan 5: Enhancing Air Transport Capability
1.1 Tracking &Facilities Improvement	2.1 Implementation of 10 Metro Lines	3.1 Accessibility to Agricultural & Tourist Areas	4.1 Inland Port Development	5.1 Airport Capacity Expansion
1.2 Dual Track Development	2.2 Construction of Roads & Bridges	3.2 Connectivity between Hub & Key Production Bases	4.2 Coastal Port Development	5.2 Enhancement in Air Traffic Management Capability
	2.3 Procurement of 3,183 NGV Buses and Depots	3.3 Connectivity between Gateways		5.3 Increased Fleet Utilization
		3.4 Promoting Seamless Multi-Modal Transport		5.4 Air Transport Industrial Park
				5.5 Human Resource Development

Figure 3-5: Thailand's Transport Infrastructure Development Action Plan

Source: Office of Transport and Traffic Policy and Planning (OTP)

stimulating the economy, and ensuring the safety of people's lives and properties. Five action plans are developing an intercity rail network; improving public transport networks; enhancing connectivity between key domestic production bases and neighboring countries; increasing water transport networks; and enhancing air transport capability.

economic wealth and security, 2) Utilizing human wisdom for innovation and value creation for sustainable development, 3) Securing social well-being and reducing social inequality, and 4) Promoting environmental wellness to raise public awareness for environmental conservation, and improving regulations and their enforcement to support environmental-friendly production and eliminate negative externalities.

3.1.2.3 Industrial Sector

National Industrial Development Master Plan 2012-2031

As climate change is one of the key factors affecting the changing dynamic of the Thai industrial sector, the National Industrial

Thailand's Industrial Development Strategy 4.0 (2017-2036)

In the fourth phase of industrial development, Thailand seeks to shift the paradigm into an

innovative drive economy targeting prosperity, security, and sustainability through three mechanisms: productive growth engine, inclusive growth engine, and green growth engine. The green growth engine focuses on environmental-friendly technology development and renewable energy transition. Development perspective shifts from cost advantage to lost advantage— considering the benefits from overall loss mitigation. The cornerstone is ensuring that the production process internalizes the negative externalities and minimizes adverse environmental effects. The green growth engine solves the "inequitable development trap" between the environment and human needs. The phases and mechanisms of industrial development in Thailand are illustrated in Figure 3-6.

Thailand's Green Industry Initiative is implemented on a voluntary basis to conduct business in a community and environmentally friendly manner for sustainable development. Green industry means industry committed to continuously improving production processes and environmental-friendly business management and adhering to business operations with the responsibility to society both inside and outside the organization throughout the supply chain. The Ministry of Industry promotes the industry sector in Thailand to achieve environmentally and socially friendly operations by encouraging establishments nationwide to integrate environmental-friendly practices into business operations and continue to evolve into green industries on five levels. The industries can acquire benefits according to the level achieved such as using Green Industry logo or acquiring governmental procurement. The five levels of implementation are as follows:
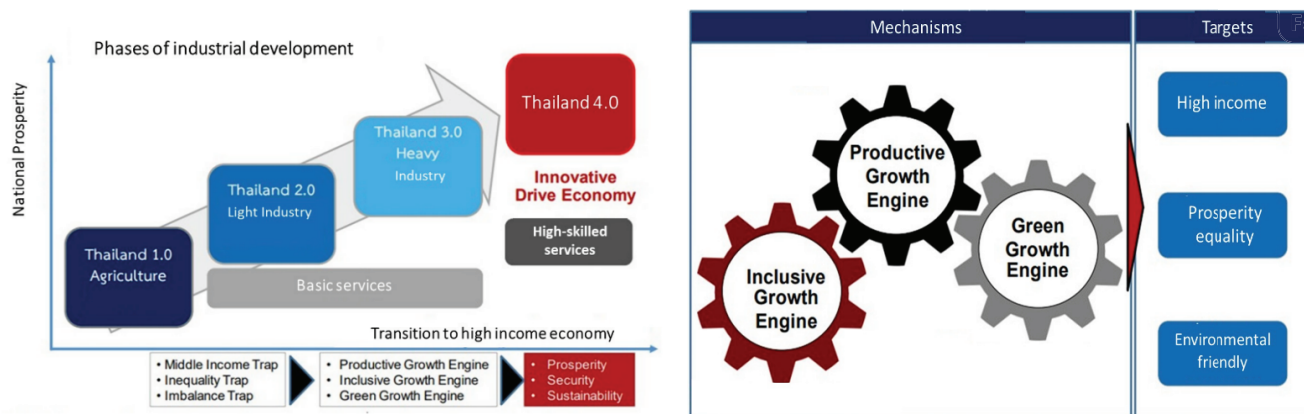
Figure 3-6: Industrial development phases of Thailand and mechanisms for industrial development 4.0

Source: 1) National Industrial Development Master Plan 2012-2031 2) Thailand's Industrial Development Strategy 4.0 (2017-2036)

Green Industry

The Ministry of Industry launched Thailand's Green Industry Initiative and established two implementation guidelines:

1. Set guidelines and create a concrete green industry under two main concepts: continuous improvement and sustainable development

2. Integrate environmentally relevant projects of all departments within the Ministry of Industry under the green industry projects

• Level 1 Green Commitment is a manifestation of commitment in the form of policies, goals, and plans to reduce environmental impacts and have communications within the organization.

• Level 2: Green Activity is the implementation of policies by having goals and a roadmap to reduce environmental impacts in a concrete way and achieve the set commitments.

• Level 3 Green System is systematic environmental management—monitoring, evaluation, and review for continuous development or awarding recognized or accredited environmental awards related to the conservation of resources and environments.

• Level 4 Green Culture is when everyone in the organization has a common conscience to preserve and maintain a good environment and cooperate in all aspects of the business to be environmentally friendly and take action to become part of the corporate culture.

• Level 5 Green Network is an extension of the scope of the green industry from within the organization itself and throughout the supply chain by encouraging partners and partners to be a green industry.

Source: Ministry of Industry

3.1.2.4 Waste Sector

Draft National Waste Management Action Plan 2022-2027

The Draft National Waste Management Action Plan 2022 – 2027 was prepared as a framework and guidelines to drive waste management operations to align with the country's development guidelines and the global context. The Action Plan is set to frame new waste management for a clean environment and promote a sustainable society using the following principles:

• Bio-Economy, Circular Economy, and Green Economy (BCG Model) consists of three elements: 1) Bio-Economy aims to enhance technology and innovation to develop biological resources or agricultural products such as the development of biodegradable plastics (compostable plastics) or alternative plastic products from natural materials, 2) Circular economy focuses on bringing used resources or products back to the production process again to be recycled or processed into a new product, creating value for waste and reducing the amount of waste in the manufacturing sector to zero (Zero Waste), and 3) Green Economy promotes the use of environmentally friendly production technology such as using bio-based substances instead of chemical pesticides. The BCG Model is a strategy to develop the national economy by balancing economic growth and natural resources sustainability.

• 3R principle (Reduce, Reuse, Recycle): Reduce the waste generation at the source in the process of design, production, and consumption, reuse the packaging waste or waste material without processing or reprocessing, and recycle waste materials by processing in the production process and producing a new product.

• Polluter Pays Principles (PPP): Economic tool used to manage natural resources and the environment. The polluters must bear the cost of preventing damage to human health or the environment.

• Public-Private Partnership: All sectors should participate in waste management from production, import, distribution, consumption, and management at the destination, which encourages the private sector to invest or jointly invest in the operation of a waste management system.

• Extended Producer Responsibility (EPR): The principle encourages producers to take responsibility for their products after public consumption by jointly paying the production handling fee and participating in waste recovery for reuse, recycling, and environmentally safe disposal. It also encourages the producers to modify the design and manufacturing process to be more environmentally friendly by reducing the use of harmful substances in products and consider designing and manufacturing products that will last a lifetime.

The objectives for implementing the National Waste Management Action Plan (2022 – 2027) are by the year 2027 to have 80% of solid waste effectively managed, 60% of household hazardous waste effectively managed, 100% of infectious waste effectively managed, and 100 % of hazardous industrial waste correctly processed in the management system. The implementation measures focus on "Reduce and Enhance"—reducing the generation of solid waste and hazardous waste at the source and enhancing capacity to manage solid waste and hazardous waste, promoting solid waste and hazardous waste management.

Source: The Office of National Higher Education Science Research and Innovation Policy Council (NXPO)

Thailand's Roadmap on Plastic Waste Management 2018 – 2030

According to the Pollution Control Department report in 2019, plastic waste accounted for 12% (2 million tons/year) of the total waste generation in Thailand. Only 0.5 million tons plastic waste was recycled. Some were disposed of in the incinerator, but the rest were disposed of in the landfill and accumulated in dumped sites. The COVID-19 pandemic also intensified the plastic waste problem. In addition, a 2021 UN comprehensive assessment report, released before COP26, emphasized that plastics are a climate problem. Plastics, the by-product of fossil fuels, contribute to GHG emissions throughout the life cycle, from production to disposal.

Acknowledging that plastic waste and the climate change problems are intertwined, Thailand has formulated the Plastic Waste Management Roadmap 2018-2030 to move towards sustainable plastic management based on the principle of a Circular Economy, seeking to serve as a framework and direction for preventing and solving the plastic waste problem in the country. The roadmap's underlying principles include Circular Economy, Responsible Production and Consumption, Public-Private Partnership, and Life Cycle Approach.

Guidelines for operation under the roadmap are divided into three measures: 1) Measures to reduce the generation of plastic waste at the source, 2) Measures to reduce the use of single-use plastic (Single-use Plastic) in the process of consumption, and 3) Measures to manage the plastic waste after consumption by supporting and encouraging them to be reused. The roadmap also defines the roles, duties, and responsibilities of relevant agencies in the implementation of the draft Roadmap in all sectors. It further defines various mechanisms for the roadmap mobilization, such as enhancing knowledge and understanding with relevant agencies, people, and consumers to develop integrated

cooperation for the operation and public relations campaign through social media. There will be studies and target setting on recycled plastics and plastic waste that cannot be recycled to be disposed of properly.

Source:1) Pollution Control Department 2) Draft National Waste Management Action Plan 2022-2027 3) Thailand's Roadmap on Plastic Waste Management 2018 – 2030

3.1.3 Municipality Plans

Draft Bangkok Climate Change Master Plan 2021-2030

In 2021, Bangkok Metropolitan Administrator (BMA) and the Japan International Cooperation Agency (JICA) developed the draft Bangkok Master Plan on Climate Change 2021-2030. The Master Plan aims to align with the Nationally Determined Contribution (NDC) in terms of both the policy and the implementation timeframe. It will make a significant contribution to the long-term vision of Bangkok to achieve net-zero GHG emissions by 2050. The plan outlines the development of key measures for GHG reduction and climate change adaptation, including institutional structures, monitoring and evaluation (M&E), and measurement, reporting, and verification (MRV) systems.

Bangkok intends to achieve the GHG emission reduction target and the response to climate change by setting the target and the commitment to reduce its GHG emissions by 19% compared to the BAU from the base year of 2018 by 2030 and to have the long-term goal under the vision to continually reduce greenhouse gases towards a "net-zero emission city" by 2050. The mitigation measures of GHG reduction under this master plan cover four sectors: Transportation, Energy, Waste and wastewater, and Green urban planning. The significant sectors for GHG emissions reduction are energy and transportation, with a reduction target of 94% of the total, and the remaining 6% is from the waste management sector. Green urban planning is the sector that does not directly reduce GHG emissions but helps to absorb GHGs in the atmosphere.

Source: Bangkok Metropolitan Administrator (BMA)

3.1.4 Agriculture plan

20-Year Agriculture and Cooperative Strategy 2017–2036

The 20-year Agricultural Development Plan 2017-2036 was adopted to lay a foundation for long-term and systematic growth of this sector. This plan aims to improve farmers' livelihoods, increase yields and quality standards of agricultural commodities, enhance the sector's competitiveness through technology and innovation under "Agriculture 4.0" model, promote a balanced and sustainable management of agricultural resources

and the environment, and enhance the capacity of the public administration system. This plan sets out strategies in five aspects: strengthening farmers and farmer institutions, increasing the productivity and quality standards of agricultural commodities, increasing competitiveness in the agriculture sector through technology and innovations, balanced and sustainable management of agricultural resources and the environment, and development of public administration system (see Figure 3-7)

Strategy 1 Strengthening farmers & Farmer Institutions	Strategy 2 Increasing the productivity & quality standards of agricultural commodities	Strategy 3 Increasing competitiveness in the agriculture sector through technology & innovations	Strategy 4 Balanced & sustainable management of agricultural resources & the environment	Strategy 5 Development of public administration system
Development Directions 1) Strengthening farmers and farmer institutions to become Smart Farmers, and Smart Groups with Smart Enterprprises. 2) Promoting pride and security in the agricultural profession. 3) Applying innovations and technology in farm labor management.	**Development Directions** 1) Develop of product quality and production efficiency. 2) Promote agriculture throughout its supply chains with the requirements of the market.	**Development Directions** 1) Develop technology and innovations to drive Agriculture 4.0 under the Thailand 4.0 Economic Model 2) Manage the agricultural information technology for ready access and utilization of farmers 3) Develop agricultural research works and information toward their commercialization	**Development Directions** 1) Sustainably manage agricultural resources. 2) Balanced and sustainably revive and conserve agricultural resources	**Development Directions** 1) Develop all government personnel to become Smart Officers and Smart Researchers. 2) Link/integrate the working system of all sectors using Civil State mechanism. 3) Improve and develop agriculture legislations to cope with the contextual changes.

Figure 3-7: 20-Year Agriculture and Cooperative Strategy 2017–2036 strategy
Source: Ministry of Agriculture and Cooperatives (MOAC)

3.2 Mitigation Measures

3.2.1 Measures in Thailand's Nationally Appropriate Mitigation Action (NAMA)

Thailand proclaimed its Nationally Appropriate Mitigation Action (NAMA) to reduce national GHG emissions from the energy and transport sectors as compared to the Business as Usual (BAU) by stating that Thailand had the potential to reduce GHG emissions by 7-20% by 2020.

After the target was set, Thailand developed a system to monitor and assess the amount of GHGs reduction from domestic measures, especially measures on energy and transportation, for Thailand to report on national GHG reduction results to the UNFCCC Secretariat. Thailand has carried out monitoring and evaluation of GHG reductions as follows:

1) A GHG reduction reporting structure was established according to the Domestic MRV

structure approved by the National Committee on Climate Change Policy, as illustrated in Chapter 1.

2)   The mechanism of the Working Group on GHG Inventory and Mitigation Measures in the energy sector, referred to in Chapter 1 as "Institutional Arrangement," was employed in selecting the appropriate measures/policies for monitoring and evaluating GHG reduction according to the criteria. Once the measures/policies were obtained, a method for calculating the GHG reduction was developed, and the Coefficient/Emission Factor was designated. The MRV process for activity data and calculating GHG reduction from measures/policy was commenced to prepare a report on greenhouse gas reduction results.

3)   When the Working Group on GHG Inventory and Mitigation Measures approved the detailed information in the second step, they would send the official information to the relevant Ministries, i.e., the Climate Change Coordinating Working Group under the Ministry of Energy, to consider the following: appropriate measures/policies for monitoring and evaluating GHG reductions, GHG reduction calculation methods, MRV process structure for activity data, and GHG reductions from measures/policy and GHG reduction reports. When the Ministries have approved, they must notify the secretary of the Working Group on GHG Inventory and Mitigation Measures. In case of disagreement or amendments, the Ministries could propose and stress the issues that need to be revised.

4)   After the relevant Ministries have considered and approved the details under the third step, the Ministry's consideration will be submitted to the Subcommittee on Climate Change Knowledge and Database for further approval.

5)   Once the Subcommittee on Climate Change Knowledge and Database has approved, the GHG reduction results will be presented to and approved by the National Committee on Climate Change Policy. After approval, GHG reduction results will be reported in the BUR and NC reports.

For the first phase of emission reduction during the period of 2013 – 2020, achieving the NAMA's target was the first steppingstone toward Thailand's success in reducing GHG emissions in line with the goals of the 20-Year National Strategy, National Reform Plans, the National Economic and Social Development Plan, and the country's Climate Change Master Plan focusing on developing a low-carbon economy. Since 2015, the Ministry of Energy through the Climate Change Coordinating Working Group has assigned the Energy Policy and Planning Office (EPPO) to be the coordination unit for implementing the monitoring and evaluation report on GHG reductions from energy measures. In 2019, the Office of Transport and Traffic Policy and Planning (OTP) started reporting GHG reductions from the transport sector.

3.2.2 NAMA Achievement

During 2013 – 2018, key measures implemented to reduce GHG emissions in Thailand were renewable energy substitution and energy efficiency improvement, especially in power generation, industry, and transport sectors. Five mitigation measures were first implemented in 2013 (details are shown in Table 3-1) and the number of measures increased twofold in the next five years. Finally, the latest mitigation measure in 2019 is the shifting of transportation mode.

Table 3-1: Mitigation measures in energy and transport sectors

Policies/Mitigation Measures	Description	First implementing year
Renewable energy		
1. Electricity generation from natural renewable energy (solar, wind, and water)	Electricity generation from natural renewable energy in substitution of fossil fuels.	2013
2. Electricity generation from bio-renewable energy (biomass, biogas, and waste)	Electricity generation from bio-renewable energy in substitution of fossil fuels.	2013
3. Heat generation from natural renewable energy (solar)	Heat generation from natural renewable energy in substitution of fossil fuels.	2014
4. Heat generation from bio-renewable energy (biomass, biogas, and waste)	Heat generation from bio-renewable energy in substitution of fossil fuels.	2014
5. Biodiesel consumption for transportation	Using biodiesel in substitution of diesel in the transportation sector.	2013
6. Ethanol consumption for transportation	Using ethanol in substitution of benzene in the transportation sector.	2013
Energy efficiency		
7. Energy efficiency standard and label no.5	Using electrical devices that meet energy efficiency standards and labeled No. 5 signifying the energy-saving qualification.	2015
8. Increasing the efficiency of electricity generation (natural gas power plant and lignite power plant)	Increasing or improving the efficiency of existing power plants or new power plants of the electricity generating authority of Thailand (EGAT) and large private power plants (IPP) that use natural gas or lignite as the main fuels.	2013
9. Increasing energy efficiency from waste heat recovery (generate electricity for use it in the factory)	Generating electricity from waste heat for utilizing in the factory.	2019
Modal shift in transportation		
10. Mass rapid transit system development	Shifting mode of transportation from fossil fuel vehicles (e.g., private cars and bused) to electric mass rapid transit system.	2019

The amount of GHG reduction was considered throughout the monitoring and evaluation processes using the methodology for GHG reduction calculation detailed in Table 3-2. The results of GHG reduction are:

• In 2013, amount of emission reduction from five measures was 14.34 $MtCO_2eq$ (3.91%), compared to the BAU emission level, shown in Figure 3-8.

• In 2014, amount of emission reduction from seven measures was 37.47 $MtCO_2eq$ (10.21%), compared to the BAU emission level.

• In 2015, amount of emission reduction from eight measures was 40.14 $MtCO_2eq$ (10.94%), compared to the BAU emission level.

• In 2016, amount of emission reduction from eight measures was 45.68 $MtCO_2eq$ (12.45%), compared to the BAU emission level.

• In 2017, amount of emission reduction from eight measures was 51.72 $MtCO_2eq$ (14.09%), compared to the BAU emission level.

• In 2018, amount of emission reduction from eight measures was 57.84 $MtCO_2eq$ (15.76%), compared to the BAU emission level.

• In 2019, amount of emission reduction from 10 measures was 64.20 MtCO$_2$eq (17.49%), compared to the BAU emission level.
• In 2020, amount of emission reduction from 10 measures was 56.54 MtCO$_2$eq (15.40%), compared to the BAU emission level.

As domestic endeavors, Thailand can achieve its GHG emission reduction target by 15.40% or 56.54 MtCO$_2$eq, compared to the BAU emissions level in 2020, from 10 mitigation measures implemented in the energy and transport sectors. The key mitigation measures are renewable energy implementation, especially bio-renewable energy used to generate both heat and electricity, which could reduce GHG emissions by 13.31% or 48.87 MtCO$_2$eq, compared to the BAU emission level in 2020, or account for more than 85% of overall reduction in 2020.

Table 3-2: Methodology for estimation of GHG reduction in NAMA achievement, 2020

| GHGs	Methodology for GHG Estimation of GHG emissions reductions	NAMA Achievement (MtCO$_2$eq)
Renewable energy		
CO$_2$	Calculated from GWh of electricity generation from RE multiplied by grid emission factors.	6.41
CO$_2$	Calculated from GWh of electricity generation from bio-renewable multiplied by grid emission factors.	11.11
CO$_2$	Calculated from ktoe of heat generation from RE multiplied by CO$_2$ emission factors of heat generation from the manufacturing industry.	0.03
CO$_2$	Calculated from ktoe of heat generation from bio-renewable energy multiplied by CO$_2$ emission factor of heat generation from the manufacturing industry.	23.01
CO$_2$	Calculated from liters of biodiesel consumed for transport multiplied by net calorific value (NCV) and CO$_2$ emission factor of fossil-based diesel.	5.04
CO$_2$	Calculated from liters of ethanol consumed multiplied by net calorific value (NCV) and CO$_2$ emission factor of gasoline.	3.27
Energy efficiency		
CO$_2$	Calculated from GWh of electricity saved by high efficiency devices multiplied by grid emission factor.	0.82
CO$_2$	Calculated from difference in tCO$_2$/MWh of thermal power in plants before and after the measure, multiplied by MWh of electricity generated from that plant.	6.34
CO$_2$	Calculated from the net amount of electricity generated from waste heat used within the factory multiplied by grid emission factor.	0.44
Modal shift in transportation		
CO$_2$	Calculated from passenger travel demand in terms of passenger-km multiplied by difference of fossil fuels and electricity emission factors in gCO$_2$/pkm.	0.075
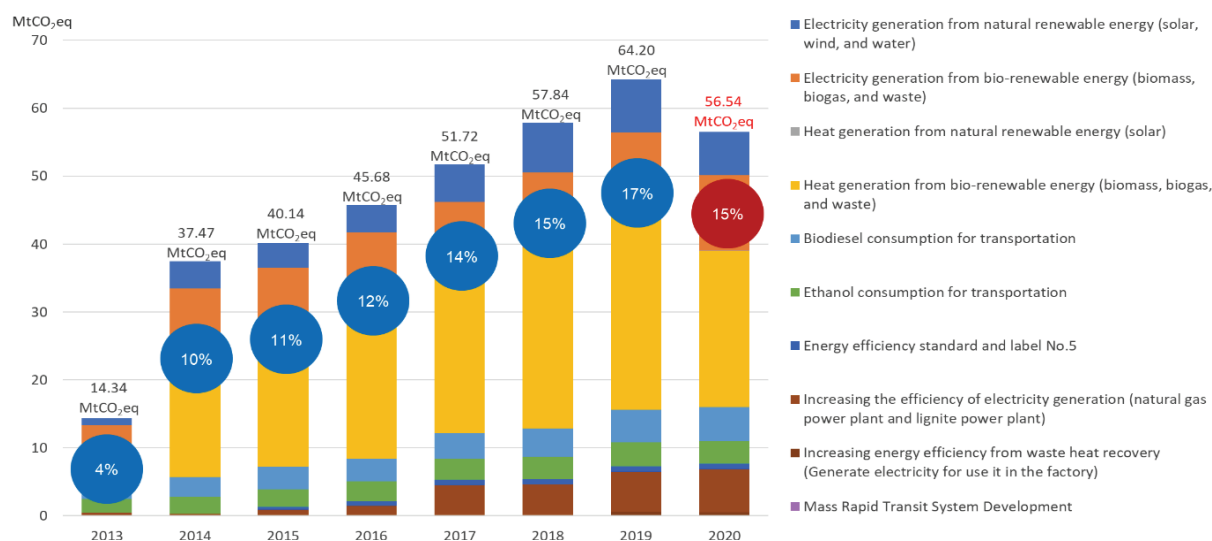
Figure 3-8: Thailand's GHG emission reduction from NAMA implementation: 2013-2020
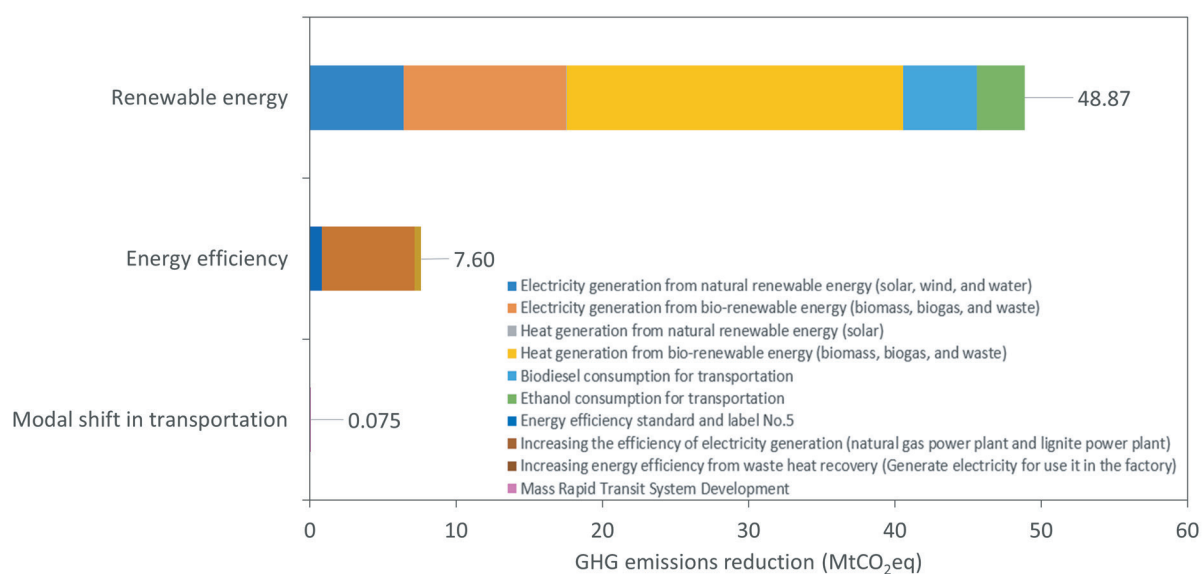

Figure 3-9: Thailand's NAMA achievement by measures, 2020

3.3 Preparation for NDC Transition

According to decision 1/CP.19 and 1/CP.20, all Parties are invited to communicate to the secretariat their Intended Nationally Determined Contributions (INDCs). Thailand herewith communicated its first NDC in 2015 to reduce its GHG emissions by 20% from the projected BAU level by 2030. The level of contribution could increase up to 25%, subject to adequate support through a balanced and ambitious global agreement under the UNFCCC.

Pursuant to decision 1/CP.21 and decision 1/CMA.3, Thailand communicated its updated NDC to the UNFCCC in 2020, 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 plan, and key information of adaptation components and support needs.

To achieve the carbon neutrality by 2050, Thailand communicated its 2nd updated NDC to the UNFCCC on 2 November 2022. Thailand intends to reduce its GHG emissions economy-wide, excluding LULUCF, by 30% from the projected BAU level by 2030. The level of contribution could increase up to 40%, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support. Furthermore, Thailand will continue vigorous efforts in its challenge to meet the long-term goal of net-zero GHG emissions by 2065.

Hence, after an accomplishment of NAMA, Thailand transitions towards the second phase of emission reduction during the period of 2021 – 2030, i.e., an NDC that focuses on reducing GHG emissions in the energy, transportation, industrial process and product use, agriculture, and waste management sectors, which is more challenging than the first phase. Therefore, it is necessary to have various mechanisms for operations to achieve the goals. Thailand has prepared the following:

3.3.1 Preparation for NDC Tracking System

Thailand has established an MRV system to track progress on climate mitigation measures under the NDC Roadmap 2021-2030. The MRV system plays a significant role in steering the implementation of mitigation measures to achieve the targets set by responsible agencies in the following sectors: Energy, Transport, IPPU, and Waste. It also enables all relevant stakeholders' engagement, including the public sector, private sector, academic institutions, international organizations, and citizens, to acknowledge problems and constraints arising from such implementation. Thus, the mitigation policies, plans, and measures can be revised, making them appropriate and in line with the current situation.

ONEP, as a national focal point of the Convention, the Ministry of Energy, the Ministry of Industry, the Ministry of Natural Resources and Environment, and the private sectors have prepared to measure, report, and verify the implementation of mitigation measures under the NDC Roadmap in three sectors: Energy, IPPU, and Waste.

In the Energy sector, the information form and methodology were developed. The handbook on MRV will be prepared to apply for 1) measures enhancing energy efficiency from reusing heat (energy production and industrial use), 2) measures enhancing energy efficiency from electricity used in the manufacturing industry, and 3) measures enhancing energy efficiency from heat production in the manufacturing industry. In the IPPU sector, the representatives from the Ministry of Industry, Thai Cement Manufacturers Association, and

Thailand Concrete Association have discussed and prepared the MRV system. As a result, the MRV framework will be applied to clinker substitution measures in hydraulic cement production. In the Waste sector, ONEP initiated a working session with TGO and PCD to develop methodology for GHG emission reduction, designate the emission factors, evaluate the MRV system, and improve the MRV handbook for measures on municipal solid waste management and biogas production from industrial wastewater.

3.3.2 Preparation for the electronic reporting to track mitigation progress in common tubular formats of the BTR

According to the annex to decision 18/CMA.1, paragraph 79, each party shall report information necessary to track progress made in implementing and achieving its NDC under Article 7 of the Paris Agreement in a narrative and Common Tubular Format (CTF), as applicable. ONEP is updating its supporting tool for the national inventory system, Thailand's Greenhouse Gas Emission Inventory System (TGEIS), to support NDC tracking in a manner consistent with the CTF template.

In addition, capacity building to support the electronic reporting process is required. The detailed summary required in the CTF template can help Thailand to understand and track progress in the implementation and achievement of its NDC. However, Thailand needs to build up capacity momentously and manage the related processes consciously to submit the first BTR within December 2024, in accordance with the modalities, procedures and guidelines of UNFCCC.

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

3.3.3 Study and analysis of guidelines for reporting GHG reduction and developing a system to collect and link data from all sectors under the Enhanced Transparency Framework (ETF) of the Paris Agreement

ONEP has prepared a study and an analysis of activity data reporting patterns and supporting information in various fields from measures under the national participation mechanism established in accordance with the Enhanced Transparency Framework under the framework of the Paris Agreement Work Program (PAWP) and the resolutions of the Conference of the Parties (COP). This preparation aims to develop a TGEIS system to support GHG inventory for report on common reporting table (CRT) and the MRV system for NDC tracking for report on CTF. ONEP has also analyzed the monitoring and evaluation guidelines to cover the NDC action plan for 2021–2030.

3.3.4 Preparation for an economic and social impact assessment on LT-LEDS measures implementation

ONEP has prepared a study to assess the economic and social impacts of the implementation of greenhouse gas reduction measures under the long-term national strategy by gathering information related to the socio-economic impact assessment, such as general information, socio-economic status, demand-supply condition (demand-supply), both current and future forecasts, the impact of COVID-19 pandemic, demographics, employment, and related policies. Subsequently, ONEP has used a model to analyze and compare the results of overall and sectoral studies of long-term GHG reduction measures implementation under the case of 1.5°C and the case where Thailand moves towards carbon neutrality.

3.3.5 Preparation for support NDC measures implementation

Before GHG emission reduction during the NDC period, Thailand received international support in two key projects to reduce GHG emissions:

RAC NAMA

RAC NAMA project, or Thailand Refrigeration and Air Conditioning Nationally Appropriate Mitigation Action, was commissioned by the NAMA Facility on behalf of the German Ministry for the Environment, Nature Conservation, and Nuclear Safety and the UK's Department for Business, Energy & Industrial Strategy and implemented by GIZ with support from the Department of Alternative Energy Development and Efficiency (DEDE) and the Office of Natural Resources and Environmental Policy and Planning (ONEP). A milestone for the IPPU sector, contributing to the NDC achievement with a total emission reduction of 35,000 tonCO$_2$eq. The project implementation can be classified and illustrated as follows:

• Policy: The MRV system has been set for the RAC NAMA project through the policy and technical recommendations so that Thailand can report the implementation following the commitment under the Convention and elevate the emission reduction targets in this sector. The RAC NAMA safety system was demonstrated to relevant stakeholders to mimic the actual leakage and designate the intensity of leakage from the system. The result showed the efficiency of the system without any hazards.

• Technology and training: The training center was founded to train chief mechanics on the safe handling of flammable refrigerants. Nine business operators were trained to transition the production line and development. The industries and prototype passed the safety test. The testing operational labs within the Ministry of Industries

were reconditioned to support the testing of air conditioning using flammable refrigerants according to new standards of IEC, EN, and TISI 1529-2561

• Financial support: The RAC NAMA fund was established with 8.3 million EUR or about 300 million THB by EGAT in the name of the Thai government to be the fund manager. The fund aims to promote the production and utilization of eco-friendly and energy-efficient refrigeration technology. EGAT has provided financial aid through various financial instruments for the past two years.

- Supply-side: for the producers to transition their production lines, EGAT provided 1) a short-term loan for one year without interest for 52 million THB and 2) grants for 80 million THB.

- Demand-side: 1) over 10 million THB as a subsidy to induce consumers to purchase eco-friendly refrigerators and 2) over 146 million THB as subsidy without interest for marketing measures

- Service sector: 1) 15 million THB of grants to purchase equipment for the eight training centers and 2) 2.5 million THB grants for reconditioning testing operational labs at electric and electronics institutes.

Thai Rice NAMA

Thai Rice NAMA is a cooperative project between MOAC and GIZ, funded by NAMA Facility. This project is conducted from 2018 to 2023 to promote converting from traditional to sustainable rice cultivation or GAP++ by adopting alternative wetting and drying (AWD), site-specific nutrient management (SSNM), and crop residue management. The project's target is 100,000 farmer households in Thailand's Central plain area (6 provinces). The implementation and progress of the project can be described as follows: GHG emission reduction: It targets GHG reduction of 1.7 million tonCO$_2$eq

in a 5-year period (2018-2023). In 2021, the emission decreased by 160,000 tCO_2eq. Due to the COVID-19 pandemic, drought, and floods, the implementation has been delayed.

· Technology transfer: Emission reduction technologies were transferred to and widely adopted by farmers consisting of Alternative wetting and drying (AWD), Laser Land Leveling, site-specific nutrient management (SSNM), and crop residue management.

· Policy and management: The Sustainable Rice Platform National Chapter was established as a forum to engage all stakeholders in developing Thai GAP++ (Sustainable rice standard). The Sustainable Rice Standard has been circulated for public hearing. Now it is in the process of revision before submission for the Agriculture Standard Committee's approval and announcement. The standard promotes a rice cultivation method that is internationally recognized as contributing to climate mitigation and adaptation.

· Technical and capacity building: A series of training on sustainable rice cultivation was provided for 295 officials from the Rice Department (RD) and the Department of Agricultural Extension (DOAE), and 13,220 farmers, covering rice fields of approximately 63,450 ha. There was a series of training to build capacity for the service providers on Laser Land Leveling technology. Subsequently, the service providers used this technology to level 151.24 ha of rice fields for 69 farmers.

· Financial mechanism: A pre-finance mechanism was established by having the Bank for Agriculture and Agricultural Cooperatives (BAAC) as a grant manager. By integrating the project into BAAC's green finance mechanism, 1,328,444 THB were provided for farmers to prepare rice fields using Laser Land Leveling technology.

From implementing the Thai Rice NAMA project, the RD, BAAC, and GIZ considered that sustainable rice cultivation benefited Thailand's economic, social, and environmental development and enhanced the farmers' standard of living. The relevant agencies continue to scale up and expand the project implementation to other provincial parts of Thailand. As an Accredited Entity, GIZ held a discussion session with the ONEP and BAAC to develop a concept note for strengthening Climate Smart Rice Farming and submit this concept project to the Green Climate Fund (GCF) in 2021.

Another extension from the Thai Rice NAMA is the project of Strengthening Climate-Smart Rice Value Chains, aiming to improve the capacity of rice farmers and service providers on climate mitigation and adaption technology. The project targets 250,000 farmer households in 15 provinces with emissions from rice fields of 3.7 million tCO_2eq. The project will be developed through a rice cultivation paradigm shift, rice value chain generation, and private sector participation.

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

CHAPTER 4 :
CONSTRAINTS, GAPS,
NEEDS, AND SUPPORT RECEIVED

Thailand has received support from various international partners to facilitate climate actions in mitigation, adaptation, and enabling environment, including the preparation of Thailand's Fourth National Communication (NC4) and Third Biennial Update Report (BUR3) to the UNFCCC. From 2020-2022, the supports received from multilateral and bilateral partners enabled a total of 34 projects, entailing 18 mitigation projects with a total amount of 31,438,771 USD; ten adaptation projects with a total amount of 48,667,056 USD; and six enabling environment projects with a total amount of 3,419,548 USD. Most support was a combination of technical support and capacity building.

The international support enables Thailand to overcome its constraints, gaps, and barriers to climate actions. We express our gratitude and appreciation for the support received.

However, considering remaining constraints and gaps, Thailand still needs support in terms of finance, technical expertise, technology transfer, and capacity building to ensure the achievement of its long-term low greenhouse gas emission development strategy (LT-LEDS) in a short-term period (2025-2035), a mid-term period (2040-2050), and a long-term period (2050-2065). Additional support is needed, particularly for technology development and transfer, which is essential for mitigation and adaptation implementation. For mitigation, Thailand needs support for the energy system transition towards renewable sources focusing on renewable energy technologies (such as solar and wind), enhancing the potential use of Carbon Capture Storage (CCS) & Carbon Capture, Utilization, and Storage (CCUS) technologies, and developing other technologies to achieve GHG emission reduction and a net-zero emission target. For adaptation, support is needed for developing a data map showing areas at risk of climate change impacts and accessible viable adaptive technology. To enhance the enabling environment, Thailand requires support for developing and strengthening mechanisms, instruments, and policy implementation, such as financial instruments and incentives to engage private sectors in green investment and capacity building for all stakeholders to integrate climate actions into their respective practice and plans.

4.1 Constraints, Gaps, and Needs in the National Greenhouse Gas Inventory

Thailand aims to improve its inventory quality in terms of transparency, accuracy, completeness, consistency, and comparability. During the national GHG inventory development, Thailand faced several constraints and gaps that needed to be addressed. This includes limitations and barriers that affect the quality of GHG inventory estimation and compilation. It is important to improve the quality of the national statistics compiled by relevant agencies to further improve the overall quality of the national GHG inventory. Support is needed to improve the inventory quality, particularly in terms of transparency, accuracy, completeness, consistency, and comparability (TACCC). The existing TGEIS database needs to be updated periodically to reflect the progress of GHG inventory quality. Enhancing the knowledge and understanding of GHG estimation methodologies among key stakeholders, particularly industrial partners, including training on sensitivity analysis and calculation, is also needed to strengthen the national GHG inventory development. The capacity building and technical transfer should be provided for relevant government agencies and other agencies.

The existing TGEIS database needs to be updated to reflect the progress of GHG inventory quality. COP26 decisions have determined that under the implementation of ETF, the national GHG inventory must follow the Common Reporting Table (CRT) format. To prepare for this reporting format, Thailand is updating the national GHG inventory system (TGEIS) and planning a training workshop for relevant officers. As of December 2022, the Climate Change Act is being revised and under consideration by the government. This will become a regulatory framework that enables the relevant agencies in the government and private sectors to collect required data for the national GHG inventory, especially those that are not currently available.

4.1.1 Energy

There are two key areas of support needed: 1) activity data and 2) emission factors which can be summarized as follows:

- Country-specific emission factors should be developed and introduced for the main fuels used in Thailand, including biofuels.
- Although Thailand has already adopted the 2006 IPCC Guidelines in all sectors, it needs to enhance the professional capacities of national experts involved in the inventory process.

A transition from default emission factors and Tier 1 methodologies to country-specific emission factors and Tier 2 and 3 methodologies is needed, focusing on key categories.

With international support through bilateral collaboration and international organizations, Thailand's national inventory has drastically improved the calculation and reporting in all sectors. However, more support is needed, which can be identified by sector, as follows.

The main area of support needed in the Energy sector is:

- The Ministry of Transport, via the Civil Aviation Authority of Thailand (CAAT), is developing an approach to collect data on fuel consumption for international aviation.

4.1.2 Industrial Processes and Product Use (IPPU)

Gaps, needs, and areas of improvement in preparing Thailand's National GHG inventory in the IPPU sector and using TGEIS are identified below:

- Estimation of GHG emissions from the IPPU sector is considered a challenge for Thailand due to the diversity of GHG sources and gas types and the complexity of calculation methodologies and data requirements. Currently, the emissions from most sub-categories under the IPPU sector can be estimated using the Tier1 approach with

adequate activity data and default EF values. Tier2 estimation is only possible for the cement industry, in which country-specific emission factors are available. For other sub-categories, specific emission factors need to be developed to shift to a more accurate Tier2 estimation.

• Currently, F-gases are estimated and included in Thailand's GHG emission inventory. There are many limitations and difficulties in data collection and classification and a lack of specific technical data, such as initial charge, lifetime of equipment, and emission factors. Thailand's Department of Industrial Works has imposed reporting requirements on F-gases consumption and import-export statistics. However, such aggregate data can be useful and possible for Tier 1 estimation. Improvement of data reporting forms is underway to collect disaggregated data at application or sub-application levels. Advanced techniques, such as monitoring and modeling approaches, are also required to obtain the activity and emission data for F-gas estimation to fill the gaps according to the 2006 IPCC guideline. To achieve more accurate GHG estimations and adopt the higher IPCC methodologies in the IPPU sector, the strengthening of data collection is required, particularly F-gas data.

4.1.3 Agriculture

Gaps, needs, and areas of improvement in the Agriculture sector in preparing Thailand's National GHG inventory are as follows:

• To achieve more accurate GHG estimations and adopt the higher IPCC methodologies in the Agriculture sector, the required data should be collected or revised from the country. These include updated livestock characteristics and fractions of manure in management systems, determining more appropriate methods to estimate areas burnt in croplands by using satellite images, the revised fractions of crop residues, gathering lime application to croplands from private sector, determining fertilizer application rates of major crops according to bottom-up

approach, developing or revising country-specific EFs for agricultural soils and rice cultivation with water management (e.g., alternative wetting and drying).

• Due to the limitation in quality assurance or quality control (QA/QC) and uncertainty of the country's activity data and emission factors, improving the QA/QC procedure and uncertainty analysis in these data may enhance the accuracy of the inventory systems.

• A better understanding of the IPCC Guidelines, GHG estimation methodologies, and quality control systems, e.g., via activities on capacity building and technical transfer, should be provided for relevant government agencies and other parties. This may be important for strengthening institutions' capacity in data collection, quality control of data, and enhancing mitigation measures.

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

Although the MRV systems for the LULUCF sector have been developed and implemented among the relevant stakeholders, activity data relevant to forest land remains incomplete because forest areas in the LULUCF sector involve multiple departments (i.e., the Royal Forest Department and the Forest Industry Organization). For instance, there is also a gap between public and private data on forest plantation areas. In addition, activity data for biomass burning in forest land reported by various departments remains unclear in terms of burned areas and/or land categories. To provide more accurate GHG estimation and adopt the higher IPCC methodologies, remote sensing-based monitoring of land use and land cover is needed to classify types of natural forests and forest plantations, monitor their changes, and detect forest area burning.

Although cropland and forest land are key land categories contributing to the GHG net removals in the LULUCF sector, wood harvested from either cropland or forest plantations is not reported

except by the Forest Industry Organization. Thus, an approach must be developed for the government and private sector to enhance the MRV systems of essential activity data for the LULUCF sector.

Country-specific values are applied in most LULUCF categories, but some emission factors are adopted from IPCC defaults due to the use of the IPCC-2006 guidelines (i.e., below-ground to above-ground biomass ratio for natural forest and woody crops, deadwood and organic litters, trace gases emission ratio and uncertainty estimation). Furthermore, some parameters are not adequate to be used as national representatives due to the limitation of information (i.e., country-specific values relevant to croplands). Therefore, a new process for developing country-specific values is recommended to improve the accuracy of GHG inventory and adopt higher methodologies for the LULUCF sector.

4.1.5 Waste

Although MRV systems in the Waste sector have been developed and implemented among relevant stakeholders, some parameters are still out-of-date, such as solid waste composition and annual per capita protein consumption. Other parameters are not adequate to be used as nationally representative, including industrial production, wastewater generated, and Chemical Oxygen Demand (COD) in specific industrial wastewater. Meanwhile, other parameters are not available, such as the degree of utilization of treatment discharge pathways or systems, including septic tanks, latrines, sewers, centralized wastewater treatment, and no treatment. Therefore, data collection systems and the creation of a centralized database need to be developed. Technical and funding support is required for capacity building within relevant agencies.

Development of country-specific values of emission factors for solid waste disposal and wastewater treatment and discharge of both domestic and industrial sources is also needed to improve data collection according to the 2006 IPCC Guidelines. This includes, for example, reaction constants and half-lives in the degradation of specific compositions of solid waste, the maximum methane producing capacity, and a methane correction factor for the wastewater treatment and discharge system. Technical and funding support is needed for initiating these studies. Some cross-cutting issues need to be addressed, including archiving procedures, the planning, development, and implementation of a QA/QC system, and a process for uncertainty assessment.

4.1.6 Support needed in preparation for the electronic reporting of the BTR

Support needed for the electronic reporting in the CRT of the BTR

Thailand is preparing to fulfil the completeness of the first BTR, and the first two elements correspond to the mandatory requirements of the decision 18/CMA.1. In accordance with the modalities, procedures and guidelines of UNFCCC, the national greenhouse gas inventory report consists of a national inventory document and the Common Reporting Table (CRT). Categories reporting in the CRT template are different from the 2006 IPCC Guidelines. The mapping exercise of the categories in the 2006 IPCC Guidelines and the CRT template for the electronic reporting of the BTR needs to be well prepared. Thus, to submit its first BTR by December 2024, Thailand needs capacity building for the electronic reporting in the CRT.

Support needed for the electronic reporting in the CTF of the BTR

In addition to the support needed for the electronic reporting in the CRT, Thailand needs capacity building to support the electronic reporting of information in the Common Tabular Format (CTF). The CTF template can help Thailand

to understand and track progress in the implementation and achievement of its NDC in accordance with the modalities, procedures, and guidelines of UNFCCC. Thus, to submit its first BTR by December 2024, Thailand needs capacity building for the electronic reporting of information in the CTF.

4.2 Constraints, Gaps, and Support Needed in mitigation, adaptation, and enabling environment

Abiding by its commitments under the Convention, Thailand has unceasingly undertaken climate actions in mitigation, adaptation, and enabling environment. However, constraints and gaps remain primarily regarding access to finance, technical expertise, technology development and transfer including capacity building. Support from international communities will help Thailand overcome these impasses and expose its full capacity to implement climate actions. This section reports constraints, gaps, and the international support needed for the climate implementation in three areas: mitigation, adaptation, and enabling environment. This information was obtained from the priorities stipulated in the LT-LEDS and the result of stakeholders' consultation via focus group meeting. The stakeholders include all relevant government agencies overseeing climate change measures in particular sectors. Under each area, a conclusion of constraints and gaps is accentuated, and a description of support needed is briefly summarized and categorized into four groups as follows:

a. Technology Development and Transfer (TT): support needed to develop and transfer innovative and practical technologies to support Thailand's actions on climate change, particularly the development of infrastructure and climate-related technology such as EV infrastructure, clean and renewable energy, and GHG reduction technology.

b. Technical Support/Assistance (TS): non-financial assistance needed from international specialists, which can take the form of sharing information and expertise, the transmission of working knowledge, and consulting services and may also involve the transfer of technical data, know-how and knowledge. This may include but not be limited to the support in policy development and implementation, development of mechanisms and instruments, climate information, and M&E systems.

c. Capacity Building (CB): support needed for developing and strengthening the skills, abilities, processes, and resources of organizations and stakeholders for planning and taking climate actions. This includes support for preparing the forthcoming National Communications and Biennial Update Reports.

d. Financial Support (FS): support needed in the form of money or financial instruments such as a grant, soft loan, equity, or guarantee to support and leverage government and private sector investment in climate actions, particularly for incremental cost or risk premium required to make the investment of climate action viable, or to cover specific activities such as technical assistance or capacity building.

4.2.1 Mitigation

As Thailand intends to achieve the carbon neutrality by 2050 and a net-zero GHG emission target by 2065, the priority is given to research development and deployment (RD&D) on mitigation measures reducing GHG emissions, particularly in the energy system and the transport sector. The energy sector, the most significant contributor to Thailand's GHG emission, has a vital role in implementing climate mitigation measures. The latest adoption of the National Energy Plan 2022 articulates elevated targets to enhance the energy efficiency, increase renewable energy production, transition towards green energy for transportation, and transform the energy business structure to embrace energy transition. The industrial development strategy also reflects the urge to stimulate the green growth engine focusing on environmental-friendly technology development and renewable energy transition.

Despite being a modest contributor to GHG emissions, the Waste sector aims to eliminate the waste from its production sources for sustainable waste management by employing three principles: Reduce, Reuse, and Recycle. The National Solid Waste Management Master Plan also seeks to enhance energy production and organic fertilizer from waste.

Constraints and Gaps

The core constraint of realizing the mitigation targets and measures is to balance between securing energy production and reducing GHG emissions. The energy transition requires high technical capacity, technological advancement, and sufficient investment funds, particularly for technology and infrastructure development costs. While attempting to reduce GHG emissions, the Energy sector must secure an energy supply bearing the cost of energy types, prices, and governmental policy on fossil fuels, which affect overall national economic growth. Thus, it is vastly challenging to maintain the equilibrium between energy security, economy, and environment. For the transport sector, the main barrier is limited resources and funding to develop and implement climate mitigation initiatives such as investment in electrification of transport and battery charging technologies, road-to-rail modal shift for both freight and passenger transport, or awareness-raising for increased use of public transportation. For waste management, limited financial resources, capacity, and technology development at subnational and local levels for waste management systems remain key obstacles, such as insufficient knowledge and development of GHG reduction technology for wastewater treatment and inadequate financial resources, technical capacity, and technology for producing energy from waste.

Support Needed

Thailand's mitigation measures focus on the Energy, IPPU, Agriculture, and Waste sectors accountable for overall national GHG emissions. In addition, with growing attention on the natural-based solutions for climate mitigation, forests and their carbon sequestration capacity have become subjects of research and technology development. Support of several types is still needed to ensure the achievement of LT-LEDS for the following:

- **Energy, IPPU, and transport:**
  - In a short-term period, Thailand urgently needs support for the energy transition towards renewable sources focusing on renewable energy technologies (such as solar and wind); approaches in advanced energy storage systems (EES) and demand-side management; development of electric vehicles (EV), batteries, and infrastructure; and increasing grid modernization, smart energy management, and Independent Power Supply (IPS).
  - In a mid-term period, Thailand needs support to enhance the potential use of Carbon Capture Storage (CCS) & Carbon Capture, Utilization, and Storage (CCUS) technologies, and Bioenergy with CCS (BECCS).
  - In a long-term period, Thailand needs support to develop other technologies to achieve GHG emission reduction and a net-zero economy (e.g., green hydrogen or bio-hydrogenated diesel)

- **Agriculture and waste**
  - In a short-term period, support is needed for enhancing the GHG reduction technologies in the agriculture and waste sectors such as methane reduction in rice cultivation, wastewater treatment, and waste-to-energy technology.
  - In a mid-term period, Thailand needs support in developing technologies for soil and manure management and water usage reduction and circulation.

The overall support needed for mitigation actions is presented in Table 4-1.

Table 4-1: Summary of financial, technology, technical and capacity-building support needed for mitigation actions

Sector	Support Needed (Policy, Plan, Measure, Program, Project)	Key Stakeholder	Support Type			
			CB	TS	TT	FS
Energy IPPU	Enhancement of Carbon Capture Storage & Utilization (CCS-CCU) Technology and development of concept and case study of Hydrogen Fuel Cell	EGAT, DIW	x	x	x	x
Energy	Development of Carbon Neutrality planning and forecasting model of GHG emission	EGAT	x			x
Renewable Energy	Development of technology for solar cooling, heating, and energy for public transport	DEDE	x	x	x	x
Renewable Energy	Research and technology transfer for reducing the production cost of biofuel and enabling biofuel use in the various transportation sector such as aviation	DEDE	x	x	x	
Energy	Technology & Innovation of renewable energy (RE) and Industrial energy efficiency (EE) & Conservation	DEDE	x	x	x	x
Energy	Implementation of the area-based emission trading system in area base, especially in the Eastern Economic Corridor	TGO	x	x		x
Energy	Intensive capacity building and technical support for the implementation of Internal Carbon Pricing	TGO	x	x		x
Wastewater	Development of knowledge and technology for water usage reduction, water circulation, and wastewater treatment appropriate for local context for GHG reduction	ONWR	x	x	x	x
Transport	Electrification for transport and battery charging technologies, a transition of public transport into EV, improving Non-Motorized Transport, and formulating policies and measures enabling the utilization of EV	OTP	x		x	x
Transport	Develop a central database for climate change and GHG data for transportation sector	OTP	x			x
Agriculture	Development of GHG reduction technology for agriculture and preparation of policy recommendations for mitigation measures	OAE	x	x	x	
Agriculture	Development of tools for tracking carbon emissions in agricultural areas, training sessions, and research on climate change impacts in the agriculture sector	LDD	x	x	x	x
Forestry	Enhancement of knowledge and technology to track the change of carbon stock in mangrove forests	DMCR		x		x
Forestry	Development of tools for tracking and reporting carbon stock in forest areas	RFD		x	x	x

Remark:
TT: Technology Development & Transfer / TS: Technical Support & Assistance /
CB: Capacity Building / FS: Financial Support

4.2.2 Adaptation

Thailand is highly vulnerable to climate change impacts. According to the Global Climate Risk Index 2021, Thailand was ranked the ninth most affected country in terms of human impacts and direct economic losses from weather-related loss events during 2000-2019.

Aiming to increase adaptive capacity and climate resilience, Thailand has formulated the National Adaptation Plan (NAP) to be an implementation framework to integrate climate change adaptation into the sectoral and local strategic plans, covering six priority sectors, including water resources management, agriculture and food security, tourism, public health, natural resources management, and human settlements and security. The objectives are 1) to increase water security and decrease losses and damage from water-related disasters, 2) to maintain productivity and food security amidst climate change risks and impacts, 3) to strengthen the capacity of the tourism sector towards climate resilience and sustainable development, 4) to establish effective public health systems to manage risks and reduce impacts from climate change, 5) to sustainably manage biodiversity resources to respond to climate change impacts, and 6) to enhance capacity of individuals, communities, and cities, to adapt to climate change impacts appropriately according to the local context.

Constraints and gaps

The fundamental barriers to the implementation of adaptation measures are 1) unfinished development of a central database and insufficient data integration and coordination on climate change projection and impacts, 2) lack of a national climate information center compiling climate-related information, 3) insufficient knowledge and research on climate-related risks for key stakeholders to comprehend and implement appropriate adaptation measures, 4) limited access to adaptive technology, and 5) inconsistent financial support and distribution.

For instance, the health sector still requires research on climate-related risks, a central database identifying climate impacts on human health at local and national levels, and uniform distribution of resources in terms of healthcare budget and technical experts. Similarly, the water management sector requires knowledge development for forecasting models, a central water resource and climate change database, and institutional arrangement for uniform budget distribution and climate measures implementation.

Support Needed

According to the ONEP database, support is needed primarily for:

Developing a data map showing areas at risk of climate change impacts. The map should show an overview and data on a specific sector (e.g., showing drought and floods for water management and agriculture sectors or showing ecological risks or disasters for the tourism sector)

Developing assessment data on climate change impacts, using both models and observation data. The data includes loss or damage from impacts and effects on ecosystems, watershed cycle, life cycle of insects, various pathogens, and outbreaks of pathogens, including their impacts on food security, tourist attractions, and communities that settle near or rely on such natural resources.
Creating a central data center that manages and links information related to adaptation, research data, weather research, forecasting information (WRF-ARW model), and relevant information between fields, such as information on agriculture and water for effective management. The overall support needed for adaptation actions identified by relevant agencies is presented in Table 4-2.

Table 4-2: Summary of financial, technology, technical, and capacity-building support needed for adaptation actions

Sector	Support Needed (Policy, Plan, Measure, Program, Project)	Key Stakeholder	Support Type			
			CB	TS	TT	FS
Natural Resources	Knowledge and technology for tracking and managing sea temperature change, coral bleaching, coral diseases, coral reef immunity, and ocean acidification	DMCR	x	x		x
Natural Resources	Database development for forecasting climate change impacts on the ecosystem and natural resources	DMCR		x		x
Natural Resources	Development of forest map indicating climate change vulnerabilities	RFD		x	x	x
Tourism	Development of sustainable tourism destination, tourist route plans, and smart tourism village design guidelines.	DOT	x	x		x
Multi-Sectoral	Developing a civil society network for climate mitigation and adaption actions	DEQP	x			x
Agriculture	Developing criteria and co-benefit assessment on mitigation and adaptation for the agricultural sector	TGO	x	x		x
Water Management	Development of the study and planning of Integrated Water Resources Management to align with Water Master Plans	ONWR	x	x	x	
Water Management	Enhancement of Integrated Water Resources Management database and assessment system: water management database center, Thai Water Plan (TWP), water management budget planning, and Thai Water Assessment (TWA)	ONWR	x	x	x	
Natural Resources	Technical support for community participation in the preservation and conservation of natural resources	DNP, DMCR		x		x
Public Health	Strengthening the health system in case of emerging diseases	DOH	x	x		x
Natural Resources	Preparation of integrated planning for coastal management across the country covering the management of critical and urgent areas such as coastal erosion and investments to prevent sea-level rise.	DMCR		x		

Remark:
TT: Technology Development & Transfer / TS: Technical Support & Assistance /
CB: Capacity Building / FS: Financial Support

4.2.3 Enabling Environment

A proper enabling environment is a core foundation for efficient and effective climate actions. The Climate Change Master Plan 2015-2050 seeks to strengthen enabling environment in four main areas, comprising 1) research and development in data and technology for climate, 2) development of legislation, economic instruments, financial mechanisms, and technical tools to support climate actions, 3) capacity building for relevant stakeholders and raising climate ethic and awareness for all, 4) development of Measurement, Reporting and Verification (MRV) and Monitoring and Evaluation (M&E) systems to enhance the transparency of climate action implementation in all levels.

Constraints and gaps

For building a suitable enabling environment for climate actions, Thailand still lacks the following: financial mechanisms to support climate actions and technology development; mechanisms for sectoral and subnational agencies to integrate adaptation and mitigation measures into their respective planning processes; a national monitoring and evaluation system of climate-related policies; formal and non-formal education and training programs to improve knowledge and awareness of teachers, educators, students, stakeholders, and the general public on climate change at all levels; and networks for climate research and information.

Support Needed

Aligning with the LT-LEDS, Thailand primarily needs the support for:
  1. Policy Implementation:
  • Building capacity in the public and private sectors to integrate climate actions into their respective plans or enterprises
  • Raising awareness of climate change, Thailand's LT-LEDS and NDCs among relevant stakeholders and the public
  2. Mechanism and instruments:
  • Financial instruments, incentives, mechanisms, and approaches to engage the private sector in the shift to green investment
  • Sharing knowledge and best practices on legal frameworks and modalities to support Thailand's LT-LEDS and NDC implementation

The overall support needed for enabling the environment is presented in Table 4-3.

Table 4-3: Summary of financial, technology, technical, and capacity-building support needed for enabling environment

Area	Support Needed (Policy, Plan, Measure, Program, Project)	Key Stakeholder	Support Type			
			CB	TS	TT	FS
Mechanism and Instruments	Expertise in climate change finance area to assist the development of financial instruments	FPO	x	x		x
Awareness Raising	Awareness-raising for relevant stakeholders and the general public on climate change measures	DEQP	x	x		x
Awareness Raising	Integration of climate change study and activity in the educational system at all levels	DEQP	x			x
Capacity Building	Enhance the capacity of teachers, instructors, trainers, and students in environmental science and climate change	IPST	x			x
Capacity Building	Development of capacity-building or intensive training courses for stakeholders in the transportation sector	OTP	x			x
Mechanism and Instruments	Mechanism promoting community roles in natural resource conservation	DMCR	x			x
Mechanism and Instruments	Establishment of a market mechanism to incentivize the implementation of community enterprises based on sustainable forest resources	RFD	x	x		x
Mechanism and Instruments	Development of matching grants financial mechanism for the IPPU sector in CCUS research, development, and technology transfer	NXPO			x	x
Mechanism and Instruments	Establishment of funding mechanism for climate change technology innovator startup	NXPO	x	x	x	x
Mechanism and Instruments	Development of financial mechanism to subsidize renewable energy technology	NXPO			x	x
MRV	Capacity Building programs for preparing MRV under EU Carbon Border Adjustment (CBAM)	TGO	x			x
Networking	Develop academic networking for climate change information sharing and research	ONEP	x	x		x

Remark:
TT: Technology Development & Transfer / TS: Technical Support & Assistance /
CB: Capacity Building / FS: Financial Support

4.3 International Support Received

Thailand has received support from various international partners, which strengthens the country to overcome some constraints, gaps, and barriers to climate action. To further enhance Thailand's effective implementation of mitigation, adaptation, and climate-resilient actions towards the goal of the Paris Agreement, adequate means of support in terms of finance, technology transfer, and capacity building are still needed, as described in the previous section. This section summarizes key messages and provides an overview of the support received by Thailand, excluding global and regional supporting projects, between 2018 and 2022. The formal support received prior to 2018 can be found in the Third National Communication (NC3) and Third Biennial Update Report (BUR3). The support received was categorized into three principal areas: mitigation, adaptation, and enabling environment.

4.3.1 Support Received for Preparing National Communication (NC) and Biennial Update Report (BUR)

Thailand, as a signatory to the UNFCCC, received financial support from the Global Environment Facility (GEF) to compile and publish Thailand's Fourth National Communication (NC4) and Third Biennial Update Report (BUR3) to the UNFCCC. The preparation was supported by GEF funding of 852,000 USD and in-kind support from the Thai Government of 700,000 USD. The United Nations Development Programme (UNDP) has been an implementing entity responsible for managing these funds for the GEF.

4.3.2 Support Received from International Donors

Thailand has received support from various multilateral and bilateral partners to facilitate climate actions in mitigation, adaptation, and enabling environment.

Global Environment Facility (GEF)

The Global Environment Facility (GEF) has provided Thailand with financial, technical, and capacity building supports through various programs. From GEF-6 and GEF-7, Thailand received support for climate change activities in six key projects with a GEF project grant of around 24 million USD and Thailand's co-financing of around 250 million USD, excluding the support on the NC and BUR preparation. Key programs supported by GEF include the Sixth Operational Phase of the GEF Small Grants Programme in Thailand, Inclusive Sustainable Rice Landscapes in Thailand, accelerating the adoption and life-cycle solutions to electric mobility in Thailand, accelerating construction of energy-efficient green housing units in Thailand, and strengthening Thailand's institutional and technical capacities. Furthermore, GEF has provided grant funding through UNDP to assist Thailand in the preparation of its NC and BUR, as described previously.

Green Climate Fund (GCF)

Thailand has received several readiness activities supported through GCF's Readiness and Preparatory Support Programme (GCF's Readiness Programme). Key activities include 1) increasing resilience to climate change impacts in marine and coastal areas along the Gulf of Thailand and 2) strengthening the capacities of the Environmental Fund Division to act as a national climate funding mechanism. Beyond the readiness support, Thailand received support for the project "Enhancing Climate Resilience in Thailand through Effective Water Management and Sustainable Agriculture." The project aims to mitigate climate change's social and economic impacts in the Yom and Nan River basins.

Multilateral Partners

Major multilateral partners include United Nations entities such as UNDP, UNEP, UNIDO, and UNESCO. United Nations partners play a crucial role in assisting Thailand to access the UNFCCC climate funds mentioned above. Multilateral partners also include financial institutions and organizations, such as the World Bank and WMO.

United Nations

United Nations entities have focused on assisting Thailand in strengthening its institutional and policy frameworks, both of which are crucial to facilitating the country's efforts to achieve national climate targets. As reported in the TBUR, ONEP together with UNDP, has implemented a project, "NDC Support Delivering Sustainability through Climate Finance Actions in Thailand," to support Thailand in making progress on its NDCs through the development of financing frameworks for climate action. Since 2019, more UNDP-led projects have been implemented: Programme Framework of Support in response to Thailand's development challenges and in supporting the achievement of the SDGs, increasing resilience to climate change impacts in marine and coastal areas along the Gulf of Thailand, Sixth Operational Phase of the GEF Small Grants Programme in Thailand, and Sustainable Mangrove Management and Coastal Ecosystem Development in Phetchaburi Province.

The World Bank

The World Bank has been a notable partner to Thailand for decades, and it has supported Thailand in two significant projects. The first project is the HCFC phase-out management plan: stage II. The project development objective is to reduce HCFC consumption in Thailand. By phasing out HCFC, Thailand will contribute to GHG reduction under the UNFCCC and fulfill the 2020 HCFC consumption phase-out obligations of the Montreal Protocol, its Multilateral Fund, and the initial requirements of the Kigali Amendment. The second project is the Thailand Readiness Preparation Proposal (R-PP) which has established the compulsory components for future implementation of REDD+ mechanism in the country. REDD+ is an international mechanism to support mitigation measures to reduce GHG emissions from deforestation and forest degradation together with enhancement of carbon stock from forest conservation, sustainable forest management and reforestation. Thailand has actively participated in the REDD+ readiness preparation program supported by the Forest Carbon Partnership Facility (FCPF). In addition, national strategies and action plans for REDD+ were completed in 2021 to increase carbon sequestration and ecosystem services in natural forests with social and environmental stability and equitable benefit sharing. The Department of National Parks, Wildlife, and Plant Conservation is the key organization implementing REDD+. The latest six-year action plan (2016-2021) focused on conserving and restoring degraded forests in watershed areas and preserving biodiversity using community participation processes based on ecological restoration that support REDD+ measures and the national REDD+ strategy plan.

Bilateral Partners

Germany

The German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU), through its funding instrument, the International Climate Initiative (IKI), has provided support to Thailand for many climate-related projects. The key projects include the Sustainable and Climate-Friendly Palm Oil Production and Procurement Project, climate and environmentally

friendly agricultural waste management, the Low Carbon Cities Programme (LCCP) through the cancellation of TVERs, Integrated Waste Management for GHG Reduction, the Climate Action Programme for the Chemical Industry (CAPCI), the revision and update of Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS), and Thailand's Nationally Determined Contribution (NDC). In addition, BMU established the Nitric Acid Climate Action Group (NACAG) to support the reduction of nitrous oxide (N_2O) in developing countries' production processes by providing technical and financial support to improve production technology, as well as training relevant officials. In 2021, Thailand signed the Statement of Undertaking (SOU) to formally join the NACAG group. Under NACAG, BMU by the GIZ will provide support for Thailand in the following areas: 1) policy and strategic consultation on nitrous oxide emission requirements, 2) technical support for reducing nitrous oxide, 3) financial support for Thailand's nitric acid industry, 4) capacity building to monitor and report nitrous oxide emissions and 5) support for reporting greenhouse gas emissions under the NDC.

Sweden

The government of Sweden, through the Swedish International Development Cooperation Agency and its Challenge Funds, has provided support to Thailand for two key projects: 1) Investment and Financial Flows Assessment (I&FF) Transport Sector under NDC Support Project: Delivering Sustainability through Climate Finance Actions in Thailand, and 2) Climate Change Financing Framework: CCFF under the NDC Support Project: Delivering Sustainability through Climate Finance Actions in Thailand.

Australia

The government of Australia, through the Australian Water Partnership, supports a new initiative as part of its Australia-Mekong Water Facility to identify, evaluate and realize the benefits associated with Nature-based Solutions (NbS) for integrated urban flood management in the Mekong region. This "Project on Valuing the Benefits of Nature-based Solutions for Integrated Urban Flood Management" is implemented in Thailand with the objectives of supporting economic analysis for selecting suitable nature-based solutions for solving urban flooding caused by climate change and strengthening the capacity of using economic assessment tools through case studies in two places in Thailand, namely Bangkok and Rayong Municipality.

The European Union

The European Union has supported Thailand to become more resilient to climate change and enhance its sustainable development goals. The key projects are 1) Strengthening urban climate governance for inclusive, resilient, and sustainable societies in Thailand (SUCCESS) aims to enhance the adaptive capacity of local urban communities through improved urban climate governance, state-of-the-art knowledge, and shared learning; and strengthen local institutional mechanisms and practices for inclusive, climate-resilient and sustainable urban development, 2) Climate-resilient Agriculture for Disaster Risk Reduction (CRADR), a collaborative project between the Disaster Mitigation Working Group (DMWG) and the Agriculture Working Group (AgWG), under the Asia-Pacific Advanced or APAN network which links members of research agencies and educational institutions from all over the world.

The project aims to study climate change's effects on agriculture in a small-scale case study (Phrae Province). It also seeks to have modern technologies transferred by "Partners" from various countries such as Japan, Taiwan, and India to solve the climate-resilient problems and develop this project into "Smart Agriculture." Moreover, the project will be participated in and shared among ASEAN members so that each country can study and adopt the outcome of this project to deploy in their own country.

Japan

After establishing the Asia-Pacific Adaptation Information Platform (AP-PLAT) to share regional climate change risk information via an online network, the Ministry of Environment of Japan (MOEJ) signed the Memorandum of Cooperation (MOC) with Thailand on 17 May 2018 to support the "Cooperation for Development of Information Infrastructure for Climate Change Adaptation in Thailand." The Thailand Climate Change Adaptation Information Platform (T-PLAT) aims to 1) create a platform providing information on climate risks and adaptation in Thailand, and 2) link data on climate change adaptation with regional platforms (AP-PLAT projects) and support the data dissemination in Southeast Asia. MOEJ assigned the Overseas Environmental Cooperation Center, Japan (OECC), in partnership with Green Pacific Co., Ltd., as a

project consultant working with ONEP and DEQP to implement the project. With technical support from Japan, Thailand has successfully installed the T-PLAT website and presented information in a comprehensive infographic format.

4.3.3 Support Received by Sector

Categorizing by sector, Thailand has received support for 18 mitigation projects with a total amount of 31,438,771 USD, 10 adaptation projects with a total amount of 48,667,056 USD, and six enabling environment projects with a total amount of 3,419,548 USD. Thailand has received the most support in climate change mitigation in the number of projects, and in climate change adaptation in the amount of support received. The number of enabling environment projects is slightly less than adaptation, but the amount of support received is much lower. Considering the small amount of support received for climate adaptation reported in the BUR3, more support has been provided to Thailand for this sector. However, more financial support is needed to strengthen the enabling environment for climate actions. The breakdown of information for each sector is detailed in Figure 4-1, providing a bigger picture of the international support Thailand receives.
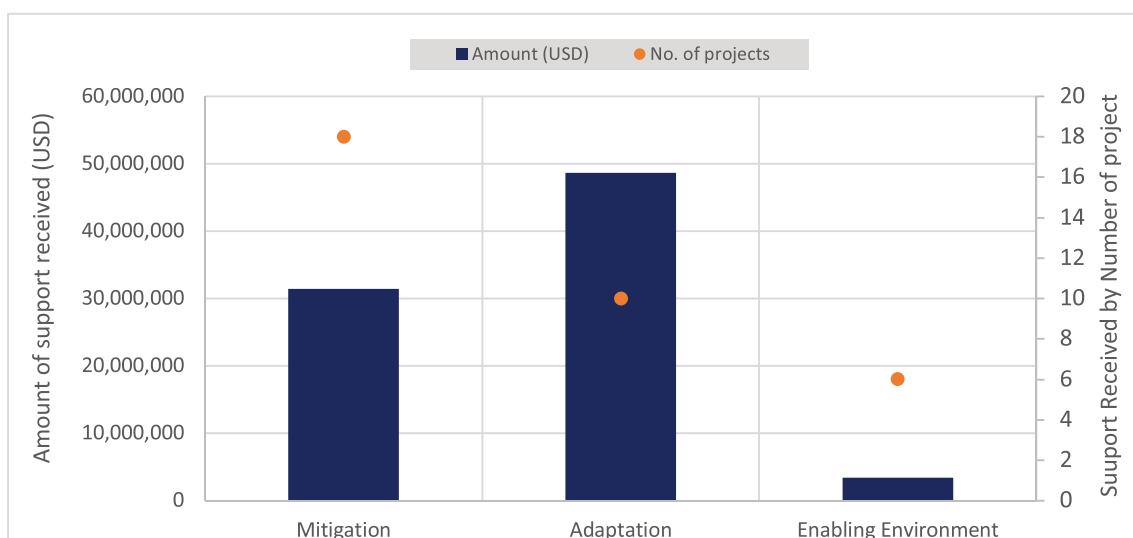

Figure 4-1: Summary of support received by number of projects

Mitigation

From the support received for mitigation actions, the IPPU sector received the most support according to the number of projects and amount of funding received. The energy, transport, and waste sectors received comparable numbers of projects and amounts of funding. Though the IPPU sector notably contributes to national GHG emissions, the national priority focuses on the energy and transport sectors as they are the most significant GHG contributors and the cornerstone for climate mitigation actions.

To align with the energy transition's priority previously described, Thailand still requires more support for mitigation projects in the energy, transport, waste, agriculture, and LULUCF sectors to achieve the NDC and LT-LEDS targets. The support received by sector for mitigation actions is summarized in Figure 4-2.
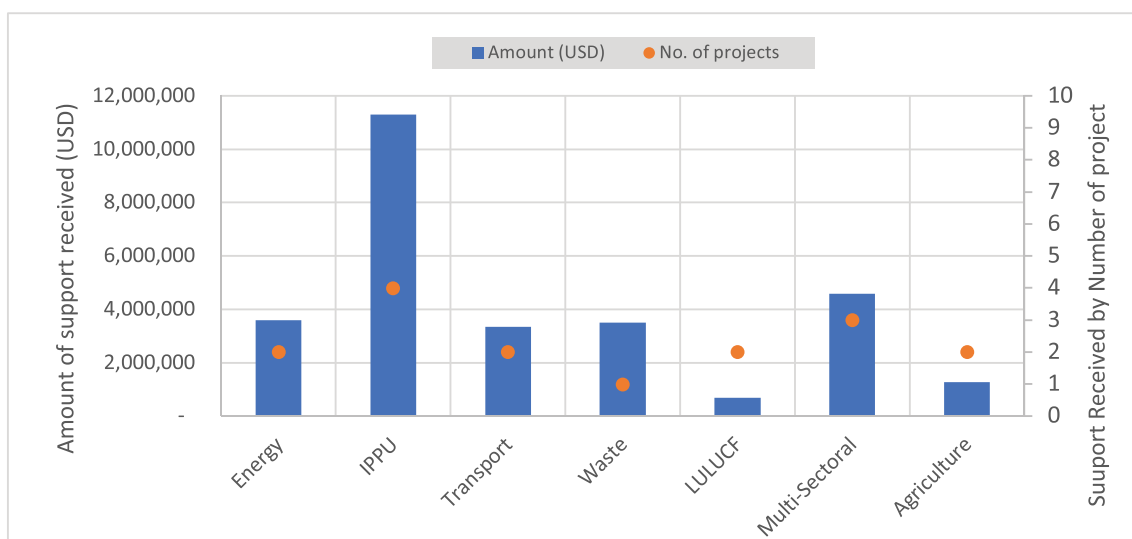

Figure 4-2: Support received by number of projects for mitigation actions

Adaptation

Thailand's support received for adaptation actions concentrates on water management, human settlement, agriculture, and multi-sector. Water management received the most support in terms of projects, while human settlement received the most support in terms of financing. However, it is essential to note that the amount of support received was far lower than the support needed by Thailand to minimize risks and vulnerability and improve the country's resilience.

As a country highly vulnerable to the impacts of climate change, Thailand needs more support in climate change adaptation, especially in tourism, public health, natural resources, and agriculture as listed in the support needed section. The support received by sector for adaptation actions is summarized in Figure 4-3.
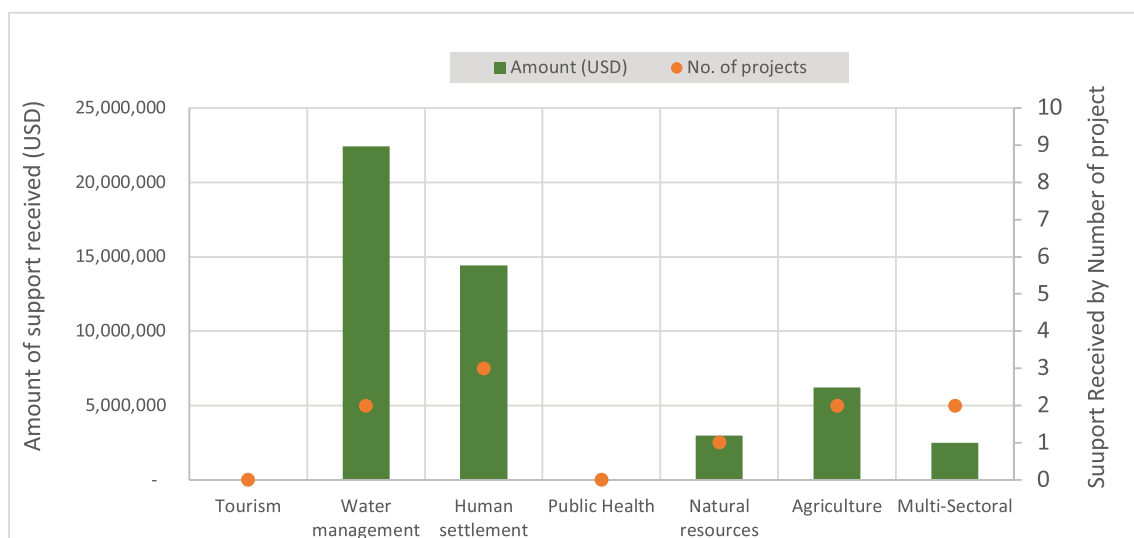
Figure 4-3: Support received by number of projects for adaptation actions

Enabling Environment

Most support for enhancing the enabling environment of climate actions in Thailand targets institutional strengthening and mechanisms and instruments. Both received a comparable amount of funding, but institutional strengthening received more numbers of projects. Based on the support needed, Thailand needs more support for awareness-raising and capacity building to enable climate actions effectively. The support received by sector for enhancing the enabling environment is summarized in Figure 4-4.
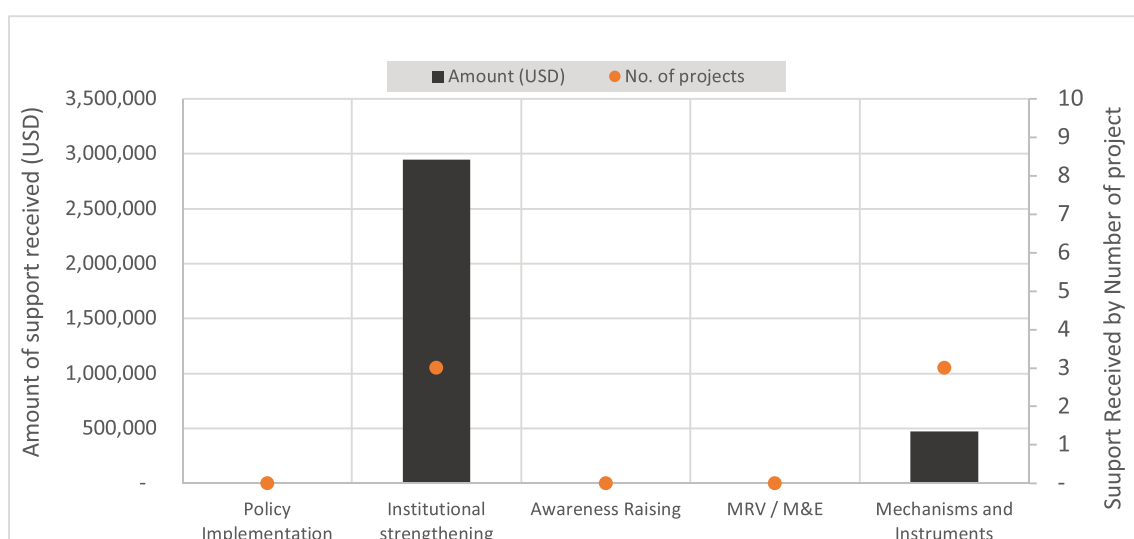

Figure 4-4: Support received by number of projects for enhancing enabling environment

4.3.4 Support Received by Types

The support received in climate actions can also be categorized into four supporting types: technology transfer, technical support, capacity building, and financial support (see Figure 4-5).

It is important to note that most projects detailed in this report involve more than one type of support. A combination of technical support and capacity building is the most common type of support that Thailand has received. In addition, Thailand only received a few projects that provided support in technology development and transfer, which play important roles in mitigation and adaptation implementation.
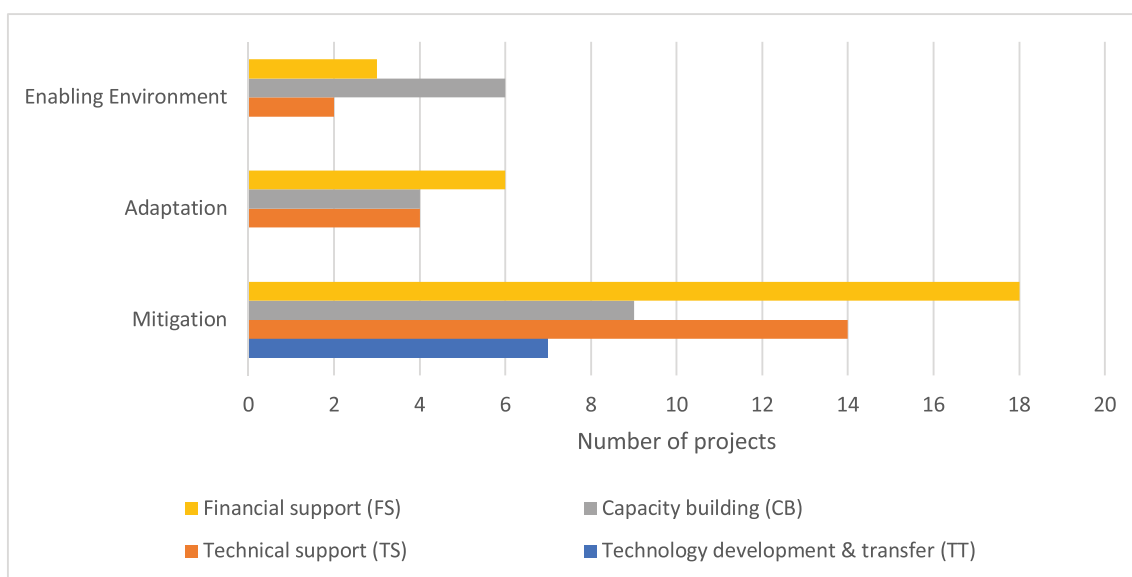

Figure 4-5: Support received by types of support

4.3.5 Summary of Support Received

While contributing to less than 1% of global emissions, Thailand bears increasingly significant climate risks of natural disasters and catastrophes. Thus, Thailand has made substantial efforts to mitigate climate change by implementing GHG emission reduction measures, enhancing national adaptive capacity to achieve climate resilience, and strengthening the enabling environment for climate measures implementation. Nevertheless, these efforts require extensive investment, innovative technology, institutional integration, and capacity and expertise.

At present, support is needed for Thailand to increase the capacities, resources, and technology development of governmental agencies, private sectors, and the public to take climate actions. To enhance Thailand's effective implementation of mitigation, adaptation, and climate-resilient actions towards the goal of the UNFCCC and Paris Agreement, the support needed by Thailand and the support provided should be aligned. From the support received during 2019-2022, there are still some gaps between support needed and support received. Fulfilling these gaps will ensure that Thailand can expose its full potential to implement climate actions effectively and efficiently.

Table 4-4: Project list of support received for mitigation actions in Thailand

Mitigation Project	Objectives/ Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	Support Type			
						CB	TS	TT	FS
Accelerating the adoption and life-cycle solutions to electric mobility development in Thailand	The project focuses on GHG reduction in the transport sector by addressing the problems concerning the scaling up of EV utilization in Thailand. It seeks to set out the institutional framework and EV usage demonstration in the EEC zone.	Transport	2020-2025	UNIDO	3,299,744 USD	x	x		
Investment and Financial Flows Assessment (I&FF) Transport Sector under NDC Support Project: Delivering Sustainability through Climate Finance Actions in Thailand	The I&FF study will draw on historical and current public and private investment data to create a projection. It is a tool to support the country's policy planning. Objective: 1) To estimate the amount of investment and funding for climate change adaptation of the transport sector, 2) To promote awareness of the impact of climate change on the transport sector, and 3) To create an adaptation guideline to support investment prioritization and coordination at the policy level, 4) To assess the financial need and investment volume for climate change adaptation of the transport sector.	Transport	2019-2021	SIDA	55,417 USD		x		x
Climate and environmentally friendly agricultural waste management in Thailand	To transform traditional waste management into climate-friendly waste management, reduce the burning of agricultural waste, and add organic matter to the soil to benefit plant growth.	Multi-Sector	2022-2026	BMU, GIZ	2,500,000 EUR		x	x	x
Learning Center and Extension of Complete Green Energy Station, Kanchanaburi	To be a center for learning and developing the production and use of integrated biomass energy (Both upstream, midstream, and downstream levels) and a model for the production and use of electricity from small biomass plants in the community / setting up a learning center and transfer knowledge to interested parties.	Energy	2019-2020	UNIDO, GEF	40,000 USD	x		x	x

Table 4-4: Project list of support received for mitigation actions in Thailand

Mitigation Project	Objectives/ Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	Support Type			
						CB	TS	TT	FS
Accelerating construction of energy-efficient green housing units in Thailand	The project aims to implement greenhouse gas reduction activities in the Housing Authority's housing project. The objective is to develop energy-efficient and environmentally friendly housing to reduce greenhouse gas emissions. The activities consist of three elements: 1) energy-efficient housing design and labeling for energy-efficient housing, 2) financial mechanisms for promoting energy-efficient housing, and 3) raising awareness and capacity for promoting energy-efficient housing	Energy	2021-2026	UNEP	3,560,000 USD	x	x		
Integrated Waste Management for GHG Reduction	The project intends to enhance the capacity of the waste (wastewater) sector to implement Thailand's GHG reduction goal and climate change action after 2020 and the country's greenhouse gas reduction navigation map after 2020.	Wastewater	2018-2022	GIZ	120,000,000 THB	x	x		x
HCFC Phase-out management plan: stage II	The objectives: 1) reduce the use of HCFCs in the spray foam industry and the commercial refrigerator and freezer sector, enabling Thailand to meet its obligations under the Montreal Protocol. 2. Provide basic tools/equipment for air conditioners that use HFC-32 as a refrigerant to the Department of Skill Development and the Office of Vocational Education Commission 3. Organize training on installation and maintenance of air conditioners that use HFC-32 for technicians working under the Department of Skill Development and the Office of Vocational Education Commission 4. Provide refrigerant identifier for the Customs Department.	IPPU	2020-2023	World Bank	152,520,000 THB	x	x		x
Enabling Activities for Kigali Amendment Ratification and supporting the preparation of Thailand HFCs Phase down strategy	The project aims to explore the consumption of HFCs in all industries in Thailand and analyze and plan to reduce the country's use of HFCs to ratify the Montreal Protocol revised in Kigali.	IPPU	2018-2021	World Bank	7,500,000 THB		x		x

Table 4-4: Project list of support received for mitigation actions in Thailand

Mitigation Project	Objectives/ Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	CB	TS	TT	FS
Technical assistance to support Market Transformation to Higher Energy Efficient Room Air Conditioning through Manufacturing Readiness	The project aims to 1) transfer inverter technology in air conditioning to Thai air conditioning manufacturers, which will enable the industry in Thailand to produce clean and environmentally friendly products and change the domestic air conditioning market, and 2) compare energy-saving performance between inverter air conditioners and fixed-speed air conditioners., and 3) develop energy efficiency plan for cooling systems in the air conditioning industry, refrigerator, and commercial freezer in the country.	IPPU	2018-2021	K-CEP, World Bank	48,000,000 THB		x	x	x
Tillage and Organic Fertilizer Production to Prevent Greenhouse Gas in the northern agricultural areas	To transform into climate-friendly agricultural waste management which can reduce the burning of agricultural waste, reduce GHG emissions, and add organic matter to the soil to benefit plant growth	Agriculture	2021-2023	GEF, UNDP	200,000 USD		x		x
Sustainable and Climate-friendly Palm Oil Production and Procurement Project in Thailand	The goal is to enhance the sustainable production of palm oil, aligning with the international standards and improving the palm farmers' quality of life. The targets are: 1) to create sustainable palm oil production throughout the supply chain, 2) to promote greenhouse gas reduction measures and appropriate supporting tools, and 3) to scale up sustainable palm oil production.	Agriculture	2018-2022	GIZ	1,000,000 EUR	x	x	x	x
EGAT Cooling Innovation Fund: CIF	To foster the development of innovations in energy-efficient refrigeration technology and drive Thai industry towards the use of green refrigeration technology that uses natural refrigerants or alternative cooling technology	IPPU	2021-2024	Germany, UK, NAMA Facility, GIZ	180,000,000 THB			x	x
Support of the Thailand Low Carbon Cities Programme (LCCP) through cancellation of TVERs	Inducing greenhouse gas reduction measures in associated cities and municipalities across Thailand through Results-Based Payment Mechanism (RBP Mechanism) for cancellation of verified emission reductions from Thailand Voluntary Emission Reduction (T-VER) Projects	Multi-Sector	2019-2022	Germany/IKI	1,800,000 EUR				x

Table 4-4: Project list of support received for mitigation actions in Thailand

Mitigation Project	Objectives/ Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	Support Type			
						CB	TS	TT	FS
Achieving Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand	Strengthening capacity development for cities/municipalities on low carbon emission urban systems management, low carbon development policy and targets, and preparedness of the innovative domestic voluntary city offsetting mechanism to reduce carbon emission and demonstrate low carbon-emitting urban system projects in cities including Khon Kaen, Chiang Mai, Nakhon Ratchasima, and Samui in a measurable, reportable and verifiable (MRV) manner, and develop city models for Low Carbon Cities Initiatives, and networking in Thailand	Multi-Sector	2017-2021	UNDP, GEF	3,150,000 USD				x
Thailand REDD+ Readiness Preparation Proposal Project	To study and analyze the underlying causes of deforestation and forest degradation and formulate the National Redd Plus Strategy; to establish a mechanism to resolve complaints and formulate a benefit-sharing framework under the Redd Plus mechanism, as well as a strategic social and environmental impact assessment for the Redd Plus Mechanism for Thailand	LULUCF	2020-2021	World Bank	13,000,000 THB				x
Assessing Carbon Stock Change in a Stratum (Carbon Fluxes) in Thailand	The objective is to estimate the amount of carbon in soil and develop a carbon map. The result should reveal the assessment of carbon loss caused by soil erosion and the mapping of areas with a substantial risk of soil erosion in Thailand.	LULUCF	2021-2023	GEF, UNEP	315,000 USD		x	x	x
Nitric Acid Climate Action Group (NACAG) in Thailand	The objective of the project is to support the reduction of nitrous oxide (N_2O) from the production processes by providing 1) policy and strategic consultation on nitrous oxide emission requirements, 2) technical support for reducing nitrous oxide, 3) financial support for Thailand's nitric acid industry 4) capacity building to monitor and report nitrous oxide emissions and 5) support for reporting greenhouse gas emissions under the NDC.	IPPU	2021 on-going	BMU/GIZ	Not specified*	x	x	x	x

Table 4-4: Project list of support received for mitigation actions in Thailand

Mitigation Project	Objectives/ Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	Support Type			
						CB	TS	TT	FS
Climate Action Programme for the Chemical Industry (CAPCI)	The project aims to enable key actors in the chemical industry to identify and tap mitigation potentials in chemicals production and associated value chains. The first phase focuses on information, knowledge, and awareness creation as well as stakeholder dialogue. The second phase focuses on action-oriented capacity building, training, and technical advice. It is a global project covering five countries: Argentina, Ghana, Peru, Thailand, and Vietnam.	Multi-sector	2021-2024	BMU Germany/IKI	2,000,000** EUR	x	x		x

Remark:

TT: Technology Development & Transfer / TS: Technical Support & Assistance / CB: Capacity Building / FS: Financial Support

* Nitric Acid Climate Action Group (NACAG) in Thailand: The amount of support received for this project is not specified. It depends on the procured technologies: secondary and tertiary abatement technologies. For the secondary abatement technology, the investment and operational costs are approximately 1.5 million EUR and 2 million EUR per tCO2eq, respectively. For the tertiary abatement technology, the investment and operational costs are about 7 million EUR and 5 million EUR per tCO2eq (for the period of 20 years), respectively.

**Climate Action Programme for the Chemical Industry (CAPCI): The amount of support received for this project were distributed among the five countries: Argentina, Ghana, Peru, Thailand, and Vietnam.

Table 4-5: Project list of support received for adaption actions in Thailand

Adaptation Project	Objectives/Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	Support Type CB	TS	TT	FS
Mekong EbA South: Enhancing Climate Resilience in the Greater Mekong Sub-region through Ecosystem-based Adaptation in the Context of South-South Cooperation	The project aims to: 1) demonstrate the EbA guidelines in the vulnerable communities in Thailand to address climate change impacts, particularly from drought and flood in the selected areas such as basin areas in Thailand, and 2) elevate the level of knowledge and awareness of climate adaptation measures, particularly the EbA to exchange climate impacts data in a different ecosystem, and 3) enhance regional cooperation leading to the establishment of roadmap and plans for climate adaptation in Mekong Sub-Region.	Multi-Sector	2022-2025	UNEP	2,506,000 USD	x			
Enhancing climate resilience in Thailand through effective water management and sustainable agriculture	The project promotes water management for agriculture and the community in the Chaopraya basin	Water Management	2021-TBA	UNDP, GCF	17,533,500 USD	x	x		x
Enhancing Climate Resilience of Mekong River Communities through Strengthening Climate Services (ECR-MEKONG)	The project aims to enhance climate resilience in Mekong River communities and reduce vulnerability to climate change effects.	Human Settlement	2021-2026	WMO	13,780,000 USD				x
Inclusive sustainable rice landscapes in Thailand	The project promoted sustainable rice production covering both highland and flood-plain land, and irrigation and rainwater fields. The project was conducted in Suphanburi and Ubon Ratchathani provinces by using new agricultural theory and standards of sustainable rice production and promoting local community participation.	Agriculture	2019	UNEP, GEF	6,125,000 USD	x	x		x
Groundwater Resources in the Greater Mekong Subregion: Collaborative Management to Increase Climate Change Resilience	Objectives: Utilize and manage groundwater resources to reduce its vulnerability and ensure climate resilience for water users, especially the low-income farmers. The project is consistent with the approaches/measures under the Climate Change Adaptation Plan to drive implementation	Water Management	2021-2025	UNESCO	4,898,755 USD				x

Table 4-5: Project list of support received for adaption actions in Thailand

Adaptation Project	Objectives/Description	Sub-Sector	Project Period	Donor/ Partner Agency	Amount	CB	TS	TT	FS
	under the International Basin Management Cooperation Mechanism and increase the efficiency of groundwater management together with the use of surface water, especially in drought-prone areas. The pilot projects can be used as a case study for future development in other areas.								
Strengthening urban climate governance for inclusive, resilient, and sustainable societies in Thailand (SUCCESS project)	To strengthen mechanisms for sustainable urban development by taking into account how to cope with climate change and urban development for people of all levels	Human Settlement	2020-2024	EU	25,000,000 THB				x
Climate-resilient Agriculture for Disaster Risk Reduction (CRADR)	Study of variables affecting farming in Thailand (Phrae Study Area) and future implementation practices	Agriculture	2020	EU, Trans-Eurasia	3,276,552.86 THB				x
Project on Valuing the Benefits of Nature-based Solutions for Integrated Urban Flood Management	Project Objectives: 1) Support economic analysis for selecting suitable Nature-based solutions for solving urban flooding caused by climate change, and 2) Strengthen the capacity of using economic assessment tools through case studies in two places in Thailand, namely Bangkok and Rayong Municipality. The expected outcomes of the project focus on the development of human resource capacity in economic analysis to choose the appropriate Nature-based Solutions (NbS), with a case study assessment presented in Thailand and successful performance in China including expanding the scope of operations in the area other Mekong sub-regions in the future.	Human Settlement	2020-2021	Australia	-	x	x		
Increasing resilience to climate change impacts in marine and coastal areas along the Gulf of Thailand	The objective is to integrate planning and budgeting for climate adaptation operations in marine and coastal areas. This project builds on the adaptation plan currently being implemented by the Office of Natural Resources and Environmental	Natural Resources	2020-2024	GCF, UNDP	3,000,000 USD	x	x		

Table 4-5: Project list of support received for adaption actions in Thailand

Adaptation Project	Objectives/Description	Sub-Sector	Project Period	Donor/ Partner Agency	Amount	Support Type			
						CB	TS	TT	FS
	Policy and Planning (ONEP). The project will focus on marine and coastal areas and local adaptation planning processes. Resources and assistance from the Green Climate Fund (GCF) will be used to address the barriers, data gathering, knowledge, and coordination for adaptation planning, especially in the private sector. The expected results are 1. Increasing the capacity and knowledge to apply climate risk data to the planning and development of regional marine and coastal areas 2. Increase the efficiency of the implementation of the National Climate Change Adaptation Plan and integration of adaptation in planning and budgeting in marine and coastal areas 3. Developing financial strategies for climate change adaptation in marine and coastal areas								
Thailand Climate Change Adaptation Information Platform (T-PLAT)	The project aims to 1) create a platform providing information on climate risks and adaptation in Thailand and 2) link data on climate change adaptation with regional platforms (AP-PLAT projects) and support the data dissemination in Southeast Asia.	Multi-Sector	2017-2021	Japan	Not disclosed		x		

Remark:
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Table 4-6: Project list of support received for enabling environment in Thailand

Enabling Environment Project	Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	Support Type			
						CB	TS	TT	FS
Building project pipeline capacities: development of GCF concept notes in the transport and health sectors in Thailand	The project seeks to enhance Thai agencies' capacity to approach Green Climate Fund for climate mitigation and adaptation.	Institutional Strengthening	2022-2024	GIZ	544,222 USD	x			
Strengthening the capacities of the Environmental Fund Division to serve as a key Thailand's national mechanism for climate finance	The project aims to strengthen the capacity of Thailand's Environmental Fund Division to be recognized and endorsed by the Green Climate Fund.	Institutional Strengthening	2020-2021	GIZ	409,142 USD	x			
Developing GCF pipeline of projects from locally driven climate actions	To enhance the capacity of local communities to adopt climate mitigation measures	Mechanism and Instrument	2022-2024	GCF	349,999 USD	x			
Inclusive, gender-responsive Climate Change Benefit Analysis: iCCBA) under NDC Support Project: Delivering Sustainability through Climate Finance Actions in Thailand (NDC Support)"	The project is to develop a plan/policy for integrating gender-inclusive factors in budget management and planning of climate change measures. Several activities were initiated, such as target training sessions for agencies, operational meetings, and a handbook on climate finance.	Mechanism and Instrument	2019-2021	Germany and Sweden	71,585 USD	x	x		x

Table 4-6: Project list of support received for enabling environment in Thailand

Enabling Environment Project	Description	Sub-Sector	Project Period	Donor/Partner Agency	Amount	Support Type CB	TS	TT	FS
The Capacity Building Initiative for Transparency (CBIT)	The project aims to strengthen Thailand's institutional and technical capacities to comply with the Enhanced Transparency Framework of the Paris Agreement. The project consists of four elements: 1) enhance the capacity to collect data activity for GHG inventory, 2) enhance the capacity of MRV system for NDC implementation, 3) elevate the assessment of received funds for NDC implementation, and 4) enhance the transparency of adaptation and mitigation measures.	Institutional Strengthening	2021-2024	GEF, UNEP	1,991,000 USD	x			x
Climate Change Financing Framework: CCFF under the NDC Support Project: Delivering Sustainability through Climate Finance Actions in Thailand	Objective: 1) To assess the degree of integration of climate change in the public finance system, 2) To identify strategies and guidelines for climate change response planning and budgeting as well as presenting a navigation map for climate change integration, 3) To develop roadmaps and action plans in the short, medium, and long term to lead to unified climate change policy implementation. This leads to efficient and effective climate change budget planning and allocation. Currently, the UNDP is in discussions with the Budget Office and the Office of the National Economic and Social Development Council, and other related agencies to develop a climate change financing framework to enhance NDC mobility and achieve the Sustainable Development Goals.	Mechanism and Instrument	2019-2021	SIDA	53,600 USD	x	x		

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BIBLIOGRAPHY

Bangkok Metropolitan Administration. *Draft Bangkok Climate Change Master Plan 2021-2030.*

Basic Education Commission (OBEC). *Basic Education Core Curriculum 2008.*

Bouman, B.A.M, and T.P Tuong. "Field Water Management to Save Water and Increase Its Productivity in Irrigated Lowland Rice." *Agricultural Water Management 49,* no. 1
(July 2001): 11–30. https://doi.org/10.1016/s0378-3774(00)00128-1.

Committee of Agricultural and Cooperative Development Policy and Plan. *Strategic Plan for Agricultural Research and Development (2023-2028).*

Department of Alternative Energy Development and Efficiency. *Energy Balance of Thailand 2020.* No.7. Bangkok: Ministry of Energy, January-December 2020.

Department of Environmental Quality Promotion. *Research Report of Environmental Research and Training Center 2018-2020*

Department of Health. *Health National Adaptation Plan (HNAP), Phase 1 (2021 – 2030).*

Department of Industrial Works. *NDC Sectoral Action Plan for IPPU Sector 2021 – 2030.*

Department of Marine and Coastal Resources. "Data Centers for Marine and Coastal Resources."
Accessed June 26, 2022. https://bigdata.dmcr.go.th/

———. *Annual Report 2020.*

Department of Provincial Administration. *Notification of the Department of Provincial Administration: Subject Administrative Information 2020.*

Department of Tourism. *Analysis Report on Thailand Tourism 2019-2021.*

Department of Women's Affairs and Family Development. *The Government of Thailand's National Review Implementation of the Beijing Declaration and Platform for Action (1995) and the Outcomes of the Twenty-Third Special Session of the General Assembly (2000) in the Context of the Twenty-Fifth Anniversary of the Fourth World Conference on Women and the adoption of the Beijing Declaration and Platform for Action 2020.*

Energy Policy and Planning Office. *NDC Sectoral Action Plan for Energy Sector 2021 – 2030.*

Forest Land Management Office. *Final Report on Forest Area Information Project 2017-2018.*

Hydrographic Department within the Royal Thai Navy. *Thailand National Report for the Meeting of the North Indian Ocean Hydrographic Commission 2019.*

Intergovernmental Panel on Climate Change. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.* Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros,

V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge: Cambridge University Press, 2014.

———. *Good Practice Guidance for Land Use, Land-Use Change, and Forestry. Japan: Institute for Global Environmental Strategies (IGES) for the IPCC, 2003.*

———. *Greenhouse Gas Inventory Reference Manual. International Panel on Climate Change.* Cambridge: Cambridge University Press, 1996.

———. *IPCC Guidelines for National Greenhouse Gas Inventories.* Japan: Institute for Global Environmental Strategies (IGES) for the IPCC, 2006.

———. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker,D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge : Cambridge University Press, Cambridge, 2012.

Isarangkun Na Ayutthaya, Adis and Kanchana Yasen. *COVID-19 Pandemic: The Sea has Re cuperated into Sustainable Tourism.* Bangkok: National Research Council of Thailand (NRCT), Knowledge Network Institution of Thailand (KHNIT), and Thailand Development Research Institute (TDRI), 2021.

Maneesan, Wirat. *Geography and Seasonal Weather of Thailand*. Thai Meteorological De partment Academic Document No. 551.582-02-1995. September 1995.

Ministry of Agriculture and Cooperatives. *Agriculture Strategic Plan on Climate Change (ASPCC) 2017-2021*

Ministry of Energy. *Alternative Energy Development Plan 2018-2037 (AEDP)*

———. *Draft National Energy Plan 2022.*

———. *Energy Efficiency Plan 2018-2037 (EEP)*

———. *Gas Plan 2018-2037*

———. *Oil Plan 2018-2037*

———. *Power Development Plan 2018-2037 (PDP)*

Ministry of Foreign Affairs. *Thailand's Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development 2021.*

Ministry of Industry. "Green Industry." Accessed June 10, 2022. https://greenindustry.diw. go.th/webgi/

———. *National Industrial Development Master Plan 2012-2031.*

―――. *Thailand's Industrial Development Strategy 4.0 (2017-2036).*

National Research Council of Thailand (NRCT). *National Research Policy and Strategy (2018-2021) and the Action Plan (2020-2022).*

Noor, S and Munazza Fatima. "Impacts of Climate Change on the Human Settlement and Their Possible Adaptive Measures: An Overview from Pakistan." Rajshahi University   Journal of Environmental Science, Vol. 1, 62-72, December 2011.

Office of Agricultural Economics. *Agricultural Statistics of Thailand 2020.*

Office of National Higher Education Science Research and Innovation Policy Council. *Climate Mitigation Technology Database and Roadmap 2019.*

―――. *Adaptation Technology Roadmap 2022*

Office of National Water Resources. *Report on Water Resource Management Plan 2021*

―――. *The 20-Year Master plan on Water Resources Management 2018-2037*

―――. *The 22 Basins and Designated River Basin Decree 2021.*

Office of Natural Resources and Environmental Policy and Planning. *Biological Diversity Status of Thailand 2020.* Bangkok: Ministry of Natural Resources and Environment, 2020.

――― . *Thailand's Environmental Circumstance 2021*. Bangkok: Ministry of Natural Re sources and Environment, 2021.

Office of Natural Resources and Environmental Policy and Planning and UNDP Thailand. *Policy Brief: Gender Responsive and Socially Inclusive Public Climate Finance.*

Office of Natural Resources and Environmental Policy and Planning. *Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030.*

―――. *Nationally Appropriate Mitigation Action 2014-2020.*

―――. *Thailand's Mid-Century, Long-Term Low Greenhouse Gas Emission Development Strategy 2021.*

―――. *Thailand's Climate Change Master Plan (2012-2050).*

―――. *Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS)*

―――. *Thailand's National Adaptation Plan.*

Office of Natural Resources and Environmental Policy and Planning and RU-CORE. *Full Report on National Climate Policy Optimization Program: Development of Database System for Geospatial Risks from Climate Change.* Bangkok: RU-CORE, 2021.

Office of the National and Social Development Council and UNDP Thailand. *Legal Gender Recognition in Thailand a Legal and Policy Review 2018.*

Office of the National Economic and Social Development Council. *Poverty and Inequality Report 2020.*

————. *Report on the Study of Hypothesis for Population Projection of Thailand 2010 - 2040 (revised version)*. First Edition. Bangkok: Office of the National Economic and Social Development Council, 2019.

————. *Report on Economic and Social Profile and Outlook 2019-2021.*

————. *The 12th National Economic and Social Development Plan (2017-2021).*

————. *The Draft 13th National Economic and Social Development Plan (2023-2027).*

Office of the National Land Policy Board. *Draft National Policy and Plan on Land and Land Resources Management (2023-2037).*

Office of Transport and Traffic Policy and Planning. *NDC Sectoral Action Plan for Transport Sector 2021 – 2030.*

————. *Thailand's Environmentally Sustainable Transport Master Plan (EST) 2013-2030*

————. *Thailand's Transport Infrastructure Development Plan 2015-2022 Pollution Control Department. Draft National Waste Management Action Plan 2022 – 2027.*

————. *NDC Sectoral Action Plan for Waste Sector 2021 – 2030.*

————. *Thailand State of Pollution Report 2020.* PCD No.06-074. Bangkok: Ministry of Natural Resources and Environment, 2021.

————. *Thailand's Roadmap on Plastic Waste Management 2018 – 2030.*

Royal Forest Department. *Final Report of Forest Information Preparation Project 2017-2019.*

Royal Irrigation Department. *The 20-year Irrigation Strategy (2017-2037).*

Singhruck, Patama, Atsamon Limsakul, Sittichai Pimonsree, Jerasorn Santisirisomboon, Waranyu Wongseree, Sujittra Ratjiranukool, Sirapong Sooktawee, and Apiwat Faikrua. *Decadal Climate Variations and the Near-Term Climate Projection over the Southeast Asian (SEA) Monsoon Region.* Bangkok: Thailand Research Fund (TRF), 2021.

Strategic Transformation Office. *The 20-Year National Strategy (2017-2036).*

Suphannachart, Waleerat and Peter Warr. *Total Factor Productivity in Thai Agriculture: Measurement and Determinants.* ARE Working Paper No. 2553/1. Bangkok: Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, 2010.

Thai Meteorological Department. *Thailand Weather Conditions 2021.*

———. *Variation and Climate Change 2020.* Bangkok: Climate Center Meteorological Development Division, 2021.

Thailand Greenhouse Gas Management Organization. "Carbon Label Project." Accessed May 20, 2022. http://thaicarbonlabel.tgo.or.th/?lang=th

———. "Clean Development Mechanism." Accessed May 20, 2022. http://ghgreduction.tgo.or.th/th/cdm.html

———. "Joint Crediting Mechanism." Accessed May 20, 2022. http://ghgreduction.tgo.or.th/th/jcm.html

———. "Low Carbon City." Accessed May 20, 2022. http://www.tgo.or.th/2020/index.php/en

———. "Low Carbon EEC." Accessed May 20, 2022. https://lowcarboneec.tgo.or.th

———. "Low Emission Support Scheme." Accessed May 20, 2022. http://ghgreduction.tgo.or.th/th/less.html

———. "Thailand Carbon Offsetting Program." Accessed May 20, 2022. http://www.tgo.or.th/2020/index.php/en/page/carbon-offsetting-program

———. "Thailand Carbon Neutral Network." Accessed May 20, 2022. (Thailand Carbon Neutral Network) (tgo.or.th)

———. "Thailand Voluntary Emission Reduction Program." Accessed May 20, 2022. http://ghgreduction.tgo.or.th/th/t-ver.html

Thailand Research Fund. "Coastal Province Information." Marine Knowledge Hub. Accessed June 1, 2022. http://www.mkh.in.th/

United Nations Development Programme. *Training Module on Gender and Climate Change: Overview of Linkages Between Gender and Climate Change.*

United Nations Environment Programme. *From Pollution to Solution: A Global Assessment of Marine Litter and Plastic Pollution.* Nairobi:UNEP, 2021.

UNFCCC. *Documents and Decisions.* Retrieved from UNFCCC: https://unfccc.int/decisions, 2022.