MINISTRY OF NATURAL RESOURCES
AND ENVIRONMENTAL SUSTAINABILITY

MALAYSIA

FIRST BIENNIAL TRANSPARENCY REPORT (BTR1)

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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This is Malaysia's First Biennial Transparency Report (BTR1)
submitted to the United Nations Framework Convention on Climate Change in December 2024

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UNIT

mm	millimetre
cm	centimetre
m	metre
km	kilometre
km^2	square kilometre
ha	hectare
m^2	cubic metre
g	gram
kg	kilogram
t	tonne
kt	kilotonne
Gg	gigagram
Mt	million tonnes
hr	hour
year	year
TJ	Tera Joule
PJ	Peta Joule
toe	Tonnes of oil equivalent
ktoe	Kilotonnes of oil equivalent
Mtoe	Million tonnes of oil equivalent
Gg CO_2 eq.	Gigagram of carbon dioxide equivalent
kWh	kilowatt hour
MW	megawatt
MWh	megawatt hour
GWh	gigawatt hour
RM	Ringgit Malaysia (Malaysia Ringgit)
°C	degree Celsius

CONVERSION TABLE

1 tonne	= 10^3 kg	= 10^6 g	
1 kt	= 10^6 kg	= 10^9 g	= 1 Gg
1 Mt	= 10^9 kg	= 10^{12} g	= 10^3 Gg
1 km^2	= 100 ha		
1 TJ	= 10^{12} Joules		
1 PJ	= 10^{15} Joules	= 10^3 TJ	

CHEMICAL ELEMENTS / COMPOUNDS

C	Carbon
K	Potassium
N	Nitrogen
P	Phosphorous
Al_2O_3	Aluminium oxide
CaC2	Calcium carbide
$CaCO_3$	Calcium carbonate
$Ca(Mg(CO_3)_2$	Dolomite
CaO	Calcium oxide

GASSES

CF_4	tetrafluoromethane
C_2F_6	hexafluoroethane
C_3F_8	octafluoropropane
CHF_3	fluoroform
CO	carbon monoxide
CO_2	carbon dioxide
CH_4	methane
HFC	hydrofluorocarbon
HFC-134a	1,1,1,2-tetrafluoroethane
NF_3	nitrogen trifluoride
N_2O	nitrous oxide
NMVOCs	non-methane volatile organic compounds
NOx	nitrogen oxide
PFC	perfluorocarbon
SF_6	sulphur hexafluoride
SO_2	sulphur dioxide

LIST OF ACRONYMS

AD	Activity data
APAD	Land Public Transport Agency
AR4	Fourth Assessment Report (IPCC)
AR5	Fifth Assessment Report (IPCC
AR6	Sixth Assessment Report (IPCC)
ASEAN	Association of Southeast Asian Nations
BAU	Business as Usual
BF	Blast furnace
BOF	Blast oxygen furnace
BTR1	First Biennial Transparency Report
BTR2	Second Biennial Transparency Report
BUR	Biennial Update Report
BUR3	Third Biennial Update Report
BUR4	Fourth Biennial Update Report
B5	A blend of 5% palm-based fatty acid methyl ester and 95% petroleum diesel
B7	A blend of 7% palm-based fatty acid methyl ester and 93% petroleum diesel
B10	A blend of 10% palm-based fatty acid methyl ester and 90% petroleum diesel
B20	A blend of 20% palm-based fatty acid methyl ester and 80% petroleum diesel
B30	A blend of 30% palm-based fatty acid methyl ester and 70% petroleum diesel
CAGR	Compound annual growth rate
CBG	Compressed Biogas
CCU	Carbon Capture and Utilisation
CFC	Chlorofluorocarbon
CKD	Cement kiln dust
CO_2 eq.	Carbon Dioxide equivalent
CWPB	Centre Worked Prebake
DAKN	*Dasar Agrikomoditi Negara* (National Agricommodity Policy)
DKN	*Dasar Komoditi Negara* (National Commodity Policy)
DMG	Department of Minerals and Geosciences
DoA	Department of Agriculture
DoF	Department of Fisheries
DoE	Department of Environment
DOSM	Department of Statistics Malaysia
DVS	Department of Veterinary Services
DWNP	Department of Wildlife and National Parks of Peninsular Malaysia
EAF	Electric Arc Furnace
EBT	Energy Balance Table
EC	Energy Commission

EEVs	Energy Efficient Vehicles
EF	Emission Factor
ERL	Express Rail Link
ETF	Enhanced Transparency Framework
ETS	Electric Train Service
EV	Electric Vehicle
FAOSTAT	Food and Agriculture Organization Statistics
FC	Fluorinated compound
F-Gasses	Fluorinated Gasses
FiT	Feed-in-Tariff
FSPV	Floating Solar Photovoltaic
GCF	Green Climate Fund
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	GHG
ICE	Internal combustion engine
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IWK	Indah Water Konsortium Sdn. Bhd.
JICA	Japan International Cooperation Agency
JLM	Malaysia Marine Department
JPP Sarawak	Sewerage Services Department Sarawak
KL	Kuala Lumpur
KLIA	Kuala Lumpur International Airport
KTM	Keretapi Tanah Melayu
KTMB	Keretapi Tanah Melayu Berhad
LRT	Light Rail Transit
LSS	Large-Scale Solar
LULUCF	Land Use, Land Use Change and Forestry
MAC	Mobile air conditioning
MADA	Muda Agricultural Development Authority
MAFS	Ministry of Agriculture and Food Security
MARDI	Malaysia Agriculture Research and Development Institute
MCB	Malaysian Cocoa Board
MCO	Movement Control Order
MET Malaysia	Malaysian Meteorological Department

MIDA	Malaysian Investment Development Authority
MITI	Ministry of Investment, Trade and Industry
Mmbtu	Million Metric British Thermal Unit
MISIF	Malaysian Iron and Steel Industry Federation
MoH	Ministry of Health
MoFA	Ministry of Foreign Affairs
MoT	Ministry of Transport
MPIC	Ministry of Plantation Industries and Commodities
MPOB	Malaysian Palm Oil Board
MPOCC	Malaysian Palm Oil Certification Council
MRB	Malaysian Rubber Board
MRT	Mass Rapid Transit
MRV	Measurement, Reporting and Verification
MSIG	Malaysian Sewerage Industry Guidelines
MSPO	Malaysian Sustainable Palm Oil
MTPIN	Malaysia Climate Change Action Council
MyGHG	National GHG Centre
NAP	National Automotive Policy
NAP 2.0	National Agrofood Policy 2021-2030
NC	National Communication
NC3	Third National Communication
NC4	Fourth National Communication
NDC	Nationally Determined Contribution
NEB	National Energy Balance
NEEAP	National Energy Efficiency Action Plan
NID	National Inventory Document
NRES	Ministry of Natural Resources and Environmental Sustainability
NSCCC	National Steering Committee on Climate Change
ODS	Ozone depleting substances
PA	Protected Area
PETRA	Ministry of Energy Transition and Water Transformation
PETRONAS	Petroliam Nasional Berhad
PFCs	Perfluorocarbons
PLANMalaysia	Department of Town and Country Planning
POME	Palm Oil Mill Effluent
PRFs	Permanent Reserved Forests
PV	Photovoltaic
PVC	Polyvinyl chloride

QA	Quality assurance
QC	Quality control
RE	Renewable Energy
REDD+	Reducing Emissions from Deforestation and Forest Degradation, and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries
SDGs	Sustainable Development Goals
SEB	Sarawak Energy Berhad
SIRIM	Standard and Industrial Research Institute of Malaysia
SLF	State Land Forests
STP	Sewage Treatment Plant
SWG/SWGs	Sub-Working Group/Sub-Working Groups
TCCC	Technical Committee on Climate Change
TNB	Tenaga Nasional Berhad
TNBR	Tenaga Nasional Berhad Research
TPA	Totally Protected Area
TTE	Team of Technical Experts
TWG/TWGs	Technical Working Group/Technical Working Groups
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNITEN	Universiti Tenaga Nasional
WEM	With Additional Measures
WCC	Wildlife Conservation Centre
WEM	With Existing Measures
WOM	Without Measures
WTP	Water Treatment Plant

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PRIME MINISTER

The challenges of the 21st century have reinforced the undeniable truth that climate change is not just an environmental issue but a defining global challenge with profound social and economic implications. As nations work towards a collective response, Malaysia is fully committed to playing a constructive and proactive role in international climate action. Our journey is one of transformation—moving towards a sustainable, low-carbon economy that benefits both our people and the planet. This First Biennial Transparency Report (BTR1) is a testament to Malaysia's dedication to accountability and international cooperation in addressing the climate crisis.

At the heart of Malaysia's climate action lies the Malaysia Madani aspiration – a vision rooted in sustainability, compassion, and inclusivity. Malaysia Madani represents our commitment to creating a society that prioritises the well-being of all citizens, fostering a just, equitable, and responsible development path. As we confront the global climate crisis, we are driven by this aspiration to build a Malaysia that embraces environmental stewardship and ensures that all share the benefits of a green economy. By integrating the values of Madani, we ensure that our transition to a low-carbon economy is not only environmentally sustainable but socially just, leaving no one behind.

Malaysia's leadership on climate change is also built on strong regional and international cooperation. As we present our BTR1, we reaffirm our commitment to working closely with our neighbours and other global partners to accelerate climate action and share knowledge and technology for a sustainable future. This moment calls for unwavering commitment and transformative change. Malaysia will continue to build on the foundations laid by this report, seeking to surpass the targets we set and lead by example in the global effort to limit temperature rise and mitigate the adverse effects of climate change. Our goal is not just to meet our obligations but to inspire collective action for the good of humanity and the planet.

Together, we can pave the way toward a future that ensures environmental sustainability and economic prosperity for generations. Let this report signal Malaysia's deep resolve and leadership in the global climate agenda.

DATO' SERI ANWAR BIN IBRAHIM
Prime Minister of Malaysia

PREFACE

MINISTER OF NATURAL RESOURCES AND ENVIRONMENTAL SUSTAINABILITY

With profound dedication and a resolute commitment to global climate action, Malaysia presents its BTR1 to the United Nations Framework Convention on Climate Change (UNFCCC). This document embodies Malaysia's sustained efforts to provide transparent and reliable information on the nation's contributions to the fight against climate change. In this report, we present updated estimates of anthropogenic greenhouse gas (GHG) emissions and removals alongside a comprehensive overview of Malaysia's climate action initiatives across the Energy, Industrial Processes and Product Use (IPPU), Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), and Waste sectors.

This report would not have been possible without the invaluable contributions of numerous experts and stakeholders, all of whom have dedicated their expertise, time, and effort to this collective endeavour. The essential data provided by various government ministries, agencies, research institutions, corporations, industry associations, universities, and non-governmental organisations exemplifies the collective commitment necessary to confront the immense challenges of climate change. I would like to extend my deepest gratitude to the National Steering Committees on Climate Change (NSCCC), the Technical Committee on Climate Change (TCCC), the Project Management Group (PMG), and the various Technical and Sub-Working Groups for their unwavering dedication and meticulous work in bringing this report to fruition.

In addition, I wish to express my sincere appreciation to the UNFCCC, the Global Environment Facility (GEF), and the United Nations Environment Programme (UNEP) for their ongoing support and facilitation throughout the preparation of this report. We anticipate continued cooperation and collaboration, ensuring that Malaysia not only fulfils its obligations under the Paris Agreement but exceeds them. May this report serve as a testament to our nation's enduring commitment to a sustainable and resilient future for all.

YB TUAN NIK NAZMI BIN NIK AHMAD
Minister of Natural Resources and Environmental Sustainability

A BRIEF LOOK AT MALAYSIA'S FIRST BIENNIAL TRANSPARENCY REPORT

OVERVIEW

The Ministry of Natural Resources and Environmental Sustainability (NRES)

as the national focal point
for the country's climate change agenda

MALAYSIA
is among
85 of the 198 Parties

to have fulfilled its commitments under the Paris Agreement
by submitting the BTR1 to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) on
31 December 2024

Malaysia achieved

37.12% reduction

in carbon intensity compared to the 2005 baseline

Nationally Determined Contribution (NDC)
target of a 45% carbon intensity reduction by 2030

GHG EMISSIONS IN 2021

amounted to
327,672.38
Gg CO_2 eq.

covering all major sectors except the Land Use, Land-Use Change, and Forestry (LULUCF) sector

SECTION I

National Inventory Document (NID)

Energy Sector

The largest source of Malaysia's GHG emissions

In 2021 this sector contributed 79.2% of total emissions

primarily due to fossil fuel combustion for electricity generation, transportation, and industrial activities.

IPPU Sector

Contributed 11.3%

The main emission sources in this sector are iron and steel, cement and petrochemical production

LULUCF Sector

net absorption of
212,284.33
Gg CO_2 eq.

Sustainable land management practices have enhanced this sector's capacity to sequester CO_2 and offset emissions from other sectors

Agriculture Sector

smallest contributor to GHG emissions compared to the energy, IPPU, and waste sectors
accounting for 2.2%

Waste Sector

Contributed 7.2%
total emissions in 2021

methane (CH_4) as the primary gas emitted from solid waste disposal and wastewater treatment

SECTION II

Nationally Determined Contribution (NDC) Tracking

Malaysia achieved
37.12% reduction
in carbon intensity in 2021 compared to 2005

Malaysia is committed to reducing GHG carbon intensity relative to GDP by 45% by 2030

These efforts are supported by key policies such as the National Climate Change Policy and the Green Technology Master Plan.

Key strategies include:

1 Energy Sector

Renewable Energy Utilization
Expanding the use of renewable energy sources, such as solar and biomass, to replace fossil fuels

2 IPPU Sector

Material Substitution in Cement Production
Replacing traditional materials with more sustainable alternatives to reduce environmental impact

3 Waste Sector

Waste Management
Enhancing recycling practices and solid waste management to reduce methane emissions from landfills

4 Agriculture Sector

MyOrganic Certification Program
Promoting organic farming practices and ensuring products meet organic standards

5 LULUCF Sector

Conservation and Reforestation
Implementing forest conservation and reforestation programs

SECTION III

Finance, Technology Transfer, and Capacity Building

Malaysia has received international funding, mainly through the Global Environment Facility (GEF), Green Climate Fund (GCF), and Adaptation Fund (AF) to implement various low-carbon initiatives.

Through the GEF, Malaysia received
USD 5.7 million
for the GEF-7 cycle (2018–2022)

This funding supports mitigation actions in sectors such as:

- Transportation
- Sustainable Forest
- Capacity Building

Additionally, Malaysia received
USD 784,000
to prepare the BTR1 report

SECTION IV

Information on Reporting Flexibility

Under the UNFCCC, developing countries have flexibility in reporting requirements compared to developed nations

In preparing this BTR1, Malaysia utilized flexibility for the reporting time series, using data from three years prior (x-3), up to 2021, compared to developed countries, which report data up to two years prior (x-2)

I

SECTION

NATIONAL INVENTORY DOCUMENT (NID)

EXECUTIVE SUMMARY

ES.1 Background Information on Climate Change and GHG Inventories: Malaysia's Context

The Malaysia's First Biennial Transparency Report (BTR1) has been prepared in accordance with international requirements outlined in the Modalities, Procedures, and Guidelines (MPGs) of the Enhanced Transparency Framework (ETF) under Article 13 of the Paris Agreement. Within the framework of Malaysia's BTR, the GHG inventory is reported following guidelines 18/CMA.1 and 5/CMA.1 ensuring full compliance with the latest reporting standards.

The sectors reported include Energy, Industrial Processes and Product Use (IPPU), Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), and Waste. Emissions and removals reported are for the period from 1990 to 2021. The national 's GHG inventory is prepared according to the 2006 IPCC Guidelines for National GHG Inventories following the Transparency, Accuracy, Consistency, Completeness and Comparability (TACCC) principles. The BTR1 preparation works are coordinated by the Ministry of Natural Resources and Environmental Sustainability of Malaysia (NRES).

ES.2 Summary of Trends Related to National Emissions and Removals

The overall GHG emissions without LULUCF in 2021 increased by 28.24% compared to 2005. For the year 2021, the total GHG emissions excluding LULUCF were 327,672.38 Gg CO_2 eq. and emissions including LULUCF were -115,388.04 Gg CO_2 eq. The details are provided in Chapter 2.

ES.3 Overview of Source and Sink Category Emission Estimates and Trends

In the 2005-2021 period, the energy and IPPU sectors had an increase in growth of emissions. However, the emissions of the agriculture and waste sectors decreased while the sinks in LULUCF sector stabilised. For 2021, the emissions from energy, IPPU, agriculture and waste sectors 259,666.83 Gg CO_2 eq., 37,028.35 Gg CO_2 eq., 7,310.04 Gg CO_2 eq. and 23,667.15 Gg CO_2 eq. respectively. GHG removals from the LULUCF sector were -212,284.33 Gg CO_2 eq.

ES.4 Other information

Malaysia uses the 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report (AR5) to report aggregate emissions and removals of GHGs, expressed in CO_2 eq. to meet the BTR reporting requirement.

Malaysia applies one (1) flexibility with regards to the GHG inventory reporting in the NID whereby the GHG inventory reported is for the 1990-2021 time series. In light of the Country's current data collection cycle, the latest reporting year is three years prior to the submission of this report (i.e. X-3).

The type of GHG reported includes all of the required seven (7) gasses, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). In the context of geographical coverage, the GHG inventory reported includes the GHG sources and sinks in Peninsular Malaysia, Sabah and Sarawak.

ES.5 Key Category Analysis

Approach 1 Level Assessment and Approach 1 Trend Assessment as outlined in the 2006 IPCC Guidelines were used for the analysis of the key categories and trend of the 2021 GHG inventory. These were carried out for the inventory including LULUCF and excluding LULUCF.

ES.6 Improvements Introduced

In this BTR1, some improvements were undertaken based on the improvement in the IPCC software. Activity data for energy, agriculture, LULUCF and waste sectors were updated in line with the latest IPCC software. There were also updates in the emission factors for agriculture and LULUCF sectors. There were also new categories included in IPPU and LULUCF sectors. Aspects of the improvement includes reallocation of fuel by types and methodologies. The improvements are intended to be prioritised according to the key categories identified in consideration with the current resources and capacity.

1
CHAPTER

NATIONAL CIRCUMSTANCES, INSTITUTIONAL ARRANGEMENTS AND CROSS-CUTTING INFORMATION

1.1 Background

Over the years, Malaysia has continuously improved its GHG inventory reporting to the United Nation Framework Convention on Climate Change (UNFCCC). The data generated from GHG inventories allow Malaysia to identify priority areas for emission reductions, assess the effectiveness of mitigation actions, and track emissions trends over time. To comply with Articles 4 and 12 of the UNFCCC, Malaysia has prepared and submitted four National Communications (NCs) and four Biennial Update Reports (BURs) respectively:

- Initial National Communication (2000);
- Second National Communication (2011);
- First Biennial Update Report (2016);
- Third National Communication and Second Biennial Update Report (2018);
- Third Biennial Update Report (2020);
- Fourth Biennial Update Report (December 2022); and
- Fourth National Communication (May 2024).

The Biennial Transparency Report (BTR) represents a key component of the Paris Agreement's transparency infrastructure, the Enhanced Transparency Framework (ETF). The ETF enable the Conference of the Parties (COP) to track progress towards achieving the goals of the Paris Agreement. BTR consist of the national GHG inventory report and information including the status of Nationally Determined Contributions (NDCs) achievement, finance, technology transfer and capacity building needs.

Malaysia intends to tap the opportunities for renewable energy (RE) sources. Hence, Malaysia has an ambitious plan to increase its renewable share in the energy mix, thus reducing the emissions from the energy sector. For the IPPU sector, the new Industrial Master Plan 2030 will be the driving force the manufacturing and manufacturing-related services sector. It is formulated with the intend to transform the industry into greater heights, capitalising on emerging global trends. Agriculture sector is the smallest sectoral emission. Malaysia has about 54% forest cover and 30% cropland. The LULUCF sector is a net sink primarily contributed from its best practices emphasising on sustainability. Emission from waste sector is primarily from the effluent discharge from industrial wastewater. Methane capture from industrial wastewater is actively being undertaken to reduce the emissions.

The GHG inventory includes emissions of CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 and NF_3 in the following five sectors: energy, IPPU, agriculture, LULUCF and waste.

1.2 National Circumstances and Institutional Arrangements

1.2.1 National Entity and National Focal Point

The Ministry of Natural Resources and Environmental Sustainability (NRES) is the UNFCCC's national focal point for climate change and responsible for the reporting obligations under the ETF. NRES coordinates and oversees the preparation of the BTR1. The primary responsibility includes timely reporting, ensuring consistency in the information and data as well as fulfilling the requirements under 18/CMA.1 and 5/CMA.3. The Secretary General of NRES chairs the National Steering Committee on Climate Change (NSCCC) which oversees the preparation of the BTR1.

1.2.2 Inventory Preparation Process

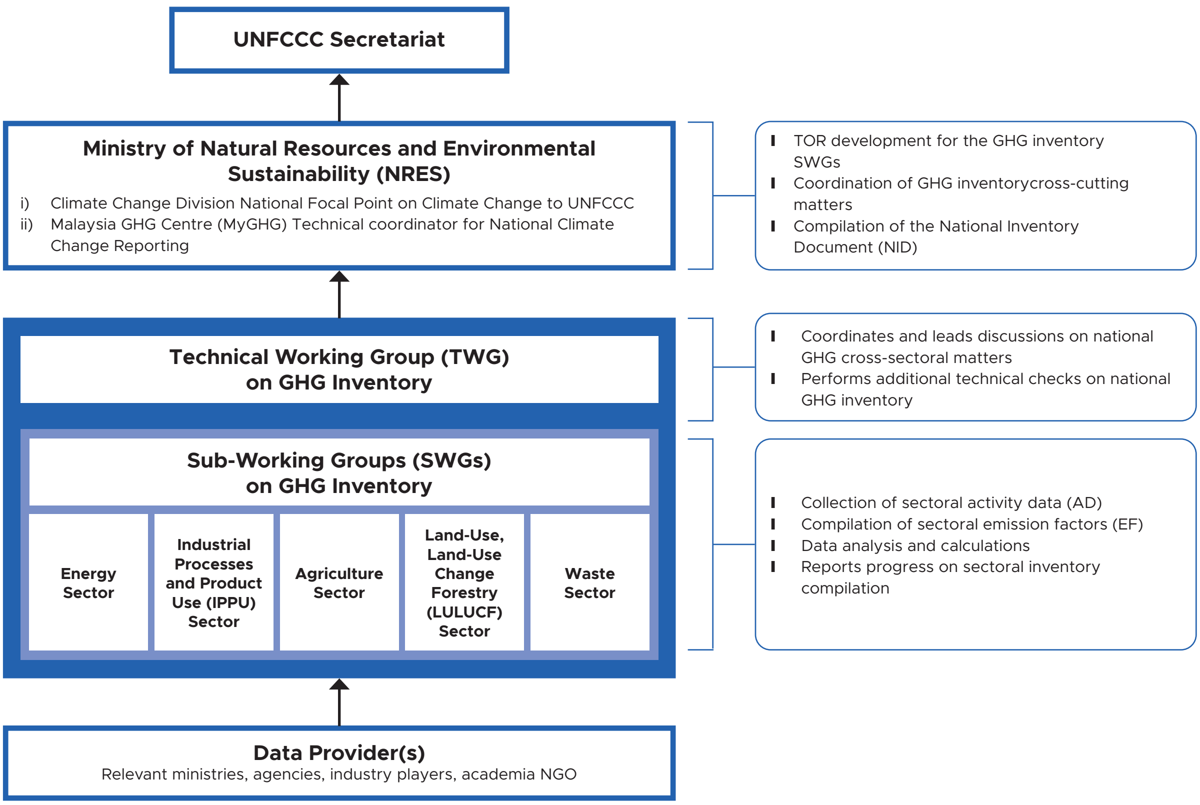
A comprehensive institutional framework has been developed in Malaysia for the regular preparation of the national GHG inventory. NRES would prepare the terms of references including the inventory period and timelines for the respective sectoral working groups (SWGs). The SWGs will coordinate the collection of activity data, emission factors and the calculations. The SWGs would consult the relevant ministries, agencies, industry players, academia as well as non-organisational organisations (NGO) when compiling and estimating their sectoral emissions. Data analysis is then performed through the utilisation of the IPCC software. The Technical Working Group (TWG) on GHG inventory will also discuss cross-sectoral matters and perform further additional technical checks. The ministry will do the cross-cutting issues and compile the report into the National Inventory Document (NID). Figure SIC1.1 demonstrates the overall institutional arrangement for Malaysia's inventory preparation process.

1.2.3 Archiving of Information

Each sector's compiler produces a set of activity data, a sectoral report, and the database in the IPCC Inventory software for each year of GHG inventory calculation.

For the archiving of the GHG Inventory, the IPCC Inventory Software database and a flat file system for the external 2006 IPCC Guidelines spreadsheets were used for each of the five sectors (Energy, IPPU, Agriculture, LULUCF and Waste). This consists of three levels of files, which is the raw data file, the analysis files and the sectoral report file. These are deposited with the GHG Inventory under the National GHG Centre (MyGHG) of NRES. The agency heading each sectoral GHG inventory group also keeps a copy of their sectoral data files, analysis spreadsheets, sectoral reports as a second level backup.

Figure SIC1.1 **Organizational Structure of the National Inventory Preparation Process**



1.2.4 Processes for official consideration and approval of inventory

The process for official consideration and approval of the inventory begins with the Sub Working Group, which comprises five sectors responsible for collecting inventory data. This data is then presented to and shared with the TWG for review. MyGHG coordinates the inventory report produced by the TWG and submits it to the TCCC, chaired by the Deputy Secretary General of NRES. Following discussion at the TCCC, the report is forwarded to the NSCCC for consideration. The NSCCC will provide recommendation to the Cabinet for final endorsement and implementation.

1.3 General Description of Methodologies and Data Sources

The 2006 IPCC Guidelines for National GHG Inventories and 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories: Wetlands were used to estimate the GHG emissions and removals. Time series were recalculated to reflect the updated methodologies, activity data and emission factors in accordance with the guidelines. The methodological tier and type of emission factors used to generate the estimates is reflected in Annex V of the National Inventory Document (NID) section.

The IPCC Inventory Software version 2.93 was used to generate the GHG inventory estimates. For the energy sector, estimates were calculated for both reference and sectoral approaches. The GHG inventory covers the national encompassing the entire territorial boundary of Malaysia. The data sources are provided in the sectoral chapters.

1.4 Key Category Analysis

Annex I of the NID section provides the details of the approach 1 Level Assessment and Approach 1 Trend Assessment. For 2005[1], level assessment excluding LULUCF and including LULUCF was conducted. For 2021, both level assessment and trend assessment excluding LULUCF and including LULUCF each were conducted. The category analysis was conducted in accordance with the 2006 IPCC Guidelines.

[1] 2005 is considered as the base year for the key category analysis given it is the reference year of Malaysia's NDC

For 2005, the key categories combining excluding and including LULUCF classifications were CO_2 removals from forest land, followed by GHG emissions each from settlement, road transportation - liquid fuels, public electricity and heat production - gaseous fuels, manufacture of solid fuels and other energy industries - gaseous fuels, public electricity and heat production - solid fuels, oil, manufacturing industries and construction - liquid fuels, industrial wastewater treatment and discharge, direct N_2O emissions from managed soils, solid waste disposal, petrochemical and carbon black production, rice cultivation, commercial/institutional - liquid fuels, residential - liquid fuels, domestic wastewater treatment and discharge, public electricity and heat production - liquid fuels and enteric fermentation

For 2021, the key categories combining excluding and including LULUCF classifications were CO_2 removals from forest land, followed by GHG emissions each from public electricity and heat production - solid fuels, road transportation - liquid fuels, settlement, manufacture of solid fuels and other energy industries - gaseous fuels, public electricity and heat production - gaseous fuels, manufacturing industries and construction - gaseous fuels, iron and steel production, industrial wastewater treatment and discharge, natural gas, petroleum refining - liquid fuels, manufacturing industries and construction - liquid fuels, oil, solid waste disposal, manufacturing industries and construction - solid fuels, cement production, petrochemical and carbon black production, oil, agriculture/ fishery/ forestry - liquid fuels, domestic navigation - liquid fuels, residential - liquid fuels, rice cultivation, aluminium production, direct N_2O emissions from managed soils, other transportation, domestic wastewater treatment and discharge, ammonia production and ferroalloys production.

Compared to 2005, the GHG emissions from the public electricity and heat production - liquid fuels, commercial/Institutional - liquid fuels and enteric fermentation were no longer being the key categories in 2021. The new key categories that emerged in the 2021 as relative to 2005 were GHG emissions from the manufacturing industries and construction - gaseous fuels, iron and steel production, natural gas, petroleum refining - liquid fuels, manufacturing industries and construction - solid fuels, cement production, petrochemical and carbon black production, agriculture/fishery/forestry - liquid fuels, domestic navigation - liquid fuels, aluminium production, other transportation, ammonia production and ferroalloys production.

Key Category Analysis for 2005

For the level assessment excluding LULUCF, 78.59% of the emissions under the key categories were from the energy sector. IPPU sector contributes 4.02% of the emissions. Emissions from agriculture sector contributes approximately 3.06% and the emissions from waste sector were about 10.01%.

For the level assessment including LULUCF, 57.02% of the emissions/removals under the key categories were from the LULUCF sector. It was followed by the energy sector (33.64%), waste sector (4.87%), IPPU sector (0.57%) and agriculture sector (3.89%). Forest land remaining forest land contributed the highest value at 46.79%.

Key Category Analysis for 2021

For the level assessment excluding LULUCF, the total contributions under the key categories were 81.42% for energy sector, followed by IPPU sector (9.80%), waste sector (7.30%) and agriculture sector (1.48%). The energy industries (gaseous, liquid and solid fuels) accounted for 46.57% of the key category emissions of which main activity, electricity and heat production (gaseous, liquid and solid fuels) accounted for 35.47% the emissions. Transport contributed 15.12% of the emissions of which 13.56% was from road transport. Manufacturing Industries and Construction contributed 10.58% of the emissions. Fugitive emissions from oil and natural gas contributed 6.09% of the emissions. Wastewater treatment and discharge (industrial and domestic) contributed 5.15% of the emissions. Solid waste disposal contributed 2.16% of the emissions. For the IPPU sector, cement production contributed 1.72% of the emissions and iron and steel production contributed 4.70% of the emissions.

For the level assessment including LULUCF, the main bulk of the emissions/removals under the key categories were from the LULUCF sector (48.53%), followed by the energy sector (43.21%), IPPU sector (4.18%), waste sector (3.64%) and agriculture sector (0.43%). Forest land contributed the highest value at 42.58%.

For the trend assessment[2] excluding LULUCF, the highest five key categories in descending order were CO_2 emissions from public electricity and heat production - solid fuels (34.11%), CO_2 emissions from fugitive emissions – oil (10.17%), CO_2 emissions from Manufacturing industries and construction - liquid fuels (8.55%), CO_2 emissions from public electricity and heat production - gaseous fuels (8.04%) and CO_2 emissions from iron and steel production (7.76%).

For the trend assessment including LULUCF, the highest five key categories in descending order were from the following sectors: CO_2 removals from forest land (42.69%), public electricity and heat production – solid fuels (14.86%), CO_2 emissions from settlement (5.97%), CO_2 emissions from public electricity and heat production – gaseous fuels (4.48%) and CO_2 emissions from fugitive emissions – oil (1.23%).

1.5 General Description of QA/QC Plan and Implementation

1.5.1 Quality Assurance, Quality Control and Verification

QA/QC and verification procedures are a vital part of the inventory development and submission process. These procedures ensure that Malaysia can meet the UNFCCC reporting requirements and its principles of transparency, accuracy, consistency, comparability, completeness (TACCC). Additionally, these procedures will also ensure continuous improvements of data and methods to maintain the quality of the inventory.

1.5.2 Quality Assurance/Quality Control Plan

The development of Malaysia's GHG inventory is based on a continuous process of data collection, methodological refinement, and review. QA/QC procedures take place at all stages of the inventory development cycle.

The Quality Assurance and Quality Control (QA/QC) procedures for compiling this GHG inventory report are depicted in Figure SIC1.2 sector compilers were responsible for implementing comprehensive QC measures for the inventory, supporting documents and the IPCC GHG inventory software. This process involved:

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[2] The base year for the trend assessment is 2005.

a) Developing QC procedures;
b) Collecting and assessing checklists for completeness and addressing any issues to ensure adherence to the applicable QC standards;
c) Submitting all documentation to the GHG Inventory and Reporting Unit within the NRES; and
d) Coordinating technical reviews by third party – for BTR1, the QA process was conducted by two (2) international organisations, i.e. Japan International Cooperation Agency (JICA) and Capacity-building Initiative for Transparency – Global Support Programme (CBIT-GSP).

Internal QA checks internally were performed by the MyGHG during the integration of sectoral GHG inventory reports into the National Inventory Document (NID). This process involved workshops led by the GHG Inventory Unit with sectoral leads and members of the GHG Inventory Technical Working Group (TWG). The results were then presented to the TCCC which the recommendation from platform will be further presented at the NSCCC for approval, confirming that the MRV process for GHG inventory estimation was thorough, as accurate as possible, and transparent. The QC procedures applied in developing the national GHG inventory are detailed in Table SIC1.1.

Figure SIC1.2 **Schematic Diagram showing Quality Assurance and Quality Control Arrangement for GHG Inventory**

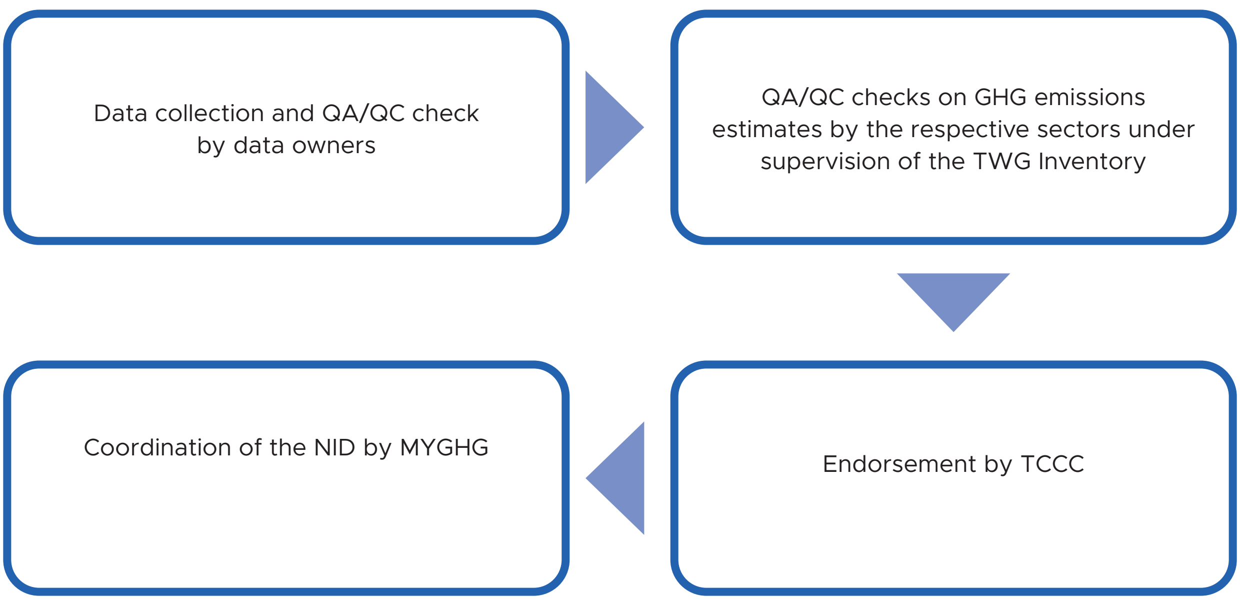


Table SIC1.1 **Procedures Undertaken in Developing the National GHG Inventory**

QC Procedures	Task	Responsibility
Internal consistency and accuracy	Ensured that the total GHG emissions equalled sum of the individual emission from the sectors and categories.	Inventory compilers Additional Q/C by MyGHG
	Ensured that the total GHG emissions equalled the sum of the emissions by gas.	Inventory compilers
	Compared data in tables to calculation spreadsheets and to the text in order to ensure that all reported the same estimates.	
	Ensured that parameters used in multiple categories (e.g., population) were consistent across categories.	
	Ensured that the emissions data is reported in a manner consistent with the reporting tables specified in Decision 18/CMA.1 and Decision 5/CMA.3 respectively.	
Documentation	Created back-ups of all documentations in hard and soft copies and uploaded files in a centralised archive platform.	Inventory compilers & MyGHG
	Moved all files and documentations to a GHG database.	MyGHG
	Reviewed and harmonized sector files to ensure consistency in filing.	Inventory compilers

1.6 General Uncertainty Assessment

Malaysia sees uncertainty assessment as a priority in the improvement plan. The Approach 1 uncertainty assessment following the 2006 IPCC Guidelines was used for the uncertainty assessment. In this report, Approach 1 methodology based on error propagation was used to assess (i) the uncertainty in individual categories in the inventory as a whole and in the trends of the inventory between 2021 and 2005 base year; and (ii) the uncertainty for 2005 inventory. The detailed results of this analysis for the (i) 2005 inventory without LULUCF and with LULUCF; and (ii) 2021 inventory without LULUCF and with LULUCF can be found in Annex II of the National Inventory Document (NID) Section. As summarised in Table SIC1.2, the 2005 inventory uncertainty without LULUCF was ±21.59%. With LULUCF, the uncertainty of the total inventory was ±327.16%. In Table SIC1.3, the 2021 uncertainty of the total inventory without LULUCF was ±15.22% and the uncertainty in trend was ±17.20%. With LULUCF, the uncertainty of the total inventory was ±76.49% and the uncertainty in trend was ±207.96%.

Table SIC1.2 Estimated Uncertainty of 2005 GHG Inventory

2005 GHG Inventory	Uncertainty of Total Inventory (%)
Total Inventory excluding LULUCF	21.59
Total Inventory including LULUCF	327.16

Table SIC1.3 Estimated Uncertainty of 2021 GHG Inventory

2021 GHG Inventory	Uncertainty of Total Inventory (%)	Uncertainty in Trend (%)
Total Inventory excluding LULUCF	15.22	17.20
Total Inventory including LULUCF	76.49	207.96

1.7 General Assessment of Completeness

Efforts had been taken to ensure completeness of the 2021 inventory and the 1990-2021 time series to the extent possible. However, there are still sub-categories where emissions have not been estimated due to the lack of activity data.

1.7.1 Information on Completeness

The GHG inventory reported is relatively comprehensive in accordance with the 2006 IPCC Guidelines. The type of GHG reported includes all of the seven (7) gasses, namely CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3. In the context of geographical coverage, the GHG inventory reported includes the GHG sources and sinks in the Peninsular Malaysia, Sabah and Sarawak.

1.7.2 Description of Insignificant Categories

There is no insignificant category which the percentage of the emissions is below 0.1 per cent of the national total GHG emissions or 1,000 kilotonnes of carbon dioxide equivalent (kt CO_2 eq.), whichever is lower.

1.7.3 Total Aggregate Emissions Considered Insignificant

All quantified emissions are reported in the national GHG inventory.

1.8 Metrics

Malaysia uses the 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report (AR5) to report aggregate emissions and removals of GHGs, expressed in CO_2 eq. to meet the BTR reporting requirement. Table SIC1.4 provides the GWP value for the GHG based on the AR5.

Table SIC1.4 **GWP Value for the GHG Reported in the BTR1 based on the AR5**

Gas	Chemical Formula	GWP
Methane	CH_4	28
Nitrogen trifluoride	NF_3	265
HFCs - Fluoroform - 1,1,1,2-tetrafluoroethane	 CHF_3 HFC-134a	 12,400 1,300
PFCs - Tetrafluoromethane - Hexafluoroethane - Octafluoropropane	 CF_4 $C2F_6$ $C3F_8$	 6,630 11,100 8,900
Sulphur hexafluoride	SF_6	23,500
Nitrogen trifluoride	NF_3	16,100

1.9 Summary of Any Flexibility Applied

Malaysia applies one (1) flexibility with regards to the GHG inventory reporting in the NID. The GHG inventory reported is for the 1990-2021 time series i.e. the latest reporting year is no more than three years prior to the submission of the national inventory report (i.e. *X-3*).

2
CHAPTER

TRENDS IN GREENHOUSE GAS EMISSIONS AND REMOVALS

2.1 Description of Emission and Removal Trends for Aggregated GHG Emissions and Removals

The overall GHG emissions in 2005 without LULUCF was 255,507.41 Gg CO_2 eq. and the overall emissions in 2021 without LULUCF was 327,672.37 Gg CO_2 eq.; the relative increase between the years was 28.24%.

For the overall GHG emissions in 2005 and 2021 each with LULUCF, the values were 64,789.67 Gg CO_2 eq. and 115,388.04 Gg CO_2 eq. as the relative increase between the years was 78.10%.

In this period, the energy and IPPU sectors experienced growth of emissions. However, the emissions of the agriculture and waste sectors decreased while the sinks in LULUCF sector stabilised. The overall increased in emissions is in tandem with the country's development plan and increase of population. Hence, these factors contributed to the increase in energy demand and need for infrastructure and housing. Table SIC2.1 provides the GHG emissions and/or removal for the energy, IPPU, agriculture, LULUCF and waste sector in the 2005, 2019 and 2021. The GHG emissions for 2019 are also included in the table to reflect the emissions that were reported in the previous BUR4[3].

[3] In this document, the GHG emissions for 2019 were recalculated according to the GWP value as the AR5. During the BUR4 submission to the UNFCCC in 2022, the GWP value utilised was based on the AR4.

Table SIC2.1 **GHG Emissions in 2005, 2019 and 2021**

Year	Emissions/Removals (Gg CO_2 eq.) by Sector					Total Emissions/Removals (Gg CO_2 eq.)	
	Energy	IPPU	Agriculture	LULUCF	Waste	Excluding LULUCF	Including LULUCF
2005	205,464.65	15,060.35	10,456.28	-190,717.74	24,526.12	255,507.41	64,789.67
2019	261,393.21	32,544.89	7,804.10	-209,290.63	25,621.59	327,363.79	118,073.16
2021	259,666.83	37,028.35	7,310.04	-212,284.33	23,667.15	327,672.37	115,388.04

For the year 2021, the total GHG emissions excluding LULUCF were 327,672.37 Gg CO_2 eq. which comprised of 259,666.83 Gg CO_2 eq. from the energy sector, 37,028.35 Gg CO_2 eq. from the IPPU sector, 23,667.15 Gg CO_2 eq. from the waste sector and 7,310.04 Gg CO_2 eq. from the agriculture sector as shown in Table SIC2.2.

The total GHG emission including LULUCF were 115,383.04 Gg CO_2 eq. which the net emissions from the LULUCF sector were -212,284.33 Gg CO_2 eq.

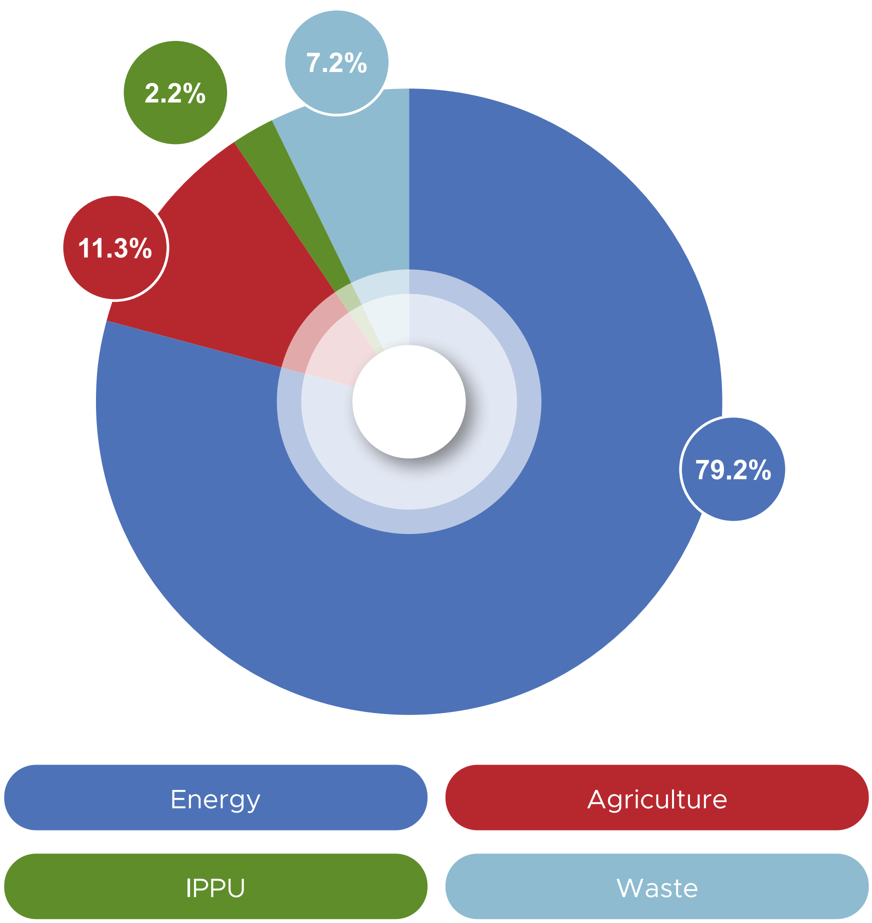
As the LULUCF acts as a net sink, the percentage breakdown of overall emissions is 79.2% from the energy sector, 11.3% from the IPPU sector, 2.2% from the agriculture sector, and 7.2% from the waste sector. Figure SIC2.1 shows the graphical breakdown of overall emissions based on these four sectors.

Table SIC2.2 **Summary of GHG Inventory for 2021**

Sector	GHG Emission/Removal (Gg CO_2 eq.)
Energy	259,666.83
IPPU	37,028.35
Agriculture	7,310.04
LULUCF	-212,284.33
Waste	23,667.15
Total (Excluding LULUCF)	**327,672.37**
Total (Including LULUCF)	**115,388.04**

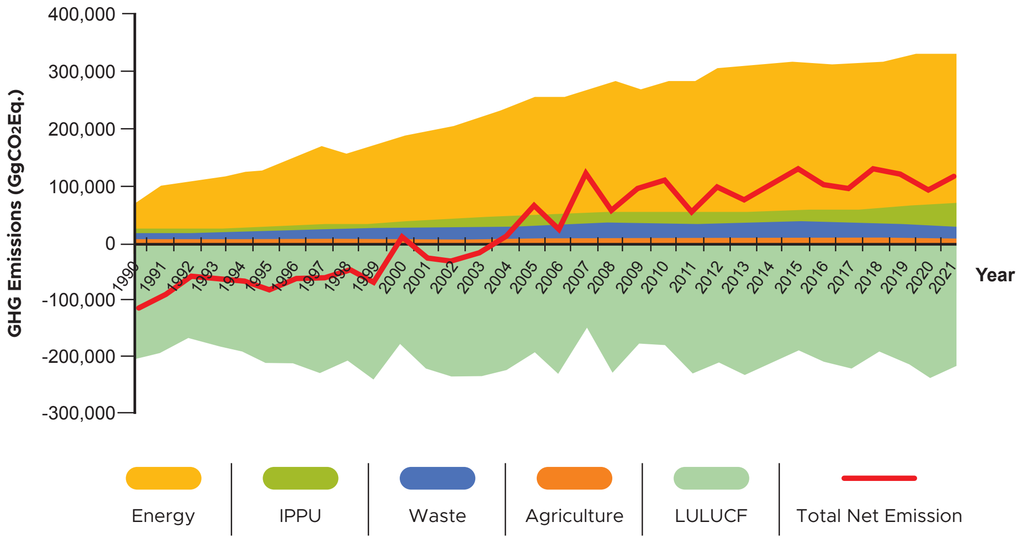
The overall GHG emissions in 2021 were slightly lower compared to 2019 which can be attributed to the impact of COVID-19. The pandemic has affected the overall emissions in all sectors. The use of energy and fuels especially in the road transport reduced significantly. Certain manufacturing activity in the IPPU sector was also impacted by the measures put during the pandemic.

Figure SIC2.1 **Percentage of overall emissions by sector in 2021**



The GHG emission time series from 1990 to 2021 is shown in Figure SIC2.2. By sequence, the source of emissions has been mainly from the energy sector, followed by the IPPU, waste and agriculture sectors.

Figure SIC2.2 **GHG Emission Time Series from 1990 to 2021**



2.2 Description of Emission and Removal Trends by Sector and by Gas

The GHG emissions for each sector in 2005 and 2021 are provided in Table SIC2.2 earlier. The GHG emissions and removal according to the time series are indicated in the Figure SIC2.2 above. As mentioned earlier, the GHG emissions for the energy, IPPU, agriculture, and waste sectors are 259,666.33 Gg CO_2 eq., 37,028.35 Gg CO_2 eq., 7,310.04 Gg CO_2 eq. and 23,667.15 Gg CO_2 eq. respectively, while the LULUCF sector acts as a sink with a value of -212,284.33 Gg CO_2 eq.

Compared to 2005, the energy and IPPU sectors have seen an increase in GHG emissions while emissions from the agriculture and waste sectors have decreased relatively in 2021. Compared to the most recent reporting year in the BUR4, i.e. 2019, the energy, agriculture and waste sectors have experienced a relative decrease in 2021, while the IPPU sector has seen an increase during that period. Sectoral emissions and removals trends are as the following:

i. **Energy**
Compared to 2005, GHG emissions from the energy sector increased in 2021. The growth is attributed to the increase in the energy demand from the domestic and commercial sectors as well as in manufacturing and construction categories. However, the fugitive emissions declined in 2021 compared to 2005.

ii. **IPPU**
Compared to 2005, GHG emissions from the IPPU sector increased in 2021. This rise is primarily associated with increased production in the iron and steel industry. However, the cement industry, a key category, experienced lower emissions due to lower production in 2020 and 2021. Certain industries saw a slight increase in 2021 compared to 2019, including the chemicals industry, the metal industry (other than the iron and steel sector), the electronics industry, and applications related to products used as substitutes for ozone-depleting substances.

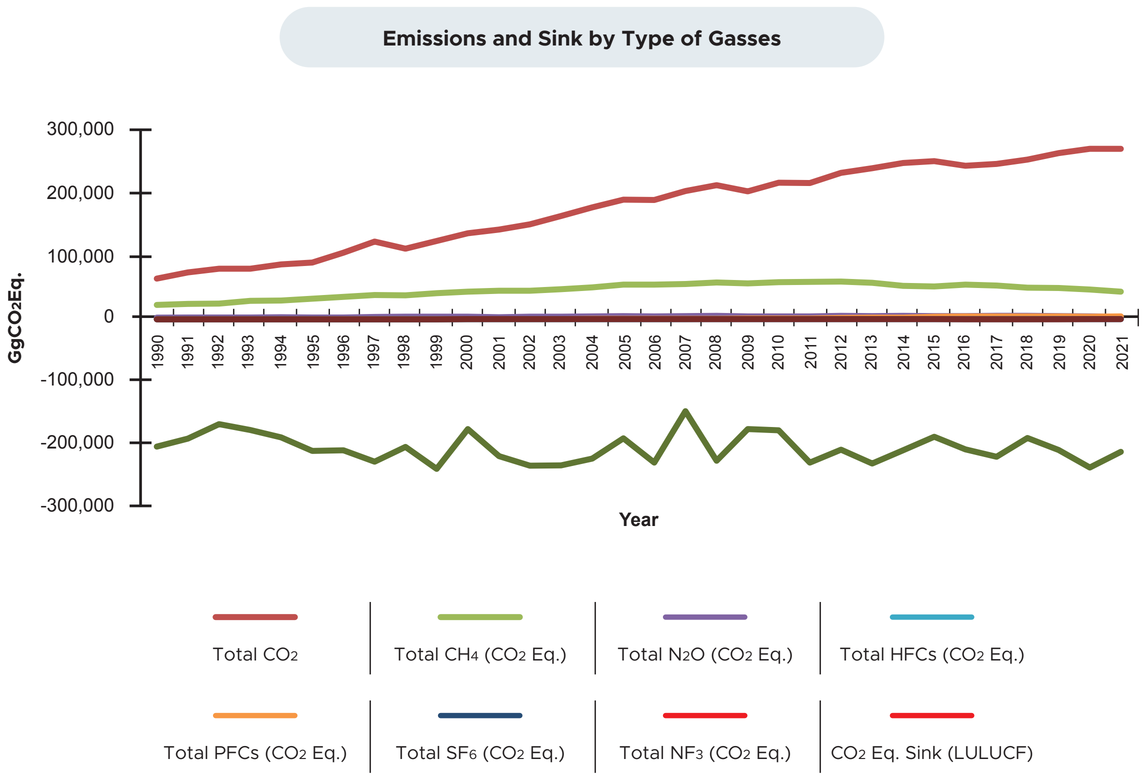
iii. **Agriculture**
Compared to 2005, GHG emissions from the agriculture sector decreased in 2021. The emissions reduction is attributed to the lower emissions resulting from decreased livestock population and use of urea.

iv. **LULUCF**
The increase in sink was attributed by the measures put in place during the COVID pandemic. The underlying trend of declining emissions from LULUCF since 1990 has been mainly driven by the decline in harvest from the forest, where a maximum cap for harvesting from natural forest has been implemented from 2006 onwards.

v. **Waste**
Compared to 2005, GHG emissions from the waste sector decreased in 2021. The emissions reduction is attributed to the increase of methane capture facilities for the industrial wastewater treatment.

In terms of GHG emissions, the highest levels, in descending order, are CO_2, CH_4, PFCs, N_2O, HFCs, SF_6 and NF_3. The top three sources of CO_2 emissions are electricity generation, transport, and the consumption of fossil fuels by manufacturing industries. The three highest sources of CH_4 emissions are industrial wastewater treatment and discharge, fugitive emissions, and solid waste disposal. For PFCs and HFCs, all emissions originate from the IPPU sector. Most N_2O emissions come from direct emissions from managed soils, with the second and third highest sources being transport-related liquid fuels and indirect N_2O emissions from managed soils, respectively. Figure SIC2.3 provides a summary of emissions and sinks by type of gas according to the time series.

Figure SIC2.3 **Summary of GHG emissions based on type of gasses**



Note:
As LULUCF is the net sink, specific GHG emissions based on type of gasses in this sector can be referred in the LULUCF sectoral chapter.

3 CHAPTER

ENERGY (CRT SECTOR 1)

3.1 Overview of the Sector

The overview of the energy sector is demonstrated in Table SIC3.1 below. The information includes gasses reported, major improvements undertaken, methodological tiers as well as emission factors used within the sector.

Table SIC3.1 **Overview of the Energy Sector**

Emission Sources	**1.A**	Fuel combustion activities (sectoral approach)
	1.A.1	Energy industries
	1.A.2	Manufacturing industries and construction
	1.A.3	Transport
	1.A.3.a	Domestic aviation
	1.A.3.b	Road transportation
	1.A.3.c	Railways
	1.A.3.d	Domestic navigation
	1.A.3.e	Other transportation
	1.A.4	Other sectors
	1.A.5	Other
	1.B	Fugitive emissions from fuels
	1.B.1	Solid fuels
	1.B.2	Oil and natural gas and other emission from energy production
Gasses Reported	CO_2, CH_4, N_2O	
Major improvements since last submission	**1.A.1**	**Energy Industries** There are changes due a new activity data of coal consumption by coal type. The total amount of sub-bituminous coal has been segregated according to sub-bituminous, other bituminous and lignite.
	1.A.3	**Transport** Improvements to the data assumption.
	1.A.4	**Other Sectors** The activity data for agricultural/forestry/fishing are assumed to have the percentage such that the ratio of fuel consumption between mobile and stationary sources is 95:5.

1.A.5 Other

The survey data was distributed to the military department and data were available from 2019 until 2021.

1.B.2 Oil and Natural Gas and Other Emission from Energy Production

According to the 2006 IPCC, when known, actual flare and vent volumes should be used rather than production rates. Obtained actual data for venting and flaring from oil and gas systems for 2020-2021.

Sector		CO_2		CH_4		N_2O	
3. Energy		**Method**	**EF**	**Method**	**EF**	**Method**	**EF**
1.A	**Fuel combustion activities**						
1.A.1	**Energy industries**						
1.A.1.a	Public electricity and heat production	T1	D	T1	D	T1	D
1.A.1.a.i	Electricity generation	T1	D	T1	D	T1	D
1.A.1. a.ii	Combined heat and power generation	T1	D	T1	D	T1	D
1.A.1.a.iii	Heat plants						
1.A.1.b	Petroleum refining	T1	D	T1	D	T1	D
1.A.1.c	Manufacture of solid fuels and other energy industries	T1	D	T1	D	T1	D
1.A.1.c.i	Manufacture of solid fuels						
1.A.1.c.ii	Oil and gas extraction	T1	D	T1	D	T1	D
1.A.1.c.iii	Other energy industries	T1	D	T1	D	T1	D
1.A.2	**Manufacturing industries and construction**						
1.A.2.a	Iron and steel	T1	D	T1	D	T1	D
1.A.2.b	Non-ferrous metals	T1	D	T1	D	T1	D
1.A.2.c	Chemicals	T1	D	T1	D	T1	D
1.A.2.d	Pulp, paper and print	T1	D	T1	D	T1	D
1.A.2.e	Food processing, beverages and Tobacco	T1	D	T1	D	T1	D
1.A.2.f	Non-metallic minerals	T1	D	T1	D	T1	D
1.A.2.g	Other						
1.A.2.g.i	Manufacturing of machinery	T1	D	T1	D	T1	D
1.A.2.g.ii	Manufacturing of transport equipment	T1	D	T1	D	T1	D
1.A.2.g.iii	Mining (excluding fuels) and quarrying						
1.A.2.g.iv	Wood and wood products	T1	D	T1	D	T1	D
1.A.2.g.v	Construction						
1.A.2.g.vi	Textile and leather	T1	D	T1	D	T1	D
1.A.2.g.viii	Other (Non-specified industry)	T1	D	T1	D	T1	D

Sector		CO_2		CH_4		N_2O	
3. Energy		**Method**	**EF**	**Method**	**EF**	**Method**	**EF**
1.A.3 Transport							
1.A.3.a	Domestic aviation	T1	D	T1	D	T1	D
1.A.3.b	Road transportation	T1	D	T1	D	T1	D
1.A.3.c	Railways	T1	D	T1	D	T1	D
1.A.3.d	Domestic navigation	T1	D	T1	D	T1	D
1.A.3.e	Other transportation	T1	D	T1	D	T1	D
1.A.4 Other sectors							
1.A.4.a	Commercial/institutional	T1	D	T1	D	T1	D
1.A.4.b	Residential	T1	D	T1	D	T1	D
1.A.4.c	Agriculture/forestry/fishing	T1	D	T1	D	T1	D
1.A.4.c.i	Stationary	T1	D	T1	D	T1	D
1.A.4.c.ii	Off-road vehicles and other machinery	T1	D	T1	D	T1	D
1.A.4.c.iii	Fishing	T1	D	T1	D	T1	D
1.A.5 Other							
1.A.5.a	Stationary						
1.A.5.b	Mobile	T1	D	T1	D	T1	D
1.B	**Fugitive emissions from fuels**						
1.B.1 Solid fuels							
1.B.1.a	Coal mining and handling			T1	D		
1.B.1.a.i	Underground maines			T1	D		
1.B.1.a.ii	Surface mines			T1	D		
1.B.1.b	Fuel transformation						
1.B.2 Oil and natural gas and other emissions from energy production							
1.B.2.a	Oil	T1	D	T1	D	T1	D
1.B.2.a.vi	Other	T1	D	T1	D		
1.B.2.b	Natural gas	T1	D	T1	D		
1.B.2.c	Venting and flaring	T1	D	T1	D		
1.B.2.c.i	Venting	T1	D	T1	D		
1.B.2.c.ii	Flaring	T1	D	T1	D		
1.B.2.d	Other	T1	D	T1	D		

The energy contribution by gasses and energy contribution by subsectors in 2021 are shown in Figure SIC3.1 and Figure SIC3.2.

Figure SIC3.1 Energy Contribution by Gasses (%) in 2021 (in Gg CO_2 eq.)

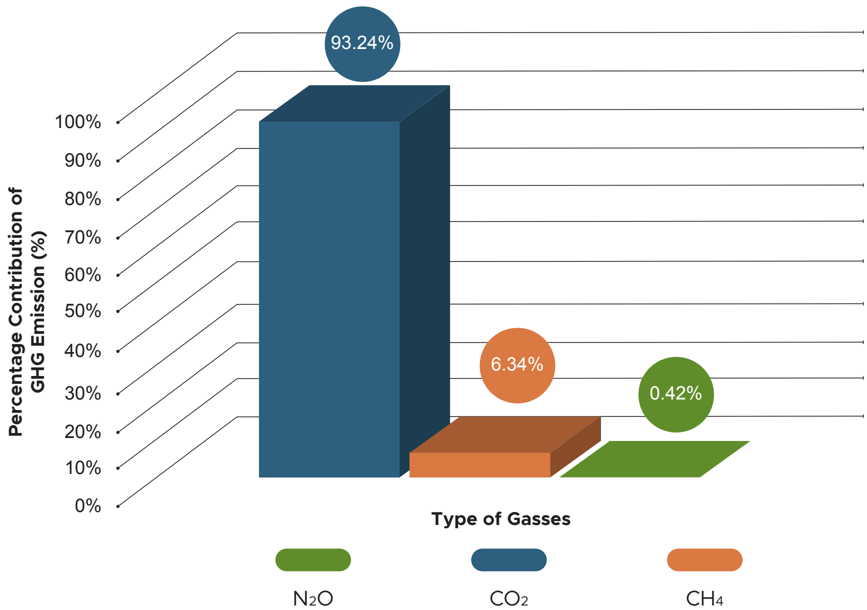


Figure SIC3.2 Energy Contribution by Subsectors (%) in 2021

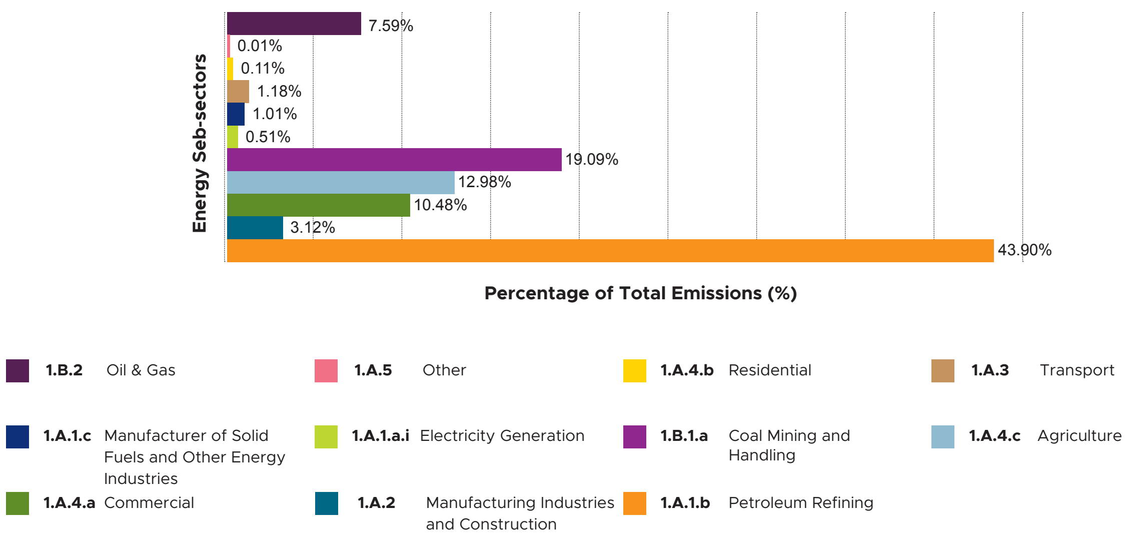


Figure SIC3.3 **CO_2 Emissions Trends of Fuel Combustion in Energy Sector, 1990-2021**

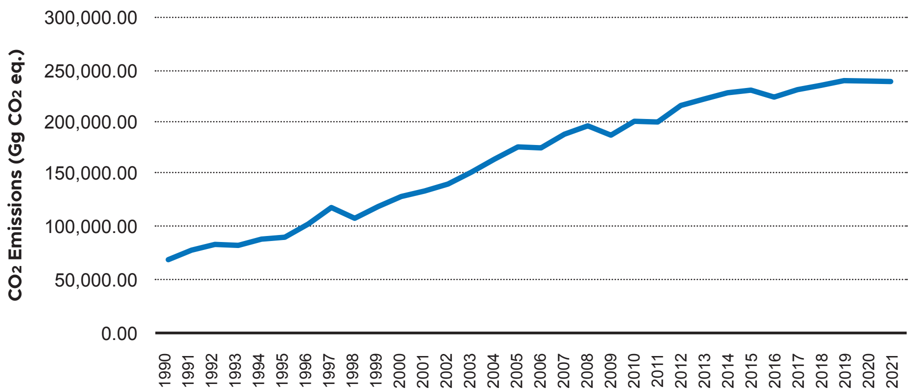
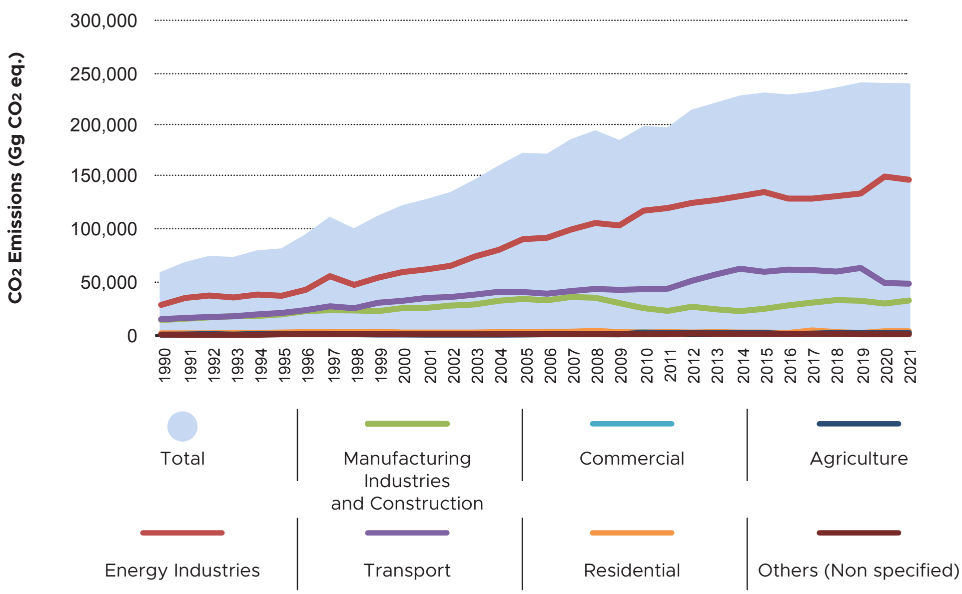


Figure SIC3.3 shows a consistent upward trend in Malaysia's CO_2 emissions, growing by 4.4% each year. Emissions increased from 173,530.27 Gg in 2005 to 239,919.93 Gg in 2021. A decrease in emissions happened during the COVID-19 pandemic, starting in 2019[4].

Figure SIC3.4 **GHG Emissions from Fuel Combustion in Sectoral Approach, 1990-2021**



[4] National Energy Balance (2019).

Figure SIC3.4 depicts GHG emission trends from fuel combustion across different sectors from 1990 to 2021. Sectoral data indicates a clear connection between lockdown measures and reduction in emissions. Specifically, in 2020, lockdowns significantly reduced activity in the transportation sector (23.8% decrease) due to travel restrictions, followed by reductions in the industrial (6.4%) and commercial (13.4%) sectors. Other key observations from the figure include[5]:

i. The decrease in emissions from the manufacturing industry and construction in 2008 is contributed by a significant drop of natural gas consumption within this sector.
ii. The sharp decline in emissions from the transport sector in 2020 reflects the impact of travel restrictions imposed during the COVID-19 pandemic.
iii. The commercial sector also experienced a (Energy Commission, 2020) decline in 2020 due to lockdown measures.
iv. Conversely, the residential sector saw an increase in emissions in 2020, likely due to the surge in work from home arrangements.
v. Data on agriculture sector emissions is only available from 1991 onwards.
vi. The energy industries, particularly electricity generation, generally exhibit an upward trend, with notable exceptions in 1997, 2003, and 2021. The decline in 1997 was the smallest, while the 2021 decline was the most significant, approximately double that of the 2003 decline, reflecting pandemic impacts. The energy industries, especially electricity generation, show a general upward trend, with declines in 1997, 2003, and 2021. The 2021 decline was the most significant, reflecting the impacts of the pandemic.

Overall, total GHG emissions from fuel combustion have shown an increasing trend from 1990-2021, despite early fluctuations in energy usage. The annual GHG emissions varied due to changes in energy demand and supply. Notably, total emissions slightly decreased from 240,751.56 Gg CO_2 eq. in 2019 to 240,266.09 Gg CO_2 eq. in 2020, before further decreasing to 239,919.93 Gg CO_2 eq. in 2021.

[5] National Energy Balance (2020).

3.2 Sectoral Summary

The sectoral summary of the energy sector is shown in Table SIC3.2.

Table SIC3.2 **Summary of GHG Emissions for Energy Sector in 2021**

Sub-sector	Gas	Emissions (Gg) A	*GWPs B	CO_2 Equivalent (Gg) C = (A x B)
1.A. Fuel combustion activities (sectoral approach)	CO_2 CH_4 N_2O	238,277.1121 20.0581 4.0800	1 28 265	238,277.1121 561.6270 1,081.1868
1.A.1. Energy industries	CO_2 CH_4 N_2O	148,843.1180 2.4090 1.5450	1 28 265	148,843.1175 67.4437 409.3216
1.A.1.a. Public electricity and heavy production	CO_2 CH_4 N_2O	113,581.9638 1.5933 1.4300	1 28 265	113,581.9638 44.6131 378.9427
1.A.1.b. Petroleum refining	CO_2 CH_4 N_2O	8,087.3410 0.3310 0.0660	1 28 265	8,087.3415 9.2679 17.5428
1.A.1.c. Manufacture of solid fuels and other energy industries	CO_2 CH_4 N_2O	27,173.8123 0.4844 0.0484	1 28 265	27,173.8122 13.5627 12.8361
1.A.2. Manufacturing industries and construction	CO_2 CH_4 N_2O	33,619.5822 1.2452 0.1830	1 28 265	33,619.5822 34.8668 48.5027
1.A.2.a. Iron and steel	CO_2 CH_4 N_2O	10,125.4949 0.2198 0.0291	1 28 265	10,125.4949 6.1533 7.7142
1.A.2.b. Non-ferrous metals	CO_2 CH_4 N_2O	350.3597 0.0063 0.0006	1 28 265	350.3597 0.1750 0.1643
1.A.2.c. Chemicals	CO_2 CH_4 N_2O	3,750.9848 0.0902 0.0132	1 28 265	3,750.9848 2.5245 3.5007
1.A.2.d. Pulp, paper and print	CO_2 CH_4 N_2O	998.9190 0.0268 0.0043	1 28 265	998.9190 0.7507 1.1369

Sub-sector		Gas	Emissions (Gg) A	*GWPs B	CO_2 Equivalent (Gg) C = (A x B)
1.A.2.e.	**Food processing, beverages and tobacco**	CO_2 CH_4 N_2O	7,038.0596 0.1317 0.01429	1 28 265	7,038.0596 3.6884 3.7869
1.A.2.f.	**Non-metallic minerals**	CO_2 CH_4 N_2O	6,642.2638 0.6119 0.0923	1 28 265	6,642.2638 17.1329 24.4542
1.A.2.g.i.	**Manufacturing of machinery**	CO_2 CH_4 N_2O	239.6757 0.0096 0.0019	1 28 265	239.6757 0.2694 0.5035
1.A.2.g. ii.	**Manufacturing of transport equipment**	CO_2 CH_4 N_2O	2,612.4633 0.0999 0.0195	1 28 265	2,612.4633 2.7983 5.1702
1.A.2.g. iv.	**Wood and wood products**	CO_2 CH_4 N_2O	430.7300 0.0154 0.0030	1 28 265	430.7300 0.4320 0.7818
1.A.2.g.vi.	**Textile and leather**	CO_2 CH_4 N_2O	896.5402 0.0208 0.0030	1 28 265	896.5402 0.5830 0.7818
1.A.2.g. viii.	**Other (Non-specific industry)**	CO_2 CH_4 N_2O	534.0913 0.0128 0.0019	1 28 265	534.0913 0.3593 0.5076
1.A.3.	**Transport**	CO_2 CH_4 N_2O	48,526.6353 15.6265 2.3087	1 28 265	48,526.6353 437.5409 611.8082
1.A.3.a.	**Domestic aviation**	CO_2 CH_4 N_2O	379.8501 0.0027 0.0106	1 28 265	379.8501 0.0745 2.8170
1.A.3.b.	**Road transportation**	CO_2 CH_4 N_2O	43,174.0216 14.3335 2.1129	1 28 265	43,174.0216 401.3377 559.9159
1.A.3.c.	**Railways**	CO_2 CH_4 N_2O	26.9445 0.0015 0.0104	1 28 265	26.9445 0.0423 2.7560
1.A.3.d.	**Domestic navigation**	CO_2 CH_4 N_2O	2,793.4999 0.2639 0.0754	1 28 265	2,793.4999 7.3889 19.9810

Sub-sector	Gas	Emissions (Gg) A	*GWPs B	CO_2 Equivalent (Gg) C = (A x B)
1.A.3.e. Other transportation	CO_2 CH_4 N_2O	2,152.3193 1.0249 0.0994	1 28 265	2,152.3193 28.6976 26.3372
1.A.4. Other sectors	CO_2 CH_4 N_2O	7,001.7943 0.7579 0.0348	1 28 265	7,001.7943 21.2220 9.2114
1.A.4.a. Commercial/institutional	CO_2 CH_4 N_2O	1,331.2275 0.1368 0.0058	1 28 265	1,331.2275 3.8310 1.5317
1.A.4.b. Residential	CO_2 CH_4 N_2O	2,625.0751 0.2086 0.0042	1 28 265	2,625.0751 5.8400 1.1183
1.A.4.c. Agriculture/forestry/ fishing	CO_2 CH_4 N_2O	3,045.4918 0.4126 0.0248	1 28 265	3,045.4918 11.5514 6.5588
1.A.5. Other	CO_2 CH_4 N_2O	285.9828 0.0198 0.0089	1 28 265	285.9828 0.5533 2.3456
1.A.5.b. Mobile	CO_2 CH_4 N_2O	285.9828 0.0198 0.0089	1 28 265	285.9828 0.5533 2.3456
1.B. Fugitive emissions from fuels	CO_2 CH_4 N_2O	3,846.8248 567.4426 0.0441	1 28 265	3,846.8248 15,888.3915 11.6838
1.B.1.a. Coal mining and handling	CO_2 CH_4 N_2O	 1.1503 0.0000	1 28 265	 32.2081 0.0000
1.B.2. Oil and natural gas and other emissions from energy production	CO_2 CH_4 N_2O	3,846.8248 566.2923 0.0441	1 28 265	3,846.8248 15,856.1834 11.6838
Total Energy Sector				**259,666.8261**

A sectoral summary in energy sector is demonstrated in Table SIC3.3 below.

Table SIC3.3 **Sectoral Summary in Energy Sector 2021**

GHG Source and Sink Categories		2021 Total Emissions Gg CO_2 eq.	2005-2021 Trend CAGR (%)	Recalculation
1.A.1.	**Energy industries**	149,319.8829	Increasing at annual growth 3.08%	Improvement on activity data of 1.A.1.a. category.
1.A.1.a.	**Public electricity and heat production**	114,005.5197	Increasing at annual growth rate 4.64%	Improvement in emissions figure due to reallocation of coal by type (bituminous, sub-bituminous and lignite). This has impact on the national total.
1.A.1.a.i.	**Electricity generation**	111,097.4182	Increasing at annual growth rate 4.73%	
1.A.1.a.ii.	**Combined heat and power generation**	2,908.1015	Increasing at annual growth rate 1.83%	
1.A.1.a.iii.	**Heat plants**			
1.A.1.b.	**Petroleum refining**	8,114.1522	Decreasing at annual growth rate 1.28%	
1.A.1.c.	**Manufacture of solid fuels and other energy industries**	27,200.2110	Increasing at annual growth rate 0.10%	
1.A.1.c.i.	**Manufacture of solid fuels**			
1.A.1.c.iii.	**Other energy industries**	27,200.2110	Increasing at annual growth rate 0.10%	
1.A.2.	**Manufacturing industries and construction**	33,702.9517	Decreasing at annual growth rate 0.29%	There is no recalculation in this source categoryin 1990-2019.
1.A.2.a.	**Iron and steel**	10,139.3623	Increasing at annual growth rate 0.69%	
1.A.2.b.	**Non-ferrous metals**	350.6990	Increasing at annual growth rate 3.13%	
1.A.2.c.	**Chemicals**	3,757.0099	Decreasing at annual growth rate 1.44%	

GHG Source and Sink Categories		2021 Total Emissions Gg CO_2 eq.	2005-2021 Trend CAGR (%)	Recalculation
1.A.2.d.	**Pulp, paper and print**	1,000.8066	Decreasing at annual growth rate 0.54%	
1.A.2.e.	**Food processing, beverages and tobacco**	7,045.5349	Increasing at annual growth rate 2.41%	
1.A.2.f.	**Non-metallic minerals**	6,683.8509	Decreasing at annual growth rate 0.82%	
1.A.2.g.i.	**Manufacturing of machinery**	240.4486	Decreasing at annual growth rate 2.83%	
1.A.2.g.ii.	**Manufacturing of transport equipment**	2,620.4317	Decreasing at annual growth rate 3.08%	
1.A.2.g.iii.	**Mining (excluding fuels) and quarrying**			
1.A.2.g.iv.	**Wood and wood products**	431.9438	Decreasing at annual growth rate 6.10%	
1.A.2.g.v.	**Construction**			
1.A.2.g.vi.	**Textile and leather**	897.9049	Decreasing at annual growth rate 0.21%	
1.A.2.g.viii.	**Other (Non-specified Industry)**	534.9582	Decreasing at annual growth rate 3.36%	
1.A.3.	**Transport**	49,575.9843	Increasing at annual growth rate 1.13%	The main recalculation due to new data supplied by stakeholders from the road, rail and aviation sector. This has no impact on the national total.
1.A.3.a.	**Domestic aviation**	382.7415	Decreasing at annual growth rate 6.95%	
1.A.3.b.	**Road transportation**	44,135.2752	Increasing at annual growth rate 1.54%	
1.A.3.c.	**Railways**	29.7427	Decreasing at annual growth rate 10.47%	
1.A.3.d.	**Domestic navigation**	2,820.8698	Decreasing at annual growth rate 2.14%	

GHG Source and Sink Categories		2021 Total Emissions Gg CO_2 eq.	2005-2021 Trend CAGR (%)	Recalculation
1.A.3.e.	**Other transportation**	2,207.3541	Increasing at annual growth rate 2.68%	
1.A.4.	**Other sectors**	7,032.2277	Increasing at annual growth rate 2.64%	There is no recalculation in this source category in 1990-2019.
1.A.4.a.	**Commercial/institutional**	1,336.5901	Decreasing at annual growth rate 3.12%	
1.A.4.b.	**Residential**	2,632.0333	Increasing at annual growth rate 1.41%	
1.A.4.c.	**Agriculture/forestry/ fishing**	3,063.6019	Increasing at annual growth rate 15.27%	
1.A.4.c.i.	**Stationary**	153.1808	Increasing at annual growth rate 15.27%	
1.A.4.c.ii.	**Off-road vehicles and other machinery**		Data only available from 1991 to 2011	
1.A.4.c.iii.	**Fishing**	2,910.4211	Data only available from 2012 to 2021	
1.A.5.	**Other**	288.8817	Increasing at slower annual growth rate 1.08%	There is no recalculation in this source category in 1990-2019.
1.A.5.b.	**Mobile**	288.8817	Increasing at annual growth rate 2.02%	
1.B.1.a.	**Coal mining and handling**	32.2081	Increasing at annual growth rate 0.95%	
1.B.2.	**Oil and natural gas and other emissions from energy production**	19,714.6920	Decreasing at annual growth rate 2.96%	There is no recalculation in this source category in 1990-2019.
1.B.2.a.	**Oil**	10,691.6945	Decreasing at annual growth rate 5.04%	
1.B.2.a.i.	**Exploration**			
1.B.2.a.ii.	**Production and upgrading**	0.4805	Decreasing at annual growth rate 2.18%	

GHG Source and Sink Categories	2021 Total Emissions Gg CO_2 eq.	2005-2021 Trend CAGR (%)	Recalculation
1.B.2.a.iii. Transport			
1.B.2.a.iv. Refining/storage	4.9240	Decreasing at annual growth rate 0.15%	
1.B.2.a.v. Distribution of oil products			
1.B.2.a.vi. Other	5.4045	Decreasing at annual growth rate 0.36%	
1.B.2.b. Natural gas	9,022.9975	Increasing at annual growth rate 1.24%	
1.B.2.b.i. Exploration			
1.B.2.b.ii. Production	6,899.3640	Increasing at annual growth rate 1.03%	
1.B.2.b.iii. Processing	672.7487	Increasing at annual growth rate 0.09%	
1.B.2.b.iv. Transmission and storage	335.6310	Increasing at annual growth rate 0.42%	
1.B.2.b.v. Distribution	502.7136	Decreasing at annual growth rate 0.27%	
1.B.2.b.vi. Other	8,410.4573	Increasing at annual growth rate 0.84%	
1.B.2.c. Venting and flaring	11,298.83	Increasing at annual growth rate 0.46%	
1.B.2.c.i. Venting	6,809.1445	Data only available from 2020 to 2021	
1.B.2.c.ii. Flaring	4,489.6856	Increasing at annual growth rate 12.87%	
1.B.2.d. Other (emissions from energy production)			

3.2.1 Trends in Emissions by Gasses and GHG Emissions from 1990 to 2021

Figure SIC3.5 shows the emission trends by gasses from 1990 to 2021. CO_2 emissions make up the largest share of total GHG emissions, primarily driven by the electricity generation, followed by transport sector.

Emissions have risen over time, reflecting economic growth. The close link between transport and CO_2 emissions is due to the rising demand for fossil fuel-powered vehicles. Similarly, emissions from the electricity sector are increasing due to growing economic activity. The fuel mix in electricity generation remains coal-dominated, although the share of natural gas is gradually increasing.

CH_4 is the second-largest GHG by volume. Although annual CH_4 emissions have increased since 1990, a decline has been observed since 2017. The main sources of CH_4 are leaks in the oil and gas distribution system and transport. In Malaysia, reductions in CH_4 emissions have been driven by investments in infrastructure improvements to reduce leakage. However, its overall contribution to total emissions remains significantly smaller than CO_4. N_2O emissions have remained low since 1990, with the transport and electricity generation sectors being the primary sources.

Figure SIC3.5 **The Trend of GHG Emissions by Gasses, 1990-2021**

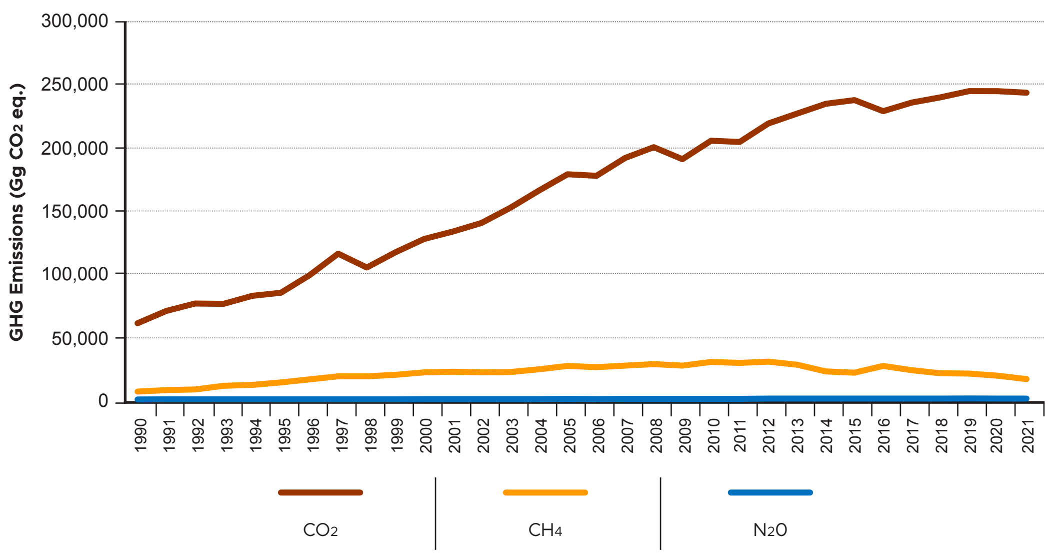
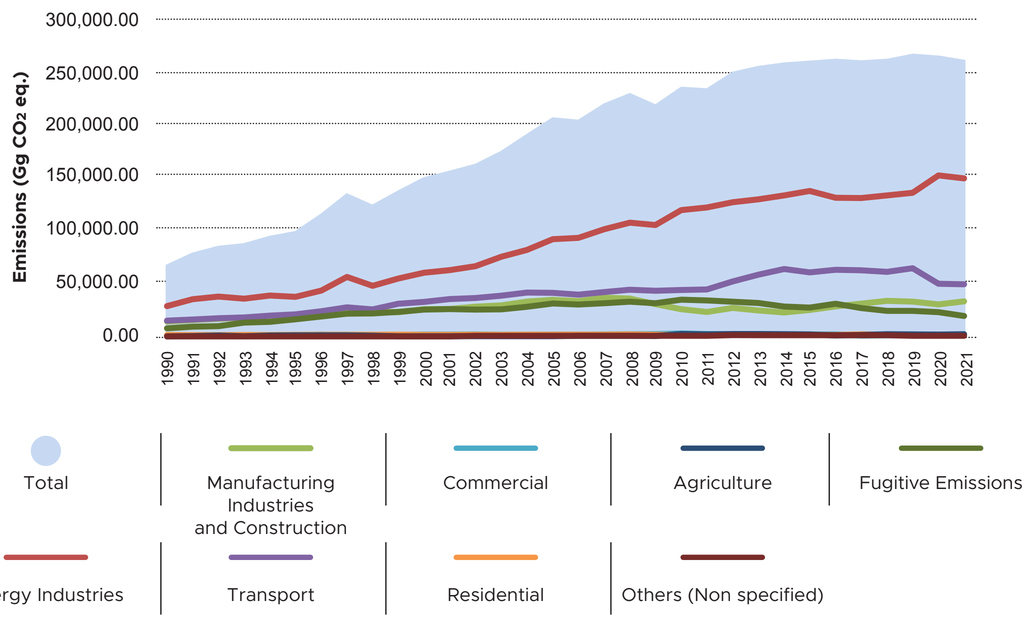


Figure SIC3.6 shows the GHG emission trends which include emissions from fuel combustion activities and fugitive emissions (non-combustion sources i.e., equipment leaks, process venting, evaporation losses, disposal of waste gas streams by venting or flaring, etc) from oil and gas systems, and coal mining and handling. The total GHG emissions (including fugitive) have decreased from 265,376.10 Gg CO_2 eq. in 2019 to 263,544.42 Gg CO_2 eq. in 2020 before further decreasing to 259,666.83 Gg CO_2 eq. in 2021 as shown in Figure SIC3.6.

Figure SIC3.6 **The Trend of GHG Emissions, 1990-2021**



3.2.2 Sectoral Improvement Undertaken

In the effort to enhance the accuracy and consistency of GHG inventory reporting, significant improvements have been made across key sectors. These sectoral enhancements focus on the refinement of activity data (AD) and emission factors (EF), crucial elements in ensuring more precise emissions estimations and indicated in Table SIC3.4.

Table SIC3.4 Sectoral Improvement Undertaken

Sub-Category	Improvement Undertaken	Description
Electricity Generation	Improvement on AD	The coal consumption from 1990 until 2021 and has been adjusted to reflect more accurate classifications of coal types (i.e. bituminous, sub-bituminous and lignite), ensuring that emissions estimates align more closely with actual energy consumption patterns and improve the overall accuracy of the national inventory. The emission by coal were calculated according to specific type of coals. The recalculation of emissions figures due to the reallocation of coal by type (bituminous, sub-bituminous, and lignite) has impacted the national total emissions. This reallocation accounts for the different emission factors associated with each coal type, leading to a reduction in total emissions within this category by approximately 0.1% to 1.6% over the reporting years from 1990 to 2021.
Transportation	Improvement on AD	**Water-borne Navigation Sector:** › The diesel consumption from the waterborne sector has been reviewed and new assumption was derived, which was validated by the transport stakeholders and Malaysia Maritime Department. The following shows the new the formulation used to obtain the diesel fuel activity data for this subsector. Total Diesel for Domestic Water- borne navigation = Total Diesel (NEB) – Total Road transport (KPDN) Diesel Consumption - Total Non-specified (Mobile) Diesel Consumption – Total Non-specified (Mobile) other Diesel Consumption - Total Railway Diesel Consumption **Road Transport Sector:** › Actual motor gasoline and diesel consumption data for the road transport sector has been sourced from the KPDN for the years 2017 to 2021. When compared with the total fuel amounts reported by the National Energy Balance (NEB), the KPDN data indicates that approximately 94% of motor gasoline and about 80% of diesel is attributed to the road transport sector. › For diesel, it is assumed that about 70 - 80% of total diesel consumption is used by the road transport sector, while the remaining 20 – 30% is allocated to Non-Specified (Mobile), Domestic Water-Borne Navigation, and Railways. › For motor gasoline, an average of about 94% is used in the road transport sector, with about 6% attributed to off-road activities such as ground operations at airports and harbours. › The entire time series from 1990 to 2019 has been recalculated using this refined approach, improving the accuracy and consistency of fuel consumption data across sectors.

Sub-Category	Improvement Undertaken	Description
Fugitives Emissions	Improvement on AD and EF	**Activity Data** › Actual flare and vent volume from oil and gas production are used to estimate the fugitive emissions. Direct emission factors from Table 4.2,5, 2006 IPCC Guidelines (footnote e for flaring and footnote g for venting) were used to estimate the CO_2, CH_4, and N_2O emissions from the reported flared and vented volumes. › The activity data under the "All Other" category have been revisited. The gas processing activity data has been improved to use actual data available from the NEB report. › In the previous reporting, activity data under the other category assumed gas consumption from distributed gas pipelines of the residential and non-residential sectors. This category has been excluded from the emissions calculation due to the unavailability of the CO_2 emission factor in the IPCC 2006 guideline. **Emission Factor** › The emission factors for all estimations of GHG from fugitive emissions of oil and gas systems derived from 10% at the lower point value of emission factor from table 4.2.5, 2006 IPCC Guidelines. › The emissions factors for all estimations of GHG from fugitive emissions of oil and gas systems have been included in this inventory and the time series from 1990 to 2019 has been recalculated.

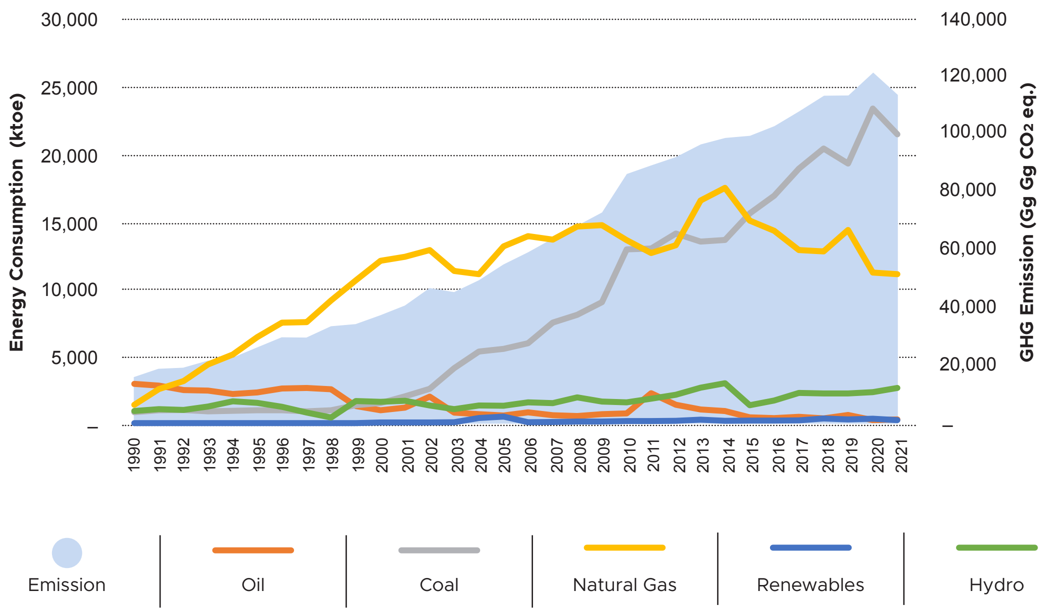
3.3 Emissions Trends in Energy Sub-sectors

This section reviews the trends in emissions within the energy sub-sector, focusing on key industries such as electricity generation and petroleum refining.

3.3.1 Electricity Industries (Electricity Generation)

Figure SIC3.7 presents the trend of GHG emissions and energy consumption in the electricity generation from 1990 to 2021.

Figure SIC3.7 **The Trend of GHG Emissions in Electricity Industries, 1990-2021**



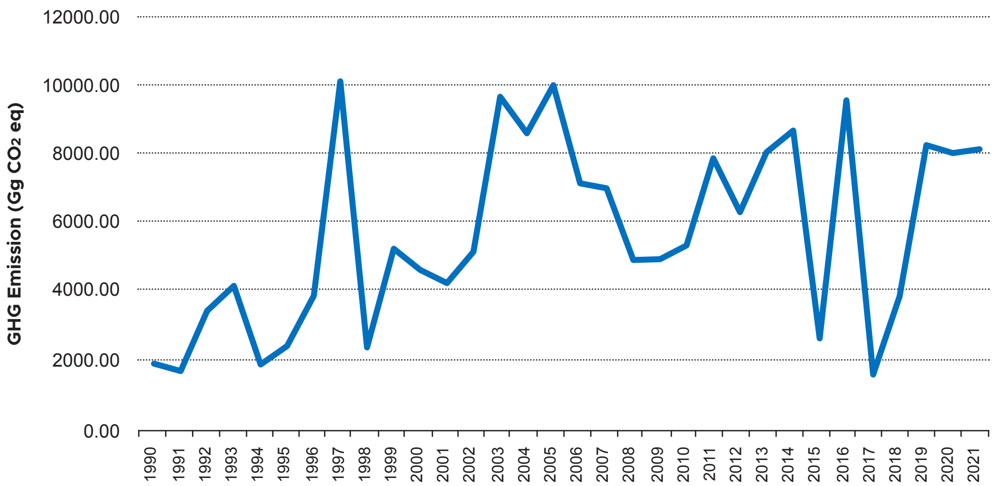
GHG emissions from electricity generation have generally increased from 1990 to 2021. While high-carbon fuels like coal and natural gas continue to dominate the energy mix, there has been a gradual shift toward lower-carbon sources, such as hydropower and renewable energy. Despite this transition, coal and natural gas remain significant contributors to rising emissions. For instance, in 2020, total electricity generation decreased by 2.3% compared to 2019[6], however, emissions during that year increased due to the predominant use of coal over gas for electricity generation. Since 2005, GHG emissions in the electricity sector including electricity generation, combined heat and power, and heat plants, have grown by an average of 4.34%, reaching 114,005.52 Gg CO_2 eq. in 2021.

[6] National Energy Balance (2020)

3.3.2 Energy Industries (Petroleum Refining)

Figure SIC3.8 illustrates the emission trends for petroleum refining from 1990 to 2021.

Figure SIC3.8 **The Trend of GHG Emissions in Petroleum Refining Industries, 1990-2021**



Petroleum refining encompasses all combustion processes required for refining petroleum products, including on-site electricity and heat generation, while excluding evaporative emissions from the refinery[7]. The graph illustrates fluctuating emission levels over the years, reflecting variations in refining activities. For example, in 2016, emissions from petroleum refining more than doubled compared to the previous year, increasing by 6,905.23 Gg CO_2 eq.to reach 9,529.67 Gg CO_2 eq. This substantial rise likely corresponds with increased crude oil production from the Sabah oil fields[8]. Since 2005, GHG emissions in the petroleum refining sector have declined at an average annual rate of 1.28%, reaching 8,114.15 Gg CO_2 eq.in 2021.

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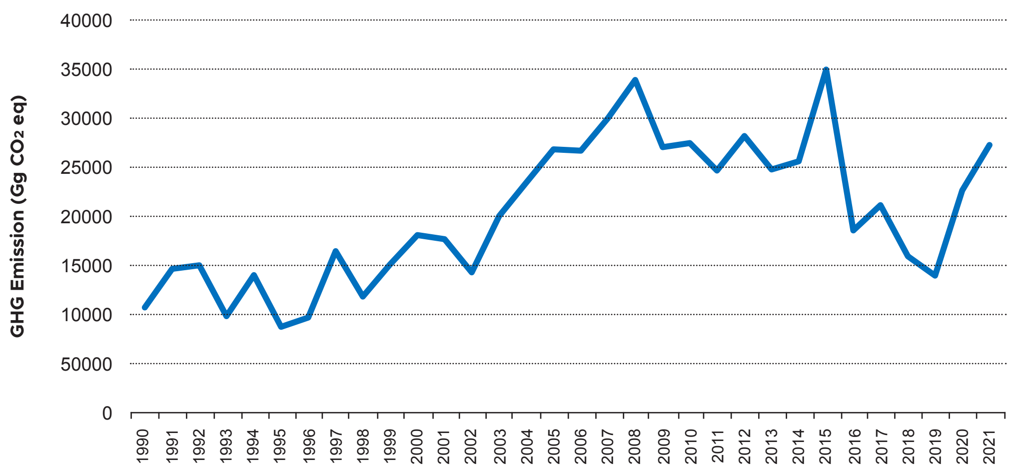
[7] IPCC 2006 Guidelines
[8] National Energy Balance (2016)

3.3.3 Other Energy Industries (Manufacture Solids Fuel)

Figure SIC3.9 presents the emission trends from 1990 to 2021 for the other energy industries category, specifically those not related to manufactured solid fuels.

Figure SIC3.9 **The Trend of GHG Emissions in Other Energy Industries, 1990-2021**



This category encompasses combustion emissions generated from the energy production industries' own energy consumption in coal mining, oil and gas extraction, and natural gas processing[9]. A significant decline in emissions occurred in 2016, with emissions dropping by 47.4% (16,580.28 Gg CO_2 eq.) from 34,976.97 Gg CO_2 eq. in 2015 to 18,396.69 Gg CO_2 eq. This sharp reduction is likely linked to a decrease in the primary supply of natural gas[10]. However, by 2020, emissions began rising again, possibly due to recovery post-COVID-19. From 2005 to 2021, emissions in this category increased slightly, with an annual growth rate of just 0.10%.

[9] IPCC 2006 Guidelines
[10] National Energy Balance (2016)

3.3.4 Manufacturing Industries and Construction

Figure SIC3.10 portrays the emission trends for manufacturing industries and construction from 1990 to 2021. In 2007, emissions from this sector reached an all-time high of 37,237.92 Gg CO_2 eq. before it decreased to 23,260.97 Gg CO_2 eq. in 2011. The most significant drop in energy consumption was contributed by gas/ diesel oil (decreased by 2,704.25 ktoe), followed by residual fuel oil (decreased by 1,583.77 ktoe) and natural gas (decreased by 1,116.86 ktoe). Despite the reduced emissions, manufacturing output substantially increased during the same period, reflecting a shift away from energy-intensive technologies. From 2005 to 2021, the growth rate of emissions in this sector has slowed, with an annual growth rate of 0.29%.

Figure SIC3.10 **The Trend of GHG Emissions and Energy Consumption in Manufacturing Industries and Construction, 1990-2021**

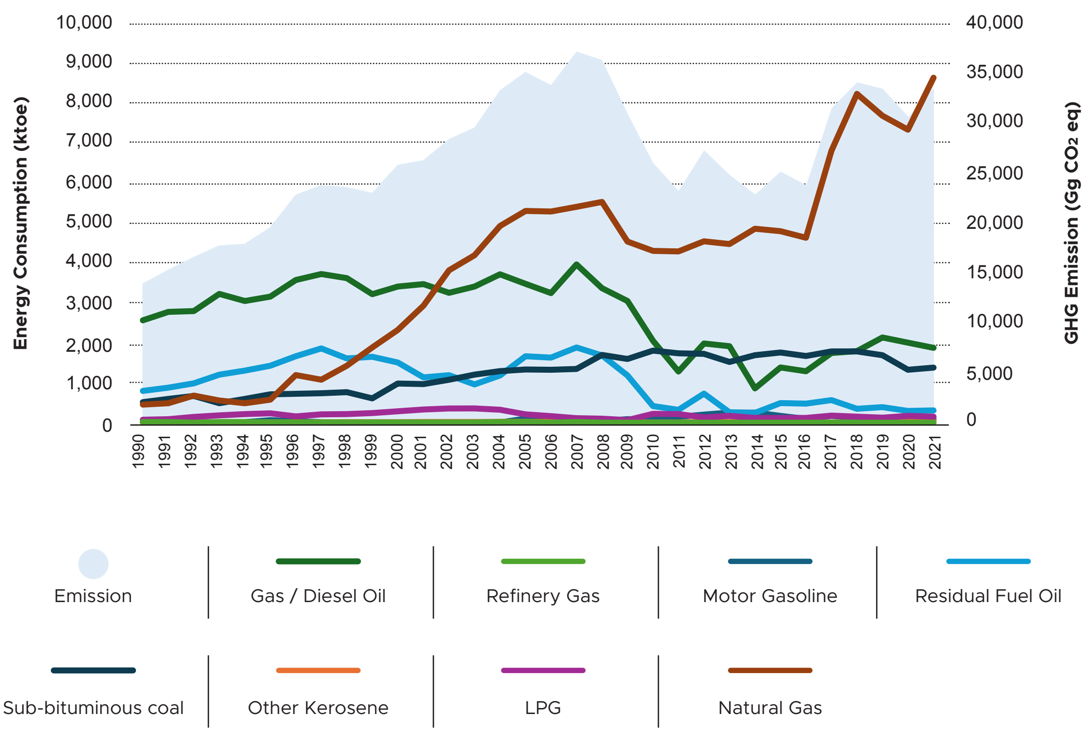


Figure SIC3.11 **The Trend of GHG Emissions in Manufacturing Industries and Construction by Manufacturing Subsectors, 1990-2021**

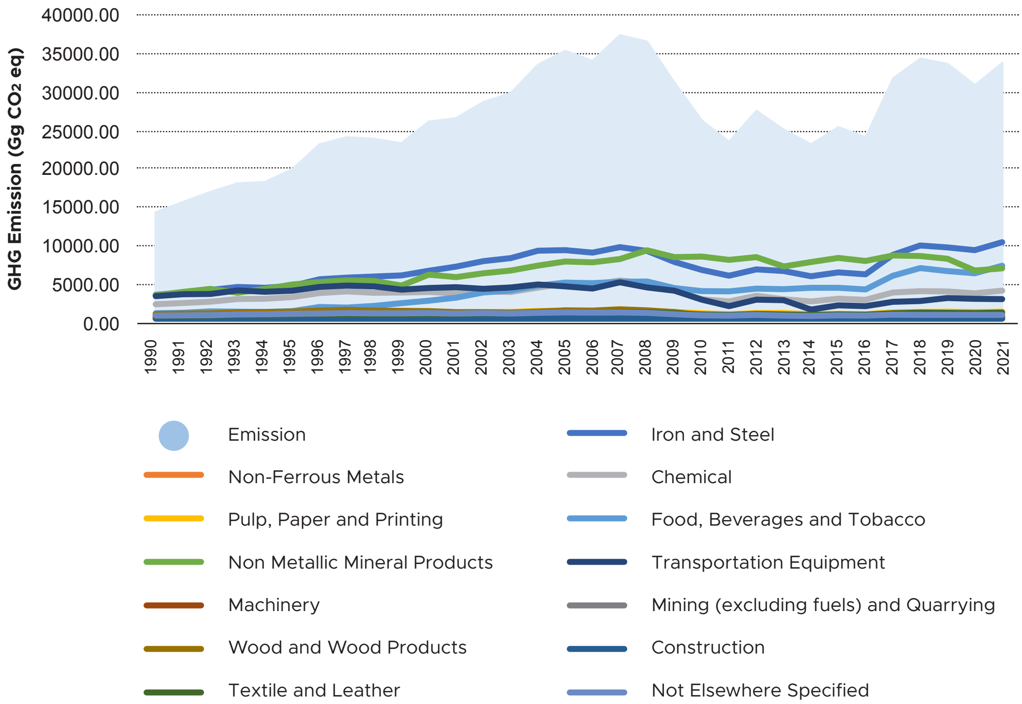


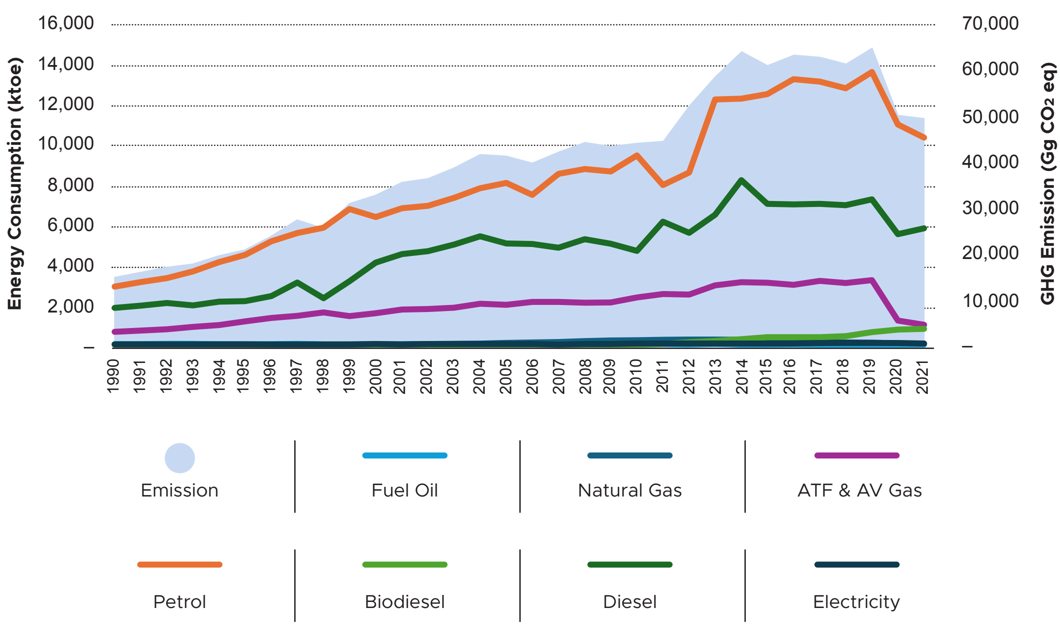
Figure SIC3.11 illustrates the emission trends according to manufacturing subsectors. Iron and steel have historically been the largest contributors to emissions. However, from 2008 to 2016, non-metallic mineral products surpassed iron and steel in terms of emissions. In 2008, non-metallic mineral products emitted 9,064.43 Gg CO_2 eq., exceeding the 8,946.34 Gg CO_2 eq. from iron and steel. By 2017, non-metallic mineral products emitted 8,380.08 Gg CO_2 eq., while iron and steel reached 8,446.35 Gg CO_2 eq. Iron and steel regained the lead in 2017 and remained the primary contributor through 2021. By 2021, iron and steel emissions made up 30% of the total, followed by food, beverages, and tobacco (20.93%), and non-metallic mineral products (19.76%).

3.3.5 Transport

Figure SIC3.12 illustrates the GHG emission trends and energy consumption in the transport sector from 1990 to 2021. The graph shows a considerable increase in emissions since 2011, followed by a sizable decline in 2019. Total emissions dropped from 65,053.17 Gg CO_2 eq. in 2019 to 49,575.98 Gg CO_2 eq.by 2021. Several factors likely contributed to this decline:

- A shift towards low-carbon fuels, such as biodiesel and electricity, within the total energy consumption, while the demand for high carbon-intensive fuels like petroleum has shown slower growth.
- Road transport remains the dominant subsector, with emissions closely following fuel consumption patterns. Efforts to diversify energy sources within road transport have reduced reliance on petrol and diesel.
- The COVID-19 pandemic caused a significant reduction in energy demand, leading to a sharp decrease in transport emissions in 2019.

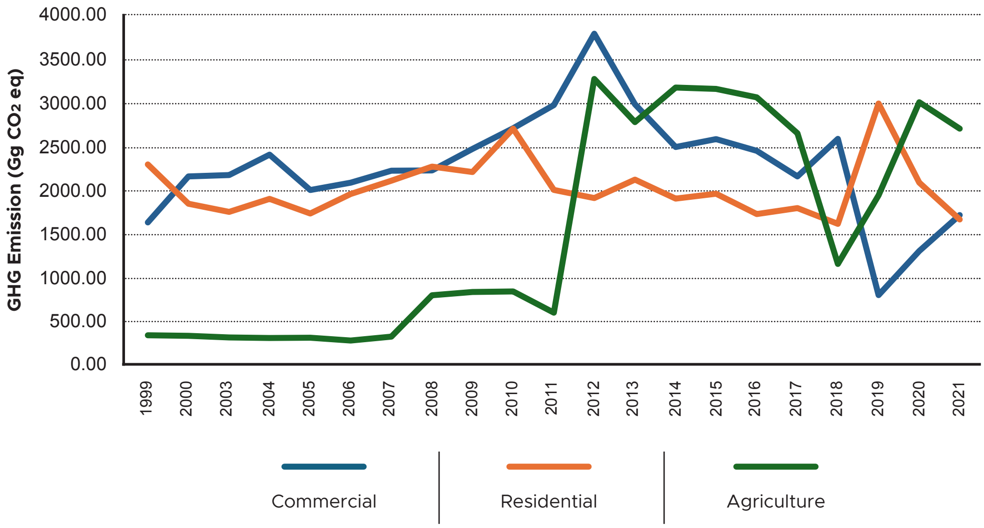
Figure SIC3.12 **The Trend of GHG Emissions and Energy Consumption in Transport Industries, 2011-2021**



3.3.6 Domestic, Commercial and Agriculture (Other Sectors)

Figure SIC3.13 illustrates the trends in GHG emissions across the domestic, commercial, and agricultural sectors from 1999 to 2021.

Figure SIC3.13 **The Trend of GHG Emissions in Domestic, Commercial and Agriculture Industries, 1999-2021**



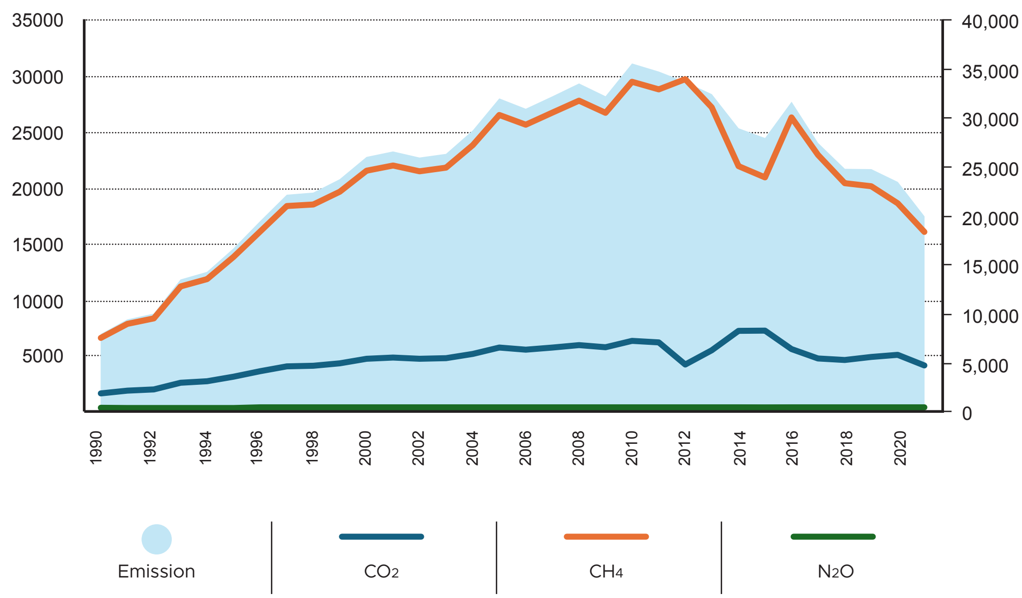
Initially, emissions from the commercial sector dominated the total sector emissions. However, a notable shift occurred in 2012 when commercial sector emissions began to decline, while emissions from agricultural fuel combustion rose in 2013. By 2019, both the agriculture and residential sectors exhibited an upward trend in emissions, whereas the commercial sector showed a decline, largely due to the impact of the COVID-19 pandemic.

3.3.7 Fugitives

Figure SIC3.14 portrays emission trends and energy consumption in oil and gas extraction, as well as natural gas distribution from 1990 to 2021.

Fugitive emissions in the energy sector primarily consist of CH_4 and CO_2 released during oil and gas extraction and natural gas distribution. Since 1990, fugitive emissions consistently rising and began to switch into declining trend in 2010, mostly contributed by decreased of CH_4 released from oil and gas extraction and natural gas distribution.

Figure SIC3.14 **The Trend of GHG Emissions in Oil and Gas Extraction and Natural Gas Distribution, 1990-2021**



3.4 Fuel Combustion Activities (CRT Category 1.A.)

This section shows Fuel Combustion Activities under CRT category 1.A.

3.4.1 Comparison of the Sectoral Approach with the Reference Approach

The comparison between Sectoral Approach (SA) and Reference Approach (RA) serves as a verification method for GHG estimates in the energy sector, in accordance with UNFCCC decision 24/CP.19 paragraph 40.

The Sectoral Approach is a detailed 'bottom-up' methodology for estimating CO_2 emissions from energy, while the Reference Approach uses a 'top-down' method based on national fuel statistics to verify the Sectoral Approach estimates.

The RA inventory method uses various sections of Malaysia's national energy statistics, combining aggregated data on fuel inputs and outputs from the entire economy. It assesses the carbon balance for combustion sources using top-level data on oil, gas, and solid fuels. The RA is a more straightforward methodology that provides a valuable quality check against the more detailed SA. Differences between the RA and SA primarily due to statistical variations between production-side and demand-side fuel estimates within national energy statistics, as well as the more aggregated application of emission factors to activity data across fuel types.

Figure SIC3.15 **Comparison of the Time-Series Analysis of CO_2 Emission from 1990 to 2021 Using the Reference and Sectoral Approaches**

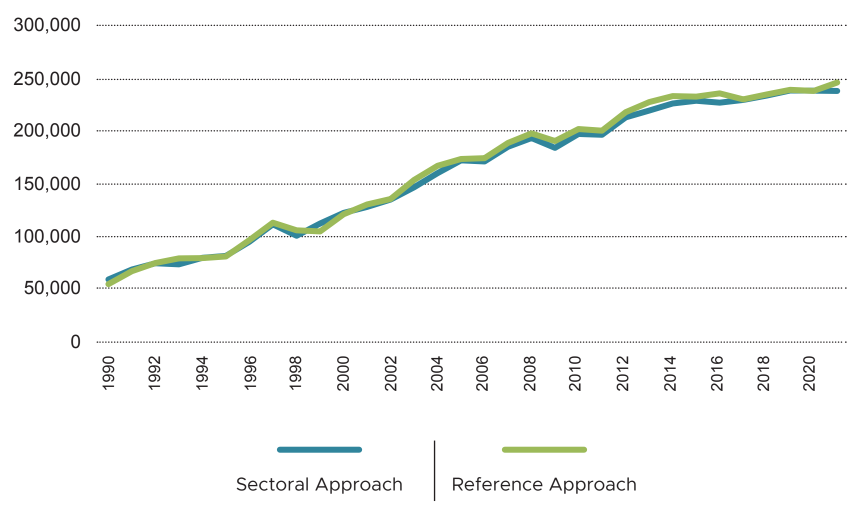


Figure SIC3.15 presents the comparison of emissions between the RA and SA from 1990 to 2021. The gap between the two approaches remains small[11] and acceptable, given the scale of total carbon flows involved. A 2020 comparison shows that the SA total of CO_2 emissions is 0.11% higher than the RA total whereas in 2021, the SA total was 3.40% lower than the RA total.

Differences between the RA and SA arise primarily due to statistical differences between production-side and demand-side fuel estimates within national energy statistics and the more aggregated approach to applying emission factors to activity data across fuel types.

3.4.1.1 Discrepancies between the IPCC Reference and Sectoral Approach

There are a number of 'known differences' between the reference approach and sectoral approach which are discussed in the subsequent sections.

3.4.1.2 Statistical Differences in Energy Balance Data

The statistical difference refers to the gap between total supply and demand in energy statistics, contributing to discrepancies between the RA and SA. Due evolving methodologies and improved data collection the statistical difference is generally quite small in later years, but as some data are not available for earlier years the gap is much more significant in the 90s.

3.4.1.3 Application of Carbon Factors: Aggregated (RA) vs. Detailed (SA)

In the RA, the carbon balance is calculated based on the apparent consumption of fuels, for primary fuels (e.g. crude oil). This mean that the estimated carbon content of fuel that's transformed into other fuels (e.g. petroleum products) is assumed to be accounted for by the commodity balance for the primary fuel from which they are derived, which differs from the SA which estimates emissions at end use.

3.4.1.4 International Bunker Fuels (Memo Item)

International bunker emissions (international aviation and shipping) are not included in the national total but are reported separately.

[11] Typically, the gap between the two approaches is less than 10 per cent when compared to the total carbon flows involved.

3.4.1.5 Feedstocks and Non-Energy Use of Fuels

The national energy statistics contain an allocation for non-energy use for each fuel in the commodity balance tables. The Malaysia inventory estimates emissions from fuels, including emissions arising from non-energy uses. The activity data used for the national inventory and any deviations from the Malaysia energy balance are presented and explained in Section 3.2.4.

3.4.2 Energy Industries (CRT Category 1.A.1.)

This section shows the Energy Industries under CRT category 1.A.1.

3.4.2.1 Category Description

The energy industries fall into two categories: Electricity Generation (1.A.1.a.i.) which consists of fuel used for electricity generation from main activity producers and Combined Heat and Power Generation (CHP) (1.A.1.a.ii.) from both heat and electrical power. At this moment, the production from the Heat Plants category (1.A.1.a.iii.) is not estimated as it is not occurring in Malaysia.

3.4.2.2 Public Electricity and Heat Production (CRT Category 1.A.1.a.)

The local electricity generation industry in Malaysia is comprised of three public utilities following geographical delineation: Peninsular Malaysia, Sabah and Sarawak. A total of 34 power plants are operated by independent power producers (IPPs), with 20 in Peninsular Malaysia, 8 in Sabah, and 6 in Sarawak. Additionally, there are 29 CHP co-generators in Peninsular Malaysia, 12 in Sabah, and 1 in Sarawak. Table SIC3.5 provides the emissions covered under 1.A.1.a. for public electricity and heat production.

The coal consumption data has been categorized by coal type: bituminous, sub-bituminous, and lignite. This data segregation of coal by type of fuel was provided by the Energy Commissions and TNB Research Sdn. Bhd. The coal consumption has been updated for Electricity Generation (1.A.1.a.i.) category.

Table SIC3.5 **Emissions Covered Under 1.A.1.a. Public Electricity and Heat Production**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.1.a.: Fuel consumption	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	Yes at 95% significant level		
Coverage	National		
Major Improvements since last submission	There are changes due a new activity data of coal consumption by coal type. The total amount of sub-bituminous coal has been segregated according to sub-bituminous, other bituminous and lignite.		

3.4.2.3 Petroleum Refining (CRT Category 1.A.1.b.)

The petroleum refineries sector consists of facilities that produce petrol, diesel, fuel oil, liquefied, kerosene, aviation turbine fuel refinery gas and non-energy products such as naphtha, lubricants, bitumen, etc. The emission in this sector includes all combustion activities supporting the refining of petroleum products including on-site combustion from the generation of electricity and heat for own use. However, in this sector, the evaporative emissions occurring at the refinery from venting, flares and fugitive leaks from equipment are reported separately under Oil (Fugitive emissions from fuels) (1.B.2.a.). Table SIC3.6 provides the emissions covered under 1.A.1.b. for petroleum refining.

Table SIC3.6 **Emissions Covered Under 1.A.1.b. Petroleum Refining**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.1.b.: Fuel consumption	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	Yes at 95% significant level		
Coverage	National		
Major Improvements since last submission	No major improvements to the data and methods.		

The data from national statistics is used for this category. The national statistic provides separate table for the supply, transformation and consumption of petroleum products and feedstock. A refinery feedstock is processed oil destined for further processing excluding blending. With further processing, it will be transformed into one or more component or finished products. Based on the IPCC 2006 definition for this category, the net of crude oil is used to calculate the total transformed in the energy industries.

3.4.2.4 Other Energy Industries (CRT Category 1.A.1.c.iii.)

The other energy industries sector consists of oil and gas extraction and the processing and upgrading of natural gas facilities. The emission in this sector includes all combustion activities supporting the transformation of natural gas from the Liquefied Natural Gas (LNG) plants and Gas to Liquid (GTL) plants, both in Sarawak and Gas Processing Plant (GPP) in Terengganu. On-site combustion from the generation of electricity and heat for own uses from these plants are also included in this category. Table SIC3.7 provides the emissions covered under 1.A.1.c.iii. Other Energy Industries.

The data from national statistics is used for this category. Based on the IPCC 2006 definition for this category, the net of natural gas is used to calculate the total transformed in the energy industries.

Table SIC3.7 **Emissions Covered Under 1.A.1.b. Petroleum Refining**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.1.c.iii.: Fuel consumption	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No major improvements to the data and methods.		

3.4.2.5 Methodological Issues

The methodological issues of 1.A.1. Energy Industry consisting of its activity data and the overview of emission factor are shown in Table SIC3.8 and Table SIC3.9.

Table SIC3.8 **Overview of Methodological Issues Under 1.A.1. Energy Industries**

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.1. Energy Industries			
	1.A.1.a. Public electricity and heat production	Sum of emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants.	Amount of fuels used for electricity generation combined heat and power generation.	EBT, NEB.
	1.A.1.a.i. Electricity generation	Fuel types from main producers of thermal power plants. Biomass and Biogas are included.	All fuel consumption from thermal stations. Coal has been segregated into Bituminous, Sub-bituminous and Lignite.	EBT, NEB.
	1.A.1.a.ii. Combined heat and power generation	Fuel types from the production of both heat and power plants. Biomass and biogas are included.	All fuel consumption from self-generation stations.	EBT, NEB.
	1.A.1.a.iii. Heat plants	No activity data.	No production of heat for sale by pipe network.	EBT, NEB Energy Commission
	1.A.1.b. Petroleum refining	Refining of petroleum products including losses & own use for generation of electricity and heat.	Estimated from the refineries and petroleum losses and own use.	EBT, NEB Energy Commission
	1.A.1.c. Manufacture of solid fuels and other energy industries	–	–	–
	1.A.1.c.i. Manufacture of solid fuels	No activity data.	No combustion for the production of coke, brown coal briquettes and patent fuel.	–
	1.A.1.c.iii. Other energy industries	Own use from the oil and gas extraction and processing of natural gas.	Estimated from the gas plants' losses and own use.	EBT, NEB Energy Commission

Table SIC3.9 Overview of Emission Factor Under 1.A.1. Energy Industries

	Emission Factor											Data Source
Sub-Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Unit	(tC/TJ)	(kg/TJ)	(kg/TJ)									
1.A. Fuel combustion activities												
1.A.1.a.i. Electricity generation												
Diesel oil	74,100	3	0.6									IPCC GLs (2006)
Residual fuel oil	77,400	3	0.6									IPCC GLs (2006)
Bituminous	94,600	1	1.5									IPCC GLs (2006)
Sub-bituminous coal	96,100	1	1.5									IPCC GLs (2006)
Lignite												IPCC GLs (2006)
Natural gas	56,100	1	0.1									IPCC GLs (2006)
Biomass (other primary solid biomass)	100,000	30	4									IPCC GLs (2006)
Biogas (other biogas)	54,600	1	0.1									IPCC GLs (2006)
1.A.1.b. Petroleum refining												
Crude oil	73,300	3	0.6									IPCC GLs (2006)
1.A.1.c. Manufacture of solid fuels and other energy industries												
Natural gas	56,100	1	0.1									IPCC GLs (2006)

3.4.3 Manufacturing Industries and Construction (CRT Category 1.A.2.)

This section shows the Manufacturing Industries and Construction under CRT category 1.A.2.

3.4.3.1 Category Description

Combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Emissions from own on-site fuel use should be included. Also includes combustion for the generation of electricity and heat for own use in these industries.

The GHG emissions for the manufacturing industries and construction sub-sector were estimated using national statistics. The NEB 2016 provides a detailed breakdown by sub-category for manufacturing industries. This information is based on a survey conducted by the Energy Commission, which involved 520 major manufacturing companies in Peninsular Malaysia. The survey collected monthly energy consumption data for the years 2010 to 2016, covering eight types of energy: electricity, natural gas, petrol, diesel, fuel oil, LPG, kerosene, and coal. Since no survey has been conducted after 2016, the sub-category proportions from the 2016 survey are used as a proxy for each source sub-category to represent the Manufacturing Industries and Construction sector in subsequent years. Table SIC3.10 provides the emissions covered under 1.A.2. Manufacturing Industries and Construction.

Table SIC3.10 **Emissions Covered Under 1.A.2. Manufacturing Industries and Construction**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.2.: Fuel consumption by sub-sectors	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No major improvements to the data and methods.		

3.4.3.2 Methodological Issues Under 1.A.2. Manufacturing Industries and Construction

The methodological issues of 1.A.2. Manufacturing Industries and Construction consisting of its activity data and the overview of emission factor are shown in Table SIC3.11 and Table SIC3.12.

Table SIC3.11 **Overview of Methodological Issues Under 1.A.2. Manufacturing Industries and Construction**

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.2. Manufacturing Industries and Construction			
	1.A.2.a. Iron and steel	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Amount of fuel used by iron and steel.	Energy Balance Table (EBT), NEB (2016)
	1.A.2.b. Non-ferrous metals	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specifically to non-ferrous metals.	Final energy consumption by sub-sectors in Manufacturing Sector of NEB (2016)
	1.A.2.c. Chemicals	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specifically to chemicals.	
	1.A.2.d. Pulp, paper and print	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specific to pulp, paper and print.	
	1.A.2.e. Food processing, beverages and tobacco	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specific to food processing, beverages and tobacco.	
	1.A.2.f. Non-metallic minerals	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specific to non-metallic minerals.	

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
	1.A.2. Manufacturing Industries and Construction			
	1.A.2.g.i. Manufacturing of machinery	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specific to manufacturing of machinery.	
	1.A.2.g.ii. Manufacturing of transport equipment	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specific to manufacturing of transport equipment.	
	1.A.2.g.iii. Mining (excluding fuels) and quarrying	No activity data Accounted as Non-specified Industry includes 1.A.2.g.iii. Mining (excluding fuels) and quarrying and 1.A.2.g.v. Construction	No activity data. Accounted as Non-specified Industry includes 1.A.2.g.iii. Mining (excluding fuels) and quarrying and 1.A.2.g.v. Construction.	
	1.A.2.g.iv. Wood and wood products	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Combustion of fuels by sub-sectors in manufacturing specific to wood and wood products.	
	1.A.2.g.v. Construction	No activity data Accounted as Non-specified Industry includes 1.A.2.g.iii. Mining (excluding fuels) and quarrying and 1.A.2.g.v. Construction	No activity data Accounted as Non-specified Industry includes 1.A.2.g.iii.	
	1.A.2.g.vi. Textile and leather	The percentage of fuel consumption by sub-categories of ISIC industry were based on survey data produced by NEB in 2016.	Mining (excluding fuels) and quarrying and 1.A.2.g.v. Construction.	
	1.A.2.g.viii. Other (Non-specified industry)	Combustion of fuels at not elsewhere specified	Combustion of fuels by sub-sectors in manufacturing specific to textile and leather Combustion of fuels at not elsewhere specified.	

Table SIC3.12 Overview of Emission Factor Under 1.A.2. Manufacturing Industries and Construction

	Emission Factor											Data Source
Sub-Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Unit	(tC/TJ)	(kg/TJ)	(kg/TJ)									
1.A. Fuel combustion activities												
1.A.2. Manufacturing industries and construction												
Natural gas	56,100	1	0.1									IPCC GLs (2006)
Motor gasoline	69,300	3	0.6									IPCC GLs (2006)
Gas/diesel oil	74,100	3	0.6									IPCC GLs (2006)
Residual fuel oil	77,400	3	0.6									IPCC GLs (2006)
Liquified petroleum gasses	63,100	1	0.1									IPCC GLs (2006)
Kerosene	71,900	3	0.6									IPCC GLs (2006)
Sub bituminous	96,100	10	1.5									IPCC GLs (2006)

3.4.4 Transport (CRT Category 1.A.3.)

This section highlights the Transport under CRT category 1.A.3.

3.4.4.1 Category Description

The direct GHG emissions from mobile sources/transport originate from the combustion and evaporation of fuel for all transport activity such as:

- Domestic aviation (1.A.3.a.)
- Road transportation (1.A.3.b.)
- Railways (1.A.3.c.)
- Domestic navigation (1.A.3.d.)
- Other transportation (1.A.3.e.)

The fuel consumption data for the transport category is derived from national statistics. Since these statistics do not offer segregated data by transportation mode, estimates for fuel consumption by domestic aviation, road, railways, and domestic navigation were made using assumptions based on data and information from transport stakeholders. The emissions covered under 1.A.3. are shown in Table SIC3.13, Table SIC3.14, Table SIC3.15, Table SIC3.16 and Table SIC3.17.

Table SIC3.13 **Emissions Covered Under 1.A.3.a. Domestic Aviation**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.3.a.: Fuel consumption for domestic aviation sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Improvements to the data assumption. The fuel consumption data for the aviation sector is reported in national statistics. However, the data are inclusive of fuel for commercial international and domestic aviation and non-specified mobile. Assumption between international and domestic aviation has been established based on communication and data provided by the aviation stakeholders (some of data are confidential).		

Table SIC3.14 Emissions Covered Under 1.A.3.b. Road Transportation

Emission Sources	Sources Included	Method	Emission Factors
	1.A.3.b.: Fuel consumption for road transportation sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	Yes at 95% significant level		
Coverage	National		
Major Improvements since last submission	Improvements to data assumptions. The fuel consumption data for the transport sector is reported in national statistics but includes all transportation modes. Various discussions with stakeholders from the road, railways, maritime, and aviation sectors have led to refined assumptions. Through stakeholder engagement, it was determined that motor gasoline is primarily consumed by road transportation, with a portion allocated for off-road and military use. Conversely, diesel fuel is predominantly used in road transport, with portions allocated for railways, waterborne transport, and military operations.		

Table SIC3.15 Emissions Covered Under 1.A.3.c. Railways

Emission Sources	Sources Included	Method	Emission Factors
	1.A.3.c.: Fuel consumption for railways sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Improvements to data assumptions.		

Table SIC3.16 **Emissions Covered Under 1.A.3.d. Domestic Navigation**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.3.d.: Fuel Consumption for domestic navigation sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Improvements to data assumptions.		

Table SIC3.17 **Emissions Covered Under 1.A.3.e. Other Transportation**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.3.e.: Fuel consumption for other transportation sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Improvements to data assumptions.		

3.4.4.2 Methodological Issues Under 1.A.3. Transport

The methodological issues of 1.A.3. Transport consisting of its activity data and the overview of emission factor are shown in Table SIC3.18 and Table SIC3.19.

Table SIC3.18 **Overview of Methodological Issues Under 1.A.2. Manufacturing Industries and Construction**

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.3. Transport			
	1.A.3.a. Domestic aviation	Fuel consumption ratio of Aviation Turbine Fuel (ATF)	The total amount of fuel consumption for international services fuel consumption and domestic aviation is in the range of 80% to 20%. The total amount of fuel consumption for domestic civil aviation is based on survey collected from the civil domestic operators and data obtained from Civil Aviation Authority Malaysia (CAAM). Not including the military. The percentage for fuel consumption is in the range of 10% to 20% of total aviation consumption.	Energy Balance Table (EBT), NEB (2020-2021) Data from CAAM which includes Air Asia, Air Asia X Berhad, Malaysia Airlines, Malindo Air, Raya Airways, Batik Air, Firefly and M Jets. Only the international services fuel consumptions were considered.
	1.A.3.b. Road transportation	Fuel type used in road transport	The percentage for fuel consumption specific to motor gasoline/ petrol disaggregated from the total EBT for transport sector and other non-specified (Mobile). For road transport, data from KPDN is used. The percentage for petrol from road transport is in the range of 90% – 95%. The remaining diesel is assumed for Other (off-road) (1.A.3.e).	EBT, NEB 2020- 2021. Motor gasoline and Diesel activity data from KPDN. Data from Malaysian Armed Forces (Angkatan Tentera Malaysia -TUDM/TDM/ TLM) (2019 - 2021), and Railway (KTMB Berhad and Jabatan Keretapi Sabah).

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
	1.A.2. Manufacturing Industries and Construction			
			The percentage for fuel consumption for diesel in the road transport is in the range of 72% to 85% of total diesel. The assumption derived from KPDN data. The remaining diesel is assumed for railways, water-navigation transportation and non-specified. The natural gas consumption by road transportation is 100%.	
	1.A.3.c. Railways	Diesel used in transport	The percentage of total diesel consumption based on survey data collected.	Data from KTMB Berhad and Jabatan Keretapi Negeri Sabah. Energy Balance Table (EBT), NEB (2020-2021).
	1.A.3.d. Domestic Navigation	Diesel and fuel oil in transport	The GHG inventory computation for the domestic navigation subsector was completed with new derivation specifically for diesel fuel (verified by the Malaysia Marine Department – JLM). The percentage of diesel fuel consumption is in the range of 10% to 27%.	EBT, NEB (2020 – 2021).
	1.A.3.e. Other transportation	Motor gasoline	The percentage of fuel consumption for diesel in road transport is about 6% to 7% of total petrol.	KPDN

Table SIC3.19 Overview of Emission Factor Under 1.A.3. Transport

	Emission Factor											
Sub-Sector	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**NF_3**	**NO_x**	**CO**	**NMVOCs**	**SO_2**	**Data Source**
Unit	(tC/TJ)	(kg/TJ)	(kg/TJ)									
1.A. Fuel combustion activities												
1.A.3. Transport												
1.A.3.a. Domestic aviation												
Jet kerosene	71,500	0.5	2					7.19	13.03	0.75	0.79	IPCC GLs (2006)
1.A.3.b. Road Transportation												
Motor gasoline (uncontrolled)	69,300	33	3.2									IPCC GLs (2006)
Gas/diesel oil	74,100	3.9	3.9									IPCC GLs (2006)
Liquified petroleum gasses												IPCC GLs (2006)
Kerosene												IPCC GLs (2006)
Lubricants												IPCC GLs (2006)
Compressed natural gas	56100	92	3									IPCC GLs (2006)
Liquified natural gas												IPCC GLs (2006)
Biodiesel	70,800	3	0.6									IPCC GLs (2006)
1.A.3.c. Railways												
Diesel oil	74,100	4.15	28.6									IPCC GLs (2006)
1.A.3.d. Domestic navigation												
Gas/diesel oil	74,100	7	2									IPCC GLs (2006)
Residual fuel oil	77,400	7	2									IPCC GLs (2006)
1.A.3.e. Other transportation												
Motor gasoline	69,300	33	3.2									IPCC GLs (2006)

3.4.5 Other Sectors (CRT Category 1.A.4.)

This section shows Other Sectors under CRT category 1.A.4.

3.4.5.1 Category Description

The emissions in this category are shown in Table SIC3.20, Table SIC3.21 and Table SIC3.22 from combustion activities for other sector including combustion for the generation of electricity and heat for own use in the following sectors:

- Commercial/institutional (1.A.4.a.)
- Residential (1.A.4.b.)
- Agricultural/forestry/fishing (1.A.4.c.)

Table SIC3.20 **Emissions Covered Under 1.A.4.a. Commercial/Institutional**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.4.a.: Fuel consumption for commercial/institutional sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Not applicable		

Table SIC3.21 **Emissions Covered Under 1.A.4.b. Residential**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.4.b.: Fuel consumption for residential sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Not applicable		

Table SIC3.22 **Emissions Covered Under 1.A.4.c. Agriculture/Forestry/Fishing**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.4.c.: Fuel consumption for agricultural/forestry/fishing sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	Yes at 95% significant level		
Coverage	No		
Major Improvements since last submission	The activity data for agricultural/forestry/fishing are assumed to have the percentage such that the ratio of fuel consumption between mobile and stationary sources is 95:5. The assumptions for the ratio between mobile and stationary is set as 95:5 based on the consultation with the Department of Statistics, Malaysia and Energy Commission, Malaysia. Thus, the data was segregated into mobile and stationary sources according to the 95:5 ratios for the years 2017 to 2021. It should be noted also that the amount reported in NEB under Fishery was counted in this inventory under Fishing (mobile combustion) and Stationary and with the same ratio of 95:5.		

3.4.5.2 Methodological Issues Under 1.A.4. Other Sectors

The methodological issues of 1.A.4. Other Sectors consisting of its activity data and the overview of emission factor are shown in Table SIC3.23 and Table SIC3.24.

Table SIC3.23 Overview of Methodological Issues Under 1.A.4. Other Sectors

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.4. Other Sectors			
	1.A.4.a. Commercial/ institutional	Fuel types in the commercial sector.	Percentage of fuel consumption is based on Energy Balance Table (EBT) of reporting year.	EBT, NEB (2020- 2021)
	1.A.4.b. Residential	Fuel types in the residential sector.	Percentage of fuel consumption is based on EBT of reporting year.	EBT, NEB (2020- 2021)
	1.A.4.c. Agriculture/ forestry/ fishing	Ratio of fuel consumption (i.e. Gasoline, diesel, fuel oil) between mobile and stationary.	The ratio of fuel consumption of mobile and stationary is 95:5. 5% of the fuel consumption is for stationary and 95% of the consumption is for mobile.	EBT, NEB
	1.A.4.c.i. Stationary	Ratio of fuel consumption (i.e. Gasoline, diesel, fuel oil) between mobile and stationary	5% of the fuel consumption is for stationary.	EBT, NEB
	1.A.4.c.ii. Off-road vehicles and other machinery	Ratio of fuel consumption (i.e. Gasoline, diesel, fuel oil) between mobile and stationary.	5% of the fuel consumption is for stationary.	EBT, NEB
	1.A.4.c.iii. Fishing	Ratio of fuel consumption (i.e. Gasoline, diesel, fuel oil) between mobile and stationary.	95% of the fuel consumption is for mobile.	EBT, NEB

Table SIC3.24 Overview of Emission Factor Under 1.A.4. Other Sectors

	Emission Factor											Data Source
Sub-Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Unit	(tC/TJ)	(kg/TJ)	(kg/TJ)									
1.A. Fuel combustion activities												
1.A.4. Other sectors												
1.A.4.a. Commercial/institutional												
Diesel oil	74,100	10	0.6									IPCC GLs (2006)
Residual fuel oil	77,400	10	0.6									IPCC GLs (2006)
LPG	63,100	5	0.1									IPCC GLs (2006)
Natural gas	56,100	5	0.1									IPCC GLs (2006)
1.A.4.b. Residential												
Kerosene	71,900	10	0.6									IPCC GLs (2006)
Liquified natural gas	63,100	5	0.1									IPCC GLs (2006)
Natural gas	56,100	5	0.1									IPCC GLs (2006)
1.A.4.c. Agriculture/forestry/fishing												
1.A.4.c.i. Stationary												
Motor gasoline	69,300	10	0.6									IPCC GLs (2006)
Diesel oil	74,100	10	0.6									IPCC GLs (2006)
Residual fuel oil	77,400	10	0.6									IPCC GLs (2006)
1.A.4.c.ii. Off-road vehicles and other machinery												
Residual fuel oil	77,400	10	0.6									IPCC GLs (2006)
1.A.4.c.iii. Fishing												
Motor gasoline	69,300	10	0.6									IPCC GLs (2006)
Diesel oil	74,100	10	0.6									IPCC GLs (2006)

3.4.6 Other (CRT Category 1.A.5.)

This section covers the other sectors under CRT Category 1.A.5.

3.4.6.1 Category Description

This category refers to all remaining emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations. They are three components in other category (mobile), i.e., aviation, water-borne navigation, and other.

Table SIC3.25 **Emissions Covered Under 1.A.5. Other**

Emission Sources	Sources Included	Method	Emission Factors
	1.A.5. a-b.: Fuel consumption for other sector	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	The survey data was distributed to the military department and data were available from 2019 until 2021.		

3.4.6.2 Methodological Issues Under 1.A.5. Other

The methodological issues of 1.A.5. Other consisting of its activity data and the overview of emission factor are shown in Table SIC3.26 and Table SIC3.27.

Table SIC3.26 Overview of Methodological Issues Under 1.A.5. Other

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.5. Other			
	1.A.5.a. Stationary			
	1.A.5.b. Mobile			
	1.A.5.b.i. Mobile (aviation component)	Data of fuel consumption from survey data for ATF and AV gas.	Total fuel consumption for ATF and AV gas	Survey data from Military (TUDM/TDM/ TLM) (2019-2021).
	1.A.5.b.ii. Mobile (water-borne component)	Data of fuel consumption from survey data of diesel.	Total fuel consumption for diesel	Survey data from Military (TUDM/TDM/ TLM) (2019-2021).
	1.A.5.b.iii. Mobile (other)	Data of fuel consumption from survey data for diesel and petrol.	Total fuel consumption for diesel and petrol	Survey data from Military (TUDM/TDM/ TLM) (2019-2021).

Table SIC3.27 Overview of Emission Factor Under 1.A.5. Other

	Emission Factor											
Sub-Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	Data Source
Unit	(tC/TJ)	(kg/TJ)	(kg/TJ)									
1.A. Fuel combustion activities												
1.A.5.b. Mobile												
1.A.5.b.i. Mobile (aviation component)												
Jet kerosene	71,500	0.5	2									IPCC GLs (2006)
1.A.5.b.ii. Mobile (water-borne component)												
Diesel oil	74,100	7	2									IPCC GLs (2006)
1.A.5.b.iii. Mobile (other)												
Diesel oil	74,100	3.9	3.9									IPCC GLs (2006)
Motor gasoline	69,300	33	3.2									IPCC GLs (2006)

3.4.6.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in sub-chapter 1.9 of the NID.

3.4.6.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

3.4.6.5 Category-specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in Sub-Chapter 1.5 of the NID.

3.4.6.6 Category-Specific Recalculations

No recalculations have been made to emissions from this category.

3.4.6.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC3.33 (in the last sub-chapter of Energy Chapter).

3.5 Fugitive Emissions from Solid Fuels and Oil and Natural Gas and Other Emissions from Energy Production (CRT Category 1.B.)

This section indicates the Fugitives Emissions from solid fuels and oil and natural gas and other emissions from energy production under the CRT category 1.B.

3.5.1 Coal Mining and Handling (CRT Category 1.B.1.a.)

Three types of coal mining-related activities release methane into the atmosphere: underground mining, surface mining, and post-mining i.e. coal-handling activities. Underground coal mines contribute the largest share of methane emissions.

In Malaysia, the large coal resources are in Sarawak and Sabah. According to the Department of Mineral and Geosciences, at present, only coal mining in Sarawak should be considered while the mining activity from Sabah is negligible. The mines are located in Abok, Silantek, Kapit and Mukah. For the underground mines (Abok & Silantek) and surface mines (Kapit & Mukah), the type of coal is sub-bituminous coal. There is also one closed or abandoned underground coal mine located in Selangor, Peninsular Malaysia. The coal mining had been operating for almost 47 years since 1910 and ceased operations in 1960 after reserves were depleted and became uneconomical to produce. Additionally, the Silantek underground coal mine was closed in 2017 following an explosion.

The raw coal production quantities shall be provided by the Department of Mineral and Geosciences of Sarawak (JMG). The required data are as follows:

i. Quantity of raw coal mined by type of mine (underground or surface).
ii. Quantity of raw coal from post-mining activities such as coal processing, transportation and utilization.

Table SIC3.28 **Emissions Covered Under 1.B.1.a. Coal Mining and Handling**

Emission Sources	Sources Included	Method	Emission Factors
	1.B.1.a. Quantity of raw coal production from underground or surface mining	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Not applicable.		

3.5.2 Oil and Natural Gas and Other Emissions from Energy Production (CRT Category 1.B.2.)

Oil and natural gas and other emissions from energy production comprise all infrastructure required to produce, collect, process or refine and deliver natural gas and petroleum products to market. The system begins at the well head, or oil and gas source, and ends at the final sales point to the consumer. The fugitive emissions are treated as a direct source of GHG due to the release of CH_4 and formation of CO_2 (i.e., CO_2 present in the produced oil and gas when it leaves the reservoir), plus some CO_2 and nitrous oxide (N_2O) from non-productive combustion activities (primarily waste gas flaring). As per the methodology for fuel combustion, CO_2 emissions are calculated in Tier 1 assuming that all hydrocarbons are fully oxidized. The actual value for vent and flare of oil and gas production in million standard cubic feet (mmscf) was obtained from Petroliam Nasional Berhad (PETRONAS). While the quantity of oil and natural gas produced, refined and consumed from NEB report in kilotonnes of equivalent (ktoe).

Table SIC3.29 **Emissions Covered Under 1.B.2.a. Oil**

Emission Sources	Sources Included	Method	Emission Factors
	1.B.2.a. Quantity of crude oil production and refining from oil system	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	Yes at 95% significant level		
Coverage	National		
Major Improvements since last submission	According to the 2006 IPCC, when known, actual flare and vent volumes should be used rather than production rates. Obtained actual data for venting and flaring from oil and gas systems for 2020-2021.		

Table SIC3.30 **Emissions Covered Under 1.B.2.b. Natural Gas**

Emission Sources	Sources Included	Method	Emission Factors
	1.B.2.b. Quantity of gas production and refining from gas associated system	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories	Yes at 95% significant level		
Coverage	National		
Major Improvements since last submission	According to the 2006 IPCC, when known, actual flare and vent volumes should be used rather than production rates. Obtained actual data for venting and flaring from oil and gas systems for 2020-2021.		

3.5.3 Methodological Issues Under 1.B. Fugitive Emissions

The methodological issues of 1.B. Fugitive Emissions consisting of its activity data and the overview of emission factor are shown in Table SIC3.31 and Table SIC3.32.

Table SIC3.31 **Overview of Methodological Issues Under 1.B. Fugitive Emissions**

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.5. Other			
	1.B.1. Solid fuels			
	1.B.1.a. Coal mining and handling			
	1.B.1.a.i. Underground mines			
	1.B.1.a.i.1. Mining activities	Coal production quantities	Total amount of coal production from underground mines	Department of Mineral and Geoscience
	1.B.1.a.i.2. Post-mining activities	Not accounted	Emission factor not applicable	
	1.B.1.a.i.3. Abandoned underground mines	Coal mine	Closed or abandoned underground coal mine	Department of Mineral and Geoscience
	1.B.1.a.i.4. Flaring of drained methane or conversion of methane to CO_2	No activity data		
	1.B.1.a.ii. Surface mines			
	1.B.1.a.ii.1. Mining activities	Coal production quantities	Total amount of coal production from surface mines	Department of Mineral and Geoscience
	1.B.1.a.ii.2. Post-mining activities	Not accounted	Emission factor not applicable	
	1.B.1.a.ii.3. Other (Abandoned underground mines)	No activity data		

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.5. Other			
	1.B.1.b. Fuel transformation			
	1.B.1.b.i. Charcoal and Biochar production	No activity data		
	1.B.1.b.ii. Coke production	No activity data		
	1.B.1.b.iii. Coal to liquids	No activity data		
	1.B.1.b.iv. Gas to liquids	No activity data		
	1.B.1.b.v. Other	No activity data		
	1.B.2. Oil and natural gas and other emissions from energy production			
	1.B.2.a. Oil			
	1.B.2.a.i. Exploration	Not accounted	Emission factor not applicable.	
	1.B.2.a.ii. Production and upgrading	Crude oil production	Assume total amount of oil from oil production occurs at the oil wellhead.	EBT, NEB
	1.B.2.a.iii. Transport	Not accounted	Emission factor not applicable.	
	1.B.2.a.iv. Refining/storage	Crude oil refineries	Assume the total amount of produces final refined products.	EBT, NEB
	1.B.2.a.v. Distribution of oil products	Not accounted	Emission factor not applicable.	
	1.B.2.a.vi. Other	Not accounted	Emission factor not applicable.	

Choice of Method	Tier 1: Fuel combustion from national energy statistics and default emission factors			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	1.A.5. Other			
	1.B.2.b. Natural Gas			
	1.B.2.b.i. Exploration	Not accounted	Emission factor not applicable.	
	1.B.2.b.ii. Production and gathering	Natural gas production	Assume the total amount of gas production from gas fields.	EBT, NEB
	1.B.2.b.iii. Processing	Natural gas production	Estimated from natural gas processing facilities.	EBT, NEB
	1.B.2.b.iv. Transmission and storage	Natural gas production	Estimated from natural gas processing including import of LNG.	EBT, NEB
	1.B.2.b.v. Distribution	Natural gas production	Estimated from natural gas transmission and storage including export of LNG.	EBT, NEB
	1.B.2.b.vi. Other	Not accounted	Emission factor not applicable.	
	1.B.2.b.vi.3. Other	No activity data		
	1.B.2.c. Venting and flaring			
	1.B.2.c.i. Venting	Venting relating to oil and gas development.	Amount of actual venting production	PETRONAS EBT, NEB
	1.B.2.c.ii. Flaring	Flaring relating to oil and gas development.	Amount of actual flaring production	PETRONAS EBT, NEB

Table SIC3.32 Overview of Emission Factors Under 1.B.2. Oil and Natural Gas and Other Emissions from Energy Production

	Emission Factor											Data Source
Sub-Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Unit	(tC/TJ)	(kg/TJ)	(kg/TJ)									
1.B. Fugitive emissions from fuels												
1.B.1.a. Coal mining and handling												
1.B.1.a.i. Underground mines												
1.B.1.a.i.1. Mining activities		10										IPCC GLs (2006)
1.B.1.a.i.2. Post-mining activities		2.45										IPCC GLs (2006)
1.B.1.a.i.3. Abandoned underground mines		0.343										IPCC GLs (2006)
1.B.1.a.ii. Surface mines												
1.B.1.a.ii.1. Mining activities		0.3										IPCC GLs (2006)
1.B.1.a.ii.2. Post-mining activities		0.1										IPCC GLs (2006)
1.B.2. Oil and natural gas and other emissions from energy production												
1.B.2.a. Oil												
1.B.2.a.i. Exploration												IPCC GLs (2006)
1.B.2.a.ii. Production and upgrading	4.3×10^{-8}	5.9×10^{-7}						NA	NA	7.4×10^{-7}	NA	IPCC GLs (2006)
1.B.2.a.iii. Transport												IPCC GLs (2006)
1.B.2.a.iv. Refining/storage		6.44×10^{-6}						NA	NA	1.3×10^{-3}	NA	IPCC GLs (2006)
1.B.2.a.v. Distribution of oil products												IPCC GLs (2006)
1.B.2.a.vi. Other												IPCC GLs (2006)

	Emission Factor											Data Source
Sub-Sector	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**NF_3**	**NO_x**	**CO**	**NMVOCs**	**SO_2**	
Unit	**(tC/TJ)**	**(kg/TJ)**	**(kg/TJ)**									
1.B.2.b. Natural gas												
1.B.2.b.i. Exploration												IPCC GLs (2006)
1.B.2.b.ii. Production and gathering	3.06×10^{-5}	2.74×10^{-3}						NA	NA	2.02×10^{-4}	NA	IPCC GLs (2006)
1.B.2.b.iii. Processing	1.7×10^{-4}	5.42×10^{-4}						NA	NA	2.49×10^{-4}	NA	IPCC GLs (2006)
1.B.2.b.iv. Transmission and storage	9.92×10^{-7}	2.59×10^{-4}						NA	NA	7.9×10^{-6}	NA	IPCC GLs (2006)
1.B.2.b.v. Distribution	5.99×10^{-5}	1.24×10^{-3}						NA	NA	1.8×10^{-5}	NA	IPCC GLs (2006)
1.B.2.b.vi. Other												IPCC GLs (2006)
1.B.2.c. Venting and flaring												
1.B.2.c.i. Venting												
1.B.2.c.i.1. Oil	4.9×10^{-3}	0.66										IPCC GLs (2006)
1.B.2.c.i.2. Gas												IPCC GLs (2006)
1.B.2.c.ii. Flaring												
1.B.2.c.ii.1. Oil	2.0	1.2×10^{-2}	2.3×10^{-5}									IPCC GLs (2006)
1.B.2.c.ii.2. Gas	2.0	1.2×10^{-2}	2.3×10^{-5}					NA	NA	NA	NA	IPCC GLs (2006)

3.5.4 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document. The X-3 reporting framework is utilised for reporting GHG inventory data from three years prior to the current reporting year. This extended reporting period is necessary due to limitations in data availability and the additional time required to compile, verify, and finalise national statistics. Several factors contribute to the use of X-3 reporting, including:

i. **Data collection delays:**
National statistical agencies may experience delays in gathering comprehensive data at the national level.

ii. **Verification processes**:
The time needed to validate and verify sectoral data to ensure its accuracy and consistency can extend beyond typical reporting timelines.

3.5.5 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

3.5.6 Category-specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in Sub-Chapter 1.5 of the NID.

3.5.7 Category-Specific Recalculations

This section highlights the category-specific recalculations under energy sector.

a. **AR5 Recalculations**

The transition to the IPCC's Fifth Assessment Report (AR5) is critical for aligning with the latest international reporting standards under the UNFCCC and the Paris Agreement. One of the key changes in moving from AR4 to AR5 is the update to Global Warming Potential (GWP) values for major GHG, particularly methane (CH_4) and nitrous oxide (N_2O). These revised GWP values reflect improved scientific understanding of the radiative forcing of these gasses over a 100-year period:

- Methane (CH_4): The GWP has been revised from 25 (AR4) to 28 (AR5).
- Nitrous Oxide (N_2O): The GWP has been adjusted from 298 (AR4) to 265 (AR5).

The increase in GWP for methane under AR5 has generally led to higher emissions values across sectors when expressed in CO_2-equivalents (CO_2 eq). The GHG emissions for energy sector from 1990 to 2019 are increasing as compared to previous reporting. For instance, in 2019, recalculated GHG emissions for the energy sector rose from 263,309.54 CO_2 eq.(AR4) to 265,376.10 CO_2 eq.(AR5). This recalibration ensures that emissions reporting reflects the latest scientific data and meets international standards.

b. **Transport Sector Recalculations**

The transport sector has been subject to recalculations due to newly received data and updated assumptions, aimed at enhancing the accuracy and consistency of GHG inventory reporting. Key factors driving these recalculations include:

i. **Updated fuel consumption data for road transport:**
Revised data has led to adjustments in fuel consumption estimates for road transport.

ii. **Vehicle category fuel consumption:**
The latest IPCC software (version 2.92) now requires fuel consumption estimates categorized by vehicle type. Assumptions based on average vehicle population, mileage, and usage patterns have been incorporated, although this does not significantly affect overall emissions in road transport.

iii. **Updated aviation fuel consumption data:**
New data, along with expert judgment on the proportion of domestic versus international aviation, has prompted recalculations of aviation emissions from 1990 to 2021.

c. Electricity Generation Recalculations

The electricity generation sector has also been recalculated to reflect updated data and assumptions. The key revisions include:

- **Updated coal consumption data:**
  National energy consumption figures for coal have been revised, with coal consumption now categorized by type – sub-bituminous, bituminous, and lignite – to reflect actual usage. These updates, along with revised assumptions regarding coal type, have resulted in changes to emission estimates for the sector.

3.5.8 Category-Specific Planned Improvements

Table SIC3.33 Sectoral Planned Improvement

Category	Improvement	Description	Progress
Cross cutting	Transition from N-3 to N-2 reporting for the Energy Sector	Develop a comprehensive plan and timeline to shift from N-3 to N-2 reporting for all subsectors in energy.	MyEnergyStats initiative by Energy Commission aims to reduce reporting lag by improving publication timelines from N-3 to X-2.
Road Transport	Enhance consistency and completeness in road transport emissions reporting	Develop a robust methodological approach to estimate emissions based on different vehicle types and fuel usage.	
Electricity	Utilise Local Emission Factors (EF)	Explore and improve the use of local emission factors (EF) for electricity generation, moving toward Tier 2 standards.	
Manufacturing Industries	Improve fuel consumption data by sub-sector	Enhance the quality and detail of activity data on fuel consumption for each manufacturing sub-sector from 2020 onward. Additionally, collaborate with relevant stakeholders, including the Energy Commission and the Department of Statistics, to assess the inclusion of the construction category within the manufacturing sector.	
Fugitives	Develop country-specific emission factors for oil and gas	Establish specific emission factors (EF) for oil and gas processing activities to better reflect local conditions.	

3.6 Uncertainty Assessment for Energy Sector

The uncertainty in energy sector for 2005 stands at 26.19%. Table SIC3.34 shows the uncertainty analysis table.

Table SIC3.34 Uncertainty for Energy Sector for 2005

CRT category		Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
			(Gg CO_2 equivalent)	%	%	%	
1.A.	**Fuel combustion activities (sectoral approach)**						
1.A.1.	**Energy industries**						
1.A.1.a. Public electricity and heat production	Liquids	CO_2 CH_4 N_2O	1,820.67 2.02 3.83	0.97% 0.97% 0.97%	0.92% 226.15% 226.86%	1.33% 226.15% 226.86%	0.00 0.00 0.00
	Solids	CO_2 CH_4 N_2O	22,279.39 6.49 92.15	0.69% 0.69% 0.69%	13.86% 138.46% 161.79%	13.88% 138.47% 161.80%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	30,969.27 15.46 14.63	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
	Biomass & Biogas	CH_4 N_2O	19.52 24.64	1.00% 1.00%	200.00% 275.00%	200.00% 275.00%	0.00 0.00
1.A.1.b. Petroleum refining	Liquids	CO_2 CH_4 N_2O	9,936.67 11.39 21.55	1.00% 1.00% 1.00%	3.00% 233.33% 233.33%	3.16% 233.34% 233.34%	0.00 0.00 0.00
1.A.1.c. Manufacture of solid fuels and other energy industries	Gas	CO_2 CH_4 N_2O	26,744.27 13.35 12.63	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
1.A.2. Manufacturing industries and construction	Liquids	CO_2 CH4 N_2O	17,297.09 18.95 35.62	2.38% 3.00% 0.00%	0.82% 4.06% 0.00%	2.52% 5.05% 0.00%	0.00 0.00 –
	Solids	CO_2 CH_4 N_2O	5,420.07 15.79 22.42	2.45% 3.00% 0.00%	190.47% 200.00% 0.00%	190.48% 200.02% 0.00%	0.00 0.00 –
	Gas	CO_2 CH_4 N_2O	12,480.19 6.23 5.90	2.47% 3.00% 0.00%	192.01% 233.33% 0.00%	192.03% 233.35% 0.00%	0.01 0.00 –
1.A.3.a. Domestic Aviation	Liquids	CO_2 CH_4 N_2O	1,202.61 0.24 8.91	5.00% 5.00% 5.00%	4.06% 233.33% 233.33%	6.44% 233.38% 233.38%	0.00 0.00 0.00

CRT category		Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
			(Gg CO_2 equivalent)	%	%	%	
1.A.3.b. Road transportation	Liquids	CO_2 CH_4 N_2O	33,600.15 311.43 430.85	0.76% 0.95% 575.91%	3.69% 221.59% 172.54%	3.77% 221.59% 601.20%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	222.99 10.24 3.16	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
	Biomass (Biodiesel)	CH_4 N_2O	– –	0.95% 575.91%	221.59% 172.54%	221.59% 601.20%	
1.A.3.c. Railways	Liquids	CO_2 CH_4 N_2O	158.12 0.25 16.17	5.00% 5.00% 5.00%	0.94% 233.33% 233.33%	5.09% 233.39% 233.39%	0.00 0.00 0.00
1.A.3.d. Domestic navigation	Liquids	CO_2 CH_4 N_2O	3,947.29 10.44 28.23	5.00% 5.00% 5.00%	0.94% 233.33% 233.33%	5.09% 233.39% 233.39%	0.00 0.00 0.00
1.A.3.e. Other transportation	Liquids	CO_2 CH_4 N_2O	1,409.64 18.80 17.25	5.00% 5.00% 5.00%	5.34% 233.33% 233.33%	7.31% 233.39% 233.39%	0.00 0.00 0.00
1.A.4.a. Commercial/ Institutional	Liquids	CO_2 CH_4 N_2O	2,156.27 6.00 2.32	3.49% 3.75% 4.13%	1.21% 173.55% 13.05%	3.70% 173.59% 13.69%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	53.99 0.13 0.03	5.00% 5.00% 5.00%	3.92% 200.00% 3.92%	6.35% 200.06% 6.35%	0.00 0.00 0.00
1.A.4.b. Residential	Liquids	CO_2 CH_4 N_2O	2,085.98 4.89 1.15	4.93% 4.87% 4.65%	3.90% 195.02% 186.29%	6.29% 195.08% 186.35%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	11.74 0.03 0.01	5.00% 5.00% 5.00%	3.92% 200.00% 200.00%	6.35% 200.06% 200.06%	0.00 0.00 0.00
1.A.4.c. Agriculture/forestry/ fishing	Liquids	CO_2 CH_4 N_2O	313.42 1.19 0.67	4.07% 4.03% 4.03%	1.92% 161.16% 188.02%	4.50% 161.21% 188.06%	0.00 0.00 0.00
1.A.5. Other	Liquids	CO_2 CH_4 N_2O	240.69 0.31 2.08	3.64% 3.24% 3.45%	2.77% 129.47% 160.94%	4.58% 129.51% 160.98%	0.00 0.00 0.00
1.B. Fugitive emissions from fuels							
1.B.1. Solid fuels	Solids	CH_4	27.70	5.00%	200.00%	200.06%	0.00
1.B.2. Oil and natural gas and other emissions from energy production	Liquids	CO_2 CH_4 N_2O	5,387.14 19,053.67 16.40	5.00% 5.00% 5.00%	3.00% 233.33% 233.33%	5.83% 233.39% 233.39%	0.00 0.05 0.00
	Gas	CO_2 CH_4 N_2O	58.49 7,353.28 0.15	5.00% 5.00% 0.00%	3.92% 200.00% 200.00%	6.35% 200.06% 200.00%	0.00 0.01 0.00
	Total		**205,464.65**				**0.07**
		Percentage uncertainty in total inventory					**26.19%**

The uncertainty in energy sector for 2021 stands at 14.90%, while the trend uncertainty (based on 2005) is 26.98%. Table SIC3.35 shows the uncertainty analysis table.

Table SIC3.35 **Uncertainty for Energy Sector for 2021**

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.A. Fuel combustion activities (sectoral approach)													
1.A.1. Energy industries													
1.A.1.a. Public electricity and heat production	Liquids	CO_2	1,820.67	871.87	0.01	0.01	0.01	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	2.02	0.99	0.01	2.26	2.26	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	3.83	1.87	0.01	2.27	2.27	0.00	0.00	0.00	0.00	0.00	0.00
	Solids	CO_2	22,279.39	86,604.62	0.01	0.14	0.14	0.00	0.25	0.42	0.03	0.00	0.00
		CH_4	6.49	25.22	0.01	1.38	1.38	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	92.15	357.99	0.01	1.62	1.62	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	30,969.27	26,105.47	0.01	0.04	0.04	0.00	0.11	0.13	0.00	0.00	0.00
		CH_4	15.46	13.03	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	14.63	12.33	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	Biomass & Biogas	CH_4	19.52	5.38	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	24.64	6.75	0.01	2.75	2.75	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b. Petroleum refining	Liquids	CO_2	9,936.67	8,087.34	0.01	0.03	0.03	0.00	0.04	0.04	0.00	0.00	0.00
		CH_4	11.39	9.27	0.01	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	21.55	17.54	0.01	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c. Manufacture of solid fuels and other energy industries	Gas	CO_2	26,744.27	27,173.81	0.01	0.04	0.04	0.00	0.08	0.13	0.00	0.00	0.00
		CH_4	13.35	13.56	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	12.63	12.84	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2. Manufacturing industries and construction	Liquids	CO_2	17,297.09	7,688.59	0.02	0.01	0.03	0.00	0.10	0.04	0.00	0.00	0.00
		CH_4	18.95	8.41	0.03	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	35.62	15.75	–	–	–	–	0.00	0.00	–	–	–
	Solids	CO_2	5,420.07	5,596.99	0.02	1.90	1.90	0.00	0.01	0.03	0.03	0.00	0.00
		CH_4	15.79	16.31	0.03	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	22.42	23.15	–	–	–	–	0.00	0.00	–	–	–
	Gas	CO_2	12,480.19	20,334.00	0.02	1.92	1.92	0.01	0.00	0.10	0.00	0.00	0.00
		CH_4	6.23	10.15	0.03	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	5.90	9.61	–	–	–	–	0.00	0.00	–	–	–

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.A.3.a. Domestic Aviation	Liquids	CO_2	1,202.61	379.85	0.05	0.04	0.06	0.00	0.01	0.00	0.00	0.00	0.00
		CH_4	0.24	0.07	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	8.91	2.82	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b. Road transportation	Liquids	CO_2	33,600.15	43,091.87	0.01	0.04	0.04	0.00	0.05	0.21	0.00	0.00	0.00
		CH_4	311.43	394.66	0.01	2.22	2.22	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	430.85	553.25	5.76	1.73	6.01	0.00	0.00	0.00	0.00	0.02	0.00
	Gas	CO_2	222.99	82.15	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	10.24	3.77	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	3.16	1.16	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	Biomass (Biodiesel)	CH_4		2.91	0.01	2.22	2.22	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O		5.50	5.76	1.73	6.01	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.c. Railways	Liquids	CO_2	158.12	26.94	0.05	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.25	0.04	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	16.17	2.76	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d. Domestic navigation	Liquids	CO_2	3,947.29	2,793.50	0.05	0.01	0.05	0.00	0.02	0.01	0.00	0.00	0.00
		CH_4	10.44	7.39	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	28.23	19.98	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e. Other transportation	Liquids	CO_2	1,409.64	2,152.32	0.05	0.05	0.07	0.00	0.00	0.01	0.00	0.00	0.00
		CH_4	18.80	28.70	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	17.25	26.34	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.a. Commercial/ Institutional	Liquids	CO_2	2,156.27	1,305.41	0.03	0.01	0.04	0.00	0.01	0.01	0.00	0.00	0.00
		CH_4	6.00	3.77	0.04	1.74	1.74	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	2.32	1.52	0.04	0.13	0.14	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	53.99	25.82	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.13	0.06	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.03	0.01	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.b. Residential	Liquids	CO_2	2,085.98	2,622.73	0.05	0.04	0.06	0.00	0.00	0.01	0.00	0.00	0.00
		CH_4	4.89	5.83	0.05	1.95	1.95	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	1.15	1.12	0.05	1.86	1.86	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	11.74	2.35	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.03	0.01	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.01	0.00	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.A.4.c. Agriculture/ forestry/fishing	Liquids	CO_2	313.42	3,045.49	0.04	0.02	0.04	0.00	0.01	0.01	0.00	0.00	0.00
		CH_4	1.19	11.55	0.04	1.61	1.61	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.67	6.56	0.04	1.88	1.88	0.00	0.00	0.00	0.00	0.00	0.00
1.A.5. Other	Liquids	CO_2	240.69	285.98	0.04	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.31	0.55	0.03	1.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	2.08	2.35	0.03	1.61	1.61	0.00	0.00	0.00	0.00	0.00	0.00
1.B. Fugitive emissions from fuels													
1.B.1. Solid fuels	Solids	CH_4	27.70	32.21	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2. Oil and natural gas and other emissions from energy production	Liquids	CO_2	5,387.14	3,503.46	0.05	0.03	0.06	0.00	0.02	0.02	0.00	0.00	0.00
		CH_4	19,053.67	7,177.56	0.05	2.33	2.33	0.00	0.11	0.03	0.26	0.00	0.07
		N_2O	16.40	10.67	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	58.49	343.36	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	7,353.28	8,678.63	0.05	2.00	2.00	0.00	0.01	0.04	0.03	0.00	0.00
		N_2O	0.15	1.01		2.00	2.00	0.00	0.00	0.00	0.00	–	0.00
Total			**205,464.65**	**327,672.37**				**0.02**					**0.07**
							Percentage uncertainty in total inventory	**14.90%**				**Trend Uncertainty**	**26.98%**

4
CHAPTER

INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU) (CRT SECTOR 2)

4.1 Overview of the Sector

The overview of the IPPU sector is shown in Table SIC4.1

Table SIC4.1 **Overview of the IPPU Sector**

Emission Sources	**2.A.**	Mineral industry
	2.A.1.	Cement production
	2.A.2.	Lime production
	2.A.3.	Glass production
	2.A.4.d.	Other process uses of carbonates
	2.B.	Chemical industry
	2.B.1.	Ammonia production
	2.B.2.	Nitric acid production
	2.B.5.	Carbide production
	2.B.8.	Petrochemicals and carbon black production
	2.C.	Metal industry
	2.C.1.	Iron and steel production
	2.C.2.	Ferroalloys production
	2.C.3.	Aluminium production
	2.D.	Non-energy products from fuels and solvent use
	2.D.1.	Lubricant use
	2.E.	Electronics industry
	2.E.1.	Integrated circuit or semiconductor
	2.E.3.	Photovoltaics
	2.F.	Product uses as substitutes for ODS
	2.F.1.e.	Mobile air-conditioning
	2.G.	Other product manufacture and use
	2.G.1.	Electrical equipment
	2.G.3.a.	Medical applications
Gasses Reported	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	
Major improvements since last submission	**2.E.**	**Electronics Industry** Enhanced activity data values based on production capacity. Updated time series activity data from 2000 – 2011 for 2.E.1. Semiconductors and integrated circuits and 2.E.3. Photovoltaics.

	2.D.	**Non-Energy Products from Fuels and Solvent Use** Newly reported sector for BTR. New calculations for 2.D.1. Lubricant Use and calculated the emissions for the time series from 1990-2021.
	2.G.	**Other Product Manufacture and Use** Collected activity data of the missing gaps in the time series from stakeholders for completeness purposes. Updated activity data in the time series from 1990-2017 for 2.G.1. Electrical Equipment.

Sector	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
2. IPPU	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
2.A. Mineral industry														
2.A.1. Cement production	T2	CS												
2.A.2. Lime production	T1	D												
2.A.3. Glass production	T2	D												
2.A.4. Other process uses of carbonates	T2	D												
2.B. Chemical industry														
2.B.1. Ammonia production	T2	D												
2.B.5. Carbide production	T1	D												
2.B.8. Petrochemical and carbon black	T1	D	T1	D										
2.C. Metal industry														
2.C.1. Iron and steel production	T1	D	T1	D										
2.C.2. Ferroalloys production	T1	D	T1	D										
2.C.3. Aluminium production	T1	D							T1	D				

Sector	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
2. IPPU	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
2.D. Non-energy products from fuels and solvent use														
2.D.1. Lubricant use	T1	D												
2.E.1. Electronics industry														
2.E.1. Integrated Circuit or Semiconductor							T1	D	T1	D	T1	D	T1	D
2.E.3. Photovoltaics									T1	D				
2.F. Product uses as substitutes for ozone depleting substances (ODS)														
2.F.1.e. Mobile air conditioning							T2	D						
2.G. Other product manufacture and use														
2.G.1. Electrical equipment											T1	D		
2.G.3.a Medical applications					T1	D								

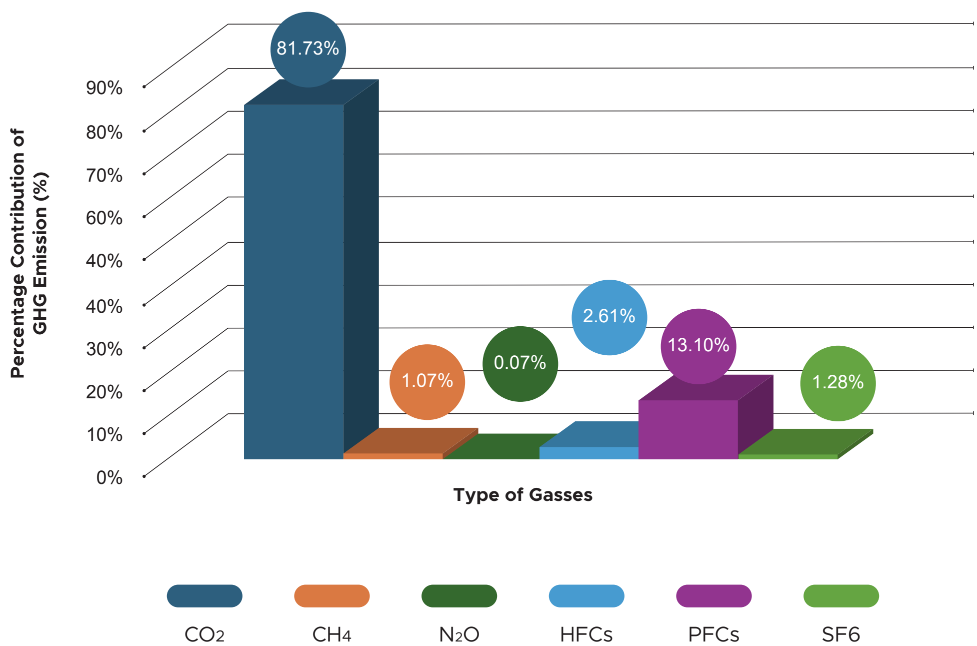
Introduction on the IPPU GHG Emissions

GHG emissions are produced from a variety of industrial activities, which are not related to energy. The main emission sources are industrial production processes that chemically or physically transform materials. During these processes, many different GHG including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and perfluorinated compound (PFCs) were released. Different halocarbons and sulphur hexafluoride (SF_6) are also consumed in industrial processes or used as alternatives to ozone depleting substances in various industrial applications.

IPPU Emission by Gasses

Emissions of GHG in the IPPU do occur for seven (7) types of GHG i.e. CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3. In descending order, the emissions from the IPPU sector according to the type of gasses in 2021 are from CO_2, PFCs, HFCs, SF_6, CH_4, NF_3 and N_2O. The percentage of GHG emissions for IPPU sector according to the type of gasses in 2021 is shown as the Figure SIC4.1 follows.

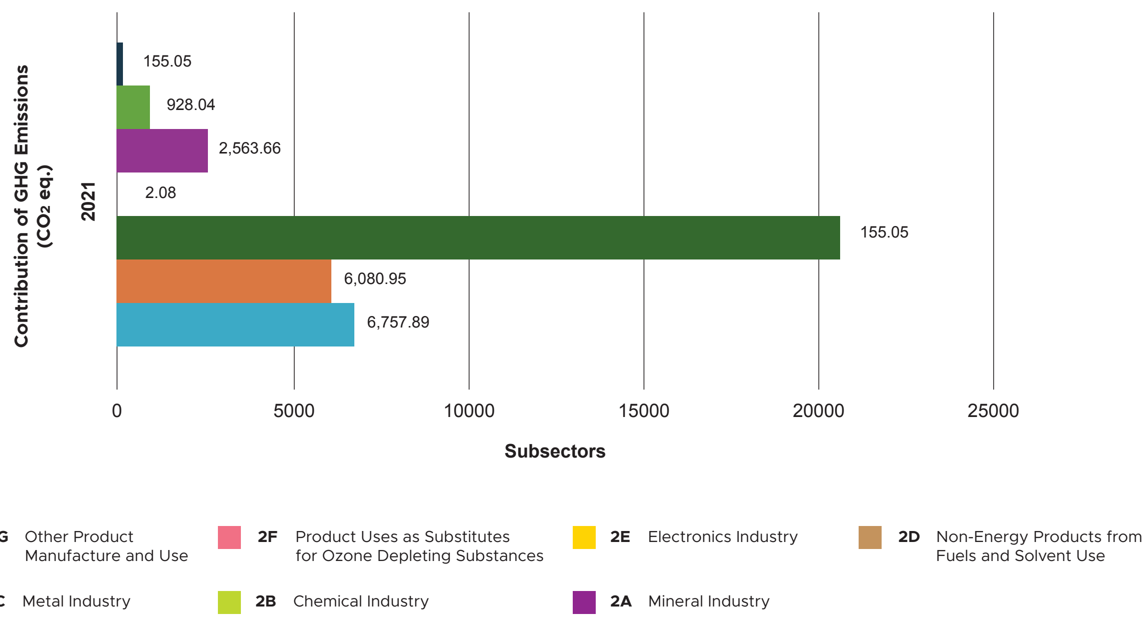
Figure SIC4.1 **IPPU Contribution by Gasses (%) in 2021 (in Gg CO_2 eq.)**



IPPU Emission by Categories

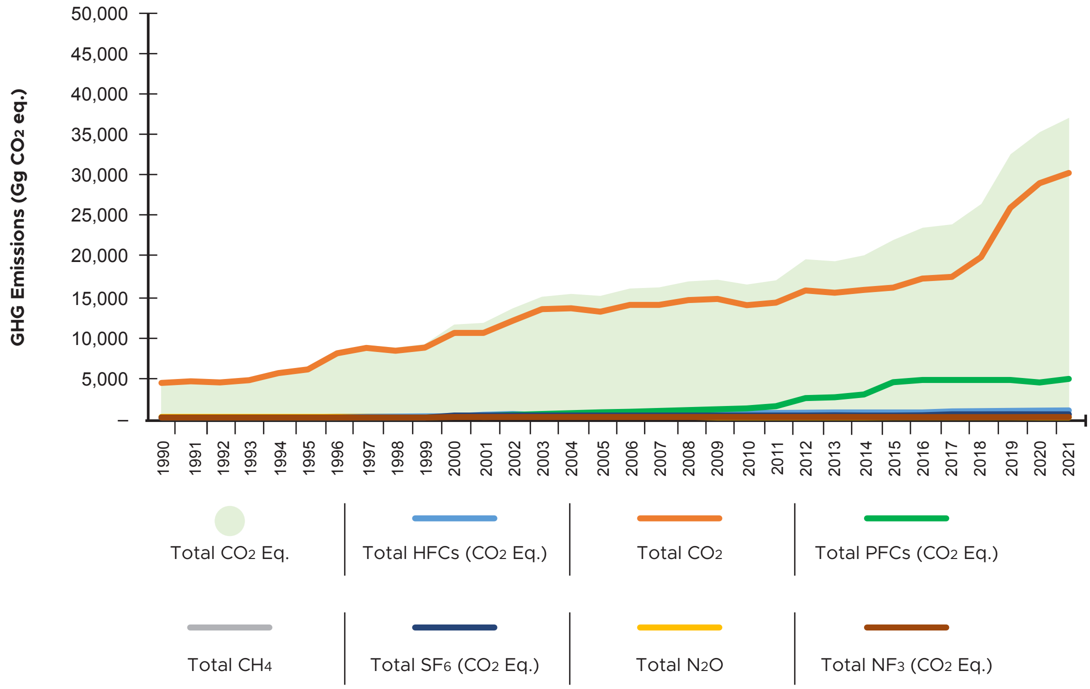
Figure SIC4.2 provides the GHG emissions for IPPU sector in 2021 according to the subsectors respectively. In descending order, the emissions from the IPPU sector are from the metal industry, mineral industry, chemical industry, electronics industry, product uses as substitutes for ozone depleting substances (ODS), other product manufacture and use, as well as non-energy products from fuels and solvent use.

Figure SIC4.2 **IPPU Contribution by Subsectors in 2021**



The IPPU GHG emission in time series 1990-2021 in Gg CO2 Eq. unit is shown as the Figure SIC4.3. The GHG emissions had increased since 2005, growing at a Compound Annual Growth Rate (CAGR) 5.7%, from 15,158.42 Gg CO_2 eq. to 37,028.35 Gg CO_2 eq. There had been a significant increase in total emissions from the IPPU sector starting from 2011, with a sharp surge in 2017 onwards, due to the increased expansion of industrial processes activities.

Figure SIC4.3 IPPU GHG Emission in Time Series 1990-2021



The emissions trends across various subsectors from 1990-2021 were affected by the following factors:

Economic Growth and Industrialization:

Rapid industrialization and economic growth at Gross Domestic Product (GDP) rate of 5% since 2005, leading to increased production in sectors like mineral and metal industries.

Demand for Building Materials:

Increased construction activities globally, leading to higher demand for materials produced by the mineral industry. Construction-related materials increased significantly due to strong demand for fabricated products, basic metals and non-metallic minerals mainly due to higher demand from infrastructure projects and maintenance of residential and non-residential projects.

Expansion of Production Capacity:

The expansion of plant production capacity from metal industry, chemical industry and electronics industry resulted in higher emissions in 2020-2021.

Regulatory Changes:

The production output of cement expanded due to abolishment of the administrative price control in 2008[12].

Market Dynamics:

Changes in global markets affecting demand and supply, particularly in sectors like electronics and chemicals. The demand for electronics was supported by continuous expansion in the electronics cycle (upcycle). This is because there was strong global demand for consumer electronics and semiconductors.

Global Events:

Events such as the global financial crisis around 2008-2009, and the COVID-19 pandemic around 2020, caused noticeable impacts on emissions trends due to reduced industrial activities.

[12] Ministry of Finance (2009)

4.1.1 Mineral Industry

Annual CO_2 emissions from cement production had declined at a Compound Annual Growth Rate (CAGR) of 2.04% compared to the 2005 baseline. This reduction is attributed to the consolidation of kilns and decreased clinker production. There was a significant drop in emissions in 2020 due to the COVID-19 pandemic and the subsequent Movement Control Order (MCO), which restricted cement production to the domestic market only.

Other mineral source categories had less impact on emission trends. Emissions from lime production increased at a CAGR of 1.61% since 2005, while emissions from glass production rose significantly, with a CAGR of 16.38%, due to the commissioning of new plants. Emissions from Other Processes Using Carbonates (e.g., limestone and dolomite) have shown a steady increase with a CAGR of 8.39%.

4.1.2 Chemical Industry

Emissions from the Chemical Industry in Malaysia have gradually increased since the baseline year of 2005. Notably, up to 70% of these emissions were attributed to the Petrochemicals subsector. Between 2020 and 2021, the chemical industry remained stable. Emissions from ammonia production grew at a CAGR of 2.64% compared to 2005, while carbide production increased at a CAGR of 8.66%. Despite challenges such as the pandemic and market volatility, the chemical industry in Malaysia demonstrated robust growth. This growth was driven by strategic investments, diversification, and technological advancements, and was supported by rising demand for chemical and pharmaceutical products.

4.1.3 Metal Industry

In Malaysia, emissions from the metal industry are primarily linked to the production of iron and steel, aluminium, and ferroalloys. The iron and steel sector had been a major industry in Malaysia since 2005 and has continued to grow rapidly. Aluminium production was added in 2011, and ferroalloys were included in 2017. Emissions from iron and steel production have increased at a compound annual growth rate (CAGR) of 16.12% since 2005, with notable growth between 2019 and 2020 due to the commissioning and full operation of new plants.

These newer plants use blast furnaces, which are preferred over electric arc furnaces when high production volumes, integrated steelmaking processes, and the use of iron ore as a primary raw material are required. Blast furnaces offer advantages in production scale and cost efficiency for large-scale steel production.

4.1.4 Non-energy Products from Fuels and Solvent Use

In the non-energy products from fuels and solvents category, lubricants are a key substance due to their primary use in engines for lubrication. Consequently, the emissions associated with lubricants are classified as non-combustion emissions and reported under the IPPU Sector.

The trend in emissions has shown a gradual decrease, with a CAGR of 22.77% for their use in industrial and transportation applications. As this sector is newly reported in the Biennial Transparency Report (BTR) and was not included in previous BURs/NCs, its inclusion will improve the completeness of the IPPU sector's GHG inventory.

4.1.5 Electronics Industry

In the electronics industry, emissions from semiconductor and photovoltaic applications were estimated under the IPPU sector. Emissions showed a steady increase (upcycle) with a CAGR of 4.9% compared to the 2005 baseline. There was recalculation for the subsector semiconductor and photovoltaics in the time series, based on disaggregation of activity data from 2000-2011. Prior to 2000, there were no electronics plant manufacturing semiconductors and photovoltaics present between 1990-1999 in Malaysia.

Between 2020 and 2021, no new plants or expansions were recorded in Malaysia. However, the Malaysia Investment Development Authority (MIDA) indicated that the industry is poised for significant growth, driven by strong foreign direct investment and increased demand for semiconductors, integrated circuits, and photovoltaics (MIDA, 2022).

A recalculation for the semiconductor and photovoltaic subsectors was conducted for the time series, based on the disaggregation of activity data from 2000 to 2011. Prior to 2000, there were no electronics plants manufacturing semiconductors or photovoltaics in Malaysia between 1990 and 1999.

4.1.6 Product Uses as Substitutes for Ozone Depleting Substances

Malaysia had reported the use of HFC-134a as a substitute for ozone-depleting substances (ODS) in the mobile air conditioning (MAC) subcategory. Over the years, the use of this gas for MAC has grown significantly, with a CAGR of 4.84% since the 2005 baseline. This growth is attributed to the rising number of passenger vehicles on the road.

4.1.7 Other Product Manufacture and Use

Despite its high global warming potential (GWP), SF_6 gas is primarily used in electrical equipment, especially switchgears and transformers, within the utility sector. Its usage has increased gradually at a CAGR of 2.24% due to higher demand for electricity generation. A recalculation of 2G1 in the time series from 1990 to 2017 was completed using improved activity data collection from utility providers to ensure accuracy and completeness.

Meanwhile, N_2O gas had also increased gradually at 2.1% from 2005 baseline. This gas continued to be used in the healthcare sector as an anaesthetic gas.

4.1.8 Overview of Methodology used

The 2006 IPCC Guidelines for National GHG Inventories provided a comprehensive methodology for estimating GHG emissions across various sectors, including IPPU sector.

For Malaysia, the application of the 2006 IPCC guidelines for the IPPU sector would involve:

- **Gathering Activity Data:** Collecting detailed production data from industries across Malaysia, including cement, lime, iron and steel, electric, and chemical manufacturing.
- **Adapting Emission Factors:** Using Malaysia-specific emission factors where available or applying IPCC default factors.
- **Implementing Tiers:** Depending on data availability and accuracy, selecting the appropriate tier for each source category.
- **Conducting QA/QC:** Ensuring robust QA/QC measures are in place to maintain data integrity.
- Comprehensive Reporting: Documenting the entire process and results in the NIR and CRF, ensuring transparency and consistency with IPCC guidelines.

Sectoral Summary of IPPU

The summary of GHG emissions in the IPPU sector for the inventory year 2021 are shown in Table SIC4.2. The summary of IPPU trends along with the recalculation notes are stated in Table SIC4.3

Table SIC4.2 Summary of GHG Emissions for IPPU Sector in 2021

Process	Emissions (Gg)	*GWPs	CO_2 Equivalent (Gg)
	A	B	C = A x B
2.A. Mineral Industry			
2.A.1. Cement Production	5,479.6402	1	5,479.6402
2.A.2. Lime Production	309.0450	1	309.0450
2.A.3. Glass Production	320.7672	1	320.7672
2.A.4. Other Process Uses of Carbonates[13]	648.4392	1	648.4392
2.B. Chemical Industry			
2.B.1. Ammonia Production	1,499.2103	1	1,499.2103
2.B.5. Carbide Production	187.0000	1	187.0000
2.B.8. Petrochemicals and Carbon Black			
CO_2	4,029.4464	1	4,029.4464
CH_4	13.0460	28	365.2888
2.C. Metal Industry			
2.C.1. Iron & Steel Production			
CO_2	14,945.9230	1	14,945.9230
CH_4	0.6176	28	17.2933
2.C.2. Ferroalloys Production			
CO_2	1,436.2703	1	1,436.2703
CH_4	0.5359	28	15.0051

[13] For this category, the emissions were from CO_2

Process	Emissions (Gg)	*GWPs	CO_2 Equivalent (Gg) C = A x B
	A	B	
2.C.3. Aluminium Production			
CO_2	1,405.8567	1	1,405.8567
PFC-14 (CF_4)	0.3515	6,630	2,330.2075
PFC-116 (C_2F_6)	0.0351	11,100	390.1252
2.D. Non-Energy Use			
2.D.1. Lubricant Use	2.0828	1	2.0828
2.E. Electronics Industry			
2.E.1. Semiconductor Production			
PFC-14 (CF_4)	0.0765	6,630	441.0155
PFC-116 (C_2F_6)	0.0739	11,100	820.3908
HFC-23 (CHF_3)	0.0030	12,400	36.6589
PFC-218 (C_3F_8)	0.0037	8,900	32.8895
SF_6	0.0148	23,500	347.3727
NF_3	0.0030	16,100	47.5974
2.E.3. Photovoltaics Production			
PFC-14 (CF_4)	0.1184	6,630	785.1521
PFC-116 (C_2F_6)	0.0047	11,100	52.5803
2.F. Emissions of Fluorinated Substitutes for Ozone Depleting Substances			
2.F.1.e. Mobile Air-Conditioning			
HFC-134a	0.7139	1,300	928.0401
2.G. Other Product Manufacture & Use			
2.G.1. Emissions of SF_6 From Electrical Equipment	0.0054	23,500	127.3500
2.G.3. N_2O in Medical Applications	0.1045	265	27.7040
			Total 37,028.3523

* Based on Fifth Assessment Report (AR5) Global Warming Potential (GWP).

Table SIC4.3 **Sectoral Summary for Industrial Processes and Product Use (IPPU) Sector in 2021**

GHG Source and Sink Categories		2021 Total Emissions Gg CO_2 eq.	2005-2021 Trend CAGR (%)	Recalculation
2.A.	Mineral Industry	6,757.8915		
2.A.1.	Cement Production	5,479.6400	Decreased by 2.04%.	
2.A.2.	Lime Production	309.0450	Increased by 1.61%	
2.A.3.	Glass Production	320.7670	Increased by 16.38%	
2.A.4.	Other Processes Use of Carbonates – Limestone and Dolomite	648.4390	Increased by 8.39%	
2.B.	Chemical Industry	6,080.9455		
2.B.1.	Ammonia Production	1,499.2103	Increased by 2.64%	Recalculation based on change of emission factor for years 2017-2019.
2.B.5.	Carbide Production	187.0000	Increased by 8.66%	
2.B.8.	Petrochemicals and Carbon Black	4,394.7352	Increased by 2.69%	
2.C.	Metal Industry	20,540.6811		
2.C.1.	Iron and Steel Production	14,963.2163	Increased by 16.12%	
2.C.2.	Ferroalloys Production	1,451.2754		
2.C.3.	Aluminium Production	4,126.1894		
2.D.	Non-Energy Use	2.0828		
2.D.1.	Lubricant	2.0828	Decreased by 22.77%	It is a new sector reported in this BTR.
2.E.	Electronics Industry	2,563.6573		Recalculation based on improved activity data from 2000-2011.
2.E.1.	Semiconductor Production	1,725.9248	Increased by 4.9%	
2.E.3.	Photovoltaics Production	837.7324		
2.F.	Product Uses as Substitutes for Ozone Depleting Substances	928.0401		
2.F.1.b.	Mobile Air-Conditioning	928.0401	Increased by 4.84%	
2.G.	Other Product Manufacture and Use			
2.G.1.	Use of SF_6 in Electrical Equipment	155.0540	Increased by 2.24%	Recalculation based on improved activity data from 1990-2017
2.G.3.	Use of N_2O in Medical Applications	27.7040	Increased by 2.10%	

Sectoral Improvement Undertaken

The sectoral improvement undertaken of the IPPU sector is shown in Table SIC4.4

Table SIC4.4 **Sectoral Improvement Undertaken**

Sub-Category	Improvement Undertaken	Description
2.E. Electronics Industry	Enhanced activity data values based on production capacity.	Update time series activity data from 2000 – 2011 for 2.E.1. Semiconductors and integrated circuits and 2.E.3. Photovoltaics.
2.D. Non-Energy Products from Fuels and Solvent Use	Newly reported sector for BTR.	New calculations for 2.D.1. Lubricant Use and calculated the emissions for the time series from 1990-2021.
2.G. Other Product Manufacture and Use	Collected activity data of the missing gaps in the time series from stakeholders for completeness purposes.	Updated activity data in the time series from 1990-2017 for 2.G.1. Use of SF6 in Electrical Equipment.

4.2 Mineral Industry (CRT Category 2.A.)

4.2.1 Category 2.A.1. Cement Production

4.2.1.1 Category Description

Cement continued to be fundamental in Malaysia's construction sector, supporting urban development, industrial expansion, and infrastructure projects such as highways and bridges. The industry's contributions to Malaysia's economic growth and modernization efforts remain significant. The local cement industry in 2021 comprised of nine major cement manufacturers of which operated integrated plants and clinker grinding plants[14].

[14] Source: Department of Environment (2024)

The manufacture of cement involved the production of clinker, during which CO_2 is generated. This occurs when limestone, primarily composed of calcium carbonate ($CaCO_3$), is heated or calcined to produce lime (CaO) and CO_2 as a by-product. The proportion of carbonates other than CaCO3 in the raw materials is typically very small and thus considered insignificant.

Additionally, cement kiln dust (CKD) can be produced during the clinker manufacturing process. Based on expert judgement with main producers of cement plants, the CKD correction factor is assumed to be 1.00, where no calcined CKD is lost to the system. Table SIC4.5 provides the overview of the emissions covered under this category.

Table SIC4.5 **Overview of Emissions Covered Under 2.A.1. Cement Production**

Emission Sources	Sources Included	Method	Emission Factors
	Cement Production	T2	0.515 tonne CO_2/ tonne clinker
Gasses Reported	CO_2		
Key Categories	Yes		
Coverage	National		
Major Improvements since last submission	No		

4.2.1.2 Methodological Issues

The methodological issues and emission factors of 2.A.1. Cement Production is shown in Table SIC4.6 and Table SIC4.7 respectively.

Table SIC4.6 Methodological Issues of 2.A.1. Cement Production

Choice of Method	Tier 2			
Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
	Cement Production (2.A.1)	Clinker production	Average overall lime fraction 0.656 used to derive EF. CKD correction factor = 1.00	Cement and Concrete Association Malaysia (CNCA) (1990-2019) Ministry of Domestic Trade and Costs of Living (KPDN) (2020-2021)

Table SIC4.7 Emission Factors of 2.A.1. Cement Production

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Cement production (2.A.1)	0.515 tonne CO_2/tonne clinker											IPCC GLs (2006)

4.2.1.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.2.1.4 Uncertainty Assessment and Time Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.2.1.5 Category-Specific QA/QC and Verifications

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.2.1.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.2.1.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.2.2 Lime Production (2.A.2.)

4.2.2.1 Category Description

In Malaysia, limestone, primarily composed of calcium carbonate, is extracted from quarries and crushed for various industrial applications. The limestone used in Malaysian lime production typically has a high calcium carbonate content, making it suitable for calcination in lime kilns. During the burning or calcination process in these kilns, the limestone undergoes thermal decomposition to produce quicklime (calcium oxide).

Quicklime in Malaysia is mainly produced using shaft or rotary kilns, which operate at high temperatures. This calcination process generates CO_2 as a by-product. Once quicklime is produced, it can be further processed by reacting it with water to create hydrated lime (calcium hydroxide). Hydrated lime is valued for its specific chemical properties and is utilized across various industries, including construction, water treatment, and agriculture. Table SIC4.8 provides the overview of the emissions covered under this category.

Table SIC4.8 **Overview of Emissions Covered Under 2.A.2. Lime Production**

Emission Sources	Sources Included	Method	Emission Factors
	Lime Production	T1	D
Gasses Reported	CO_2		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No		

4.2.2.2 Methodological Issues

The methodological issues and emission factors of 2.A.2. Lime Production is shown in Table SIC4.9 and Table SIC4.10 respectively.

Table SIC4.9 **Methodological Issues of 2.A.2. Lime Production**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Lime production (2.A.2)	High-calcium lime production	Type of lime: High-calcium Lime	Department of Mineral and Geoscience Malaysia (JMG)

Table SIC4.10 **Emission Factors of 2.A.2. Lime Production**

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Lime production (2.A.2)	0.75 tonne CO_2/tonne lime produced											IPCC GLs (2006)

4.2.2.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.2.2.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.2.2.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.2.2.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.2.2.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.2.3 Glass Production (2.A.3.)

4.2.3.1 Category Description

Glass production in Malaysia is categorised into four main types: containers, flat (window) glass, fibre glass, and specialty glass. Flat glass production, particularly through the float glass-making method, remains a key focus of Malaysia's glass manufacturing industry, with significant applications in construction and automotive sectors.

Glass is extensively used across various applications in Malaysia, including construction (windows and facades), automotive (windshields and windows), packaging (bottles and containers), and electronics (displays and screens). This highlights its crucial role in multiple industries. The Malaysian glass industry is primarily concentrated on producing float glass, which forms a substantial part of the country's glass manufacturing output.

The production of flat glass had increased in Malaysia due to the expansion of existing plants and the commissioning of new ones15, leading to a notable rise in CO_2 emissions. An average annual cullet ratio of 25% is assumed, based on expert judgment from the main glass manufacturers in Malaysia.

The cullet ratio represents the proportion of recycled glass (cullet) used in the production of new glass relative to the total batch of raw materials. Table SIC4.11 provides the overview of the emissions covered under this category.

Table SIC4.11 Overview of Emissions Covered Under 2.A.3. Glass Production

Emission Sources	Sources Included	Method	Emission Factors
	Glass Production	T2	D
Gasses Reported	CO_2		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No		

4.2.3.2 Methodological Issues

The methodological issues and emission factors of 2.A.3. Glass Production is shown in the following Table SIC4.12 and Table SIC4.13 respectively.

Table SIC4.12 Methodological Issues of 2.A.3. Glass Production

Choice of Method	Tier 2			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Glass production (2.A.3)	Glass production	Average annual cullet ratio of 25%	Department of Mineral and Geoscience Malaysia (JMG)

[15] MIDA (2021)

Table SIC4.13 **Emission Factors of 2.A.2. Lime Production**

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Glass production (2.A.3)	0.15 tonnes CO_2/tonnes glass											IPCC GLs (2006)

4.2.3.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.2.3.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.2.3.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.2.3.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.2.3.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.2.4 Other Process Uses of Carbonates (2.A.4.)

4.2.4.1 Category Description

Limestone ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), and other carbonates are crucial raw materials with diverse commercial applications. Beyond their roles in cement, lime, and glass production, these carbonates are extensively used in Malaysia's metallurgy sector, particularly for iron and steel production. They also play a significant role in agriculture by improving soil quality and in construction as a key component of concrete and other building materials.

According to the IPCC 2006 Guidelines, some applications of carbonates, such as their use as aggregates in construction, do not contribute to CO_2 emissions and are therefore not included in GHG estimations. As a result, the total accounted limestone production includes imports but excludes exports. Limestone used for cement manufacturing, rock aggregates, lime production, and agriculture was omitted from estimates to avoid double counting.

The demand for the use of limestone continued to increase, and this exceeded the production output of the country which was restricted due to COVID-19 between 2019-2021. Thus, resulted in the use of limestone (from stockpile) exceeding production. The use of existing reserves (stockpile) in limestone was necessary to ensure continuity in supply during this period, inadvertently led to an excess in the use of limestone, surpassing initial production outputs.

The increased demand for limestone and dolomite since the baseline year of 2005 has been driven by their essential roles in various industries, including construction, steelmaking, agriculture, glass manufacturing, and water treatment. This rise in demand corresponds with increased production activities across these sectors. Table SIC4.14 provides the overview of the emissions covered under this category.

Table SIC4.14 **Overview of Emissions Covered Under 2.A.4. Other Process Uses of Carbonates**

Emission Sources	Sources Included	Method	Emission Factors
	Limestone Production	T2	D
	Dolomite Production		D
Gasses Reported	CO_2		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No		

4.2.4.2 Methodological Issues

The methodological issues and emission factors of 2.A.4. Other Process Uses of Carbonates is shown in Table SIC4.15 and Table SIC4.16 respectively.

Table SIC4.15 **Methodological Issues of 2.A.4. Other Process Uses of Carbonates Production**

Choice of Method	Tier 2			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Other Process Uses of Carbonates (2.A.4)	Limestone and Dolomite production	Total Accounted Limestone Production include: imports; and exclude: exports, limestone for cement manufacturing, rock aggregates, lime production, and agriculture use. Total Accounted Dolomite Production include imports and exclude exports.	Department of Mineral and Geoscience Malaysia (JMG)

Table SIC4.16 Emission Factors of 2.A.4. Other Process Uses of Carbonates

Sub-Sector		Emission Factor											Data Source
		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Other Process Uses of Carbonates (2.A.4)	Limestone	0.43971 tonnes CO_2 / tonnes carbonate											IPCC GLs (2006)
	Dolomite	0.47732 tonnes CO_2 / tonnes carbonate											IPCC GLs (2006)

4.2.4.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.2.4.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.2.4.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.2.4.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.2.4.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.3 Chemical Industry (CRT Category 2.B.)

4.3.1 Ammonia Production (2.B.1.)

4.3.1.1 Category Description

Ammonia is widely used in Malaysia for producing fertilizers, which are essential for the agricultural sector, as well as in the manufacture of pharmaceuticals and various chemical intermediates. The ammonia production industry in Malaysia is crucial for both meeting domestic demands and supporting export markets, playing a significant role in the country's economic and industrial growth.

During the primary steam reforming stage and shift conversion stage, the carbon (C) content of the hydrocarbon is converted to carbon dioxide (CO_2), which constitutes the main potential direct GHG emission. The main producer of ammonia utilises natural gas in the synthesis process resulting in CO_2 emissions being released. Since the urea production data was available from the main producer, a deduction was made for CO_2 emissions used in this calculation. Due diligence was made to ensure that the urea production emissions were included elsewhere in the inventory, specifically in the agriculture sector. Table SIC4.17 provides the overview of the emissions covered under this category.

Table SIC4.17 Overview of Emissions Covered Under 2.B.1. Ammonia Production

Emission Sources	Sources Included	Method	Emission Factors
	Ammonia Production	T2	D
Gasses Reported	CO_2		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No		

4.3.1.2 Methodological Issues

The methodological issues and emission factors of 2.B.1. Ammonia Production is shown in Table SIC4.18 and Table SIC4.19.

Table SIC4.18 Methodological Issues of 2.B.1. Ammonia Production

Choice of Method	Tier 2			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Ammonia production (2.B.1)	Amount of Ammonia produced	Fuel Type: Natural Gas (Dry) Removal of CO_2 emissions for the urea production was completed and included in the agriculture sector	PETRONAS

Table SIC4.19 Emission Factors of 2.B.1. Ammonia Production

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Ammonia production (2.B.1)	29.7 GJ/t.p. Ammonia											IPCC GLs (2006)

* t.p. = tonne of production

4.3.1.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.3.1.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.3.1.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.3.1.6 Category-Specific Recalculations

Recalculation was completed based on change in emission factor (based on stakeholder request to use default values) for 2017-2019 activity data.

4.3.1.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.3.2 Carbide Production (2.B.5.)

4.3.2.1 Category Description

The calcium carbide production is less prominent compared to other chemical sectors in Malaysia. Calcium carbide is mainly used to produce acetylene, which serves various industrial purposes such as welding and cutting. It is also used in the desulphurisation of iron, contributing to the production of high-quality steel. Additionally, calcium carbide finds applications in the chemical industry for producing chemicals like calcium cyanamide.

The production of calcium carbide (CaC_2) involves heating a mixture of lime and carbon to high temperatures (2000 to 2100°C) in an electric arc furnace. The lime needed is typically produced by calcining limestone in a kiln at the plant site. The lime is then reduced by carbon to form calcium carbide, with carbon monoxide (CO) as a by-product. CO emissions are generally minimal, as CO is oxidised to CO_2 in an open furnace, effectively eliminating CO emissions. Table SIC4.20 provides the overview of the emissions covered under this category.

Table SIC4.20 Overview of Emissions Covered Under 2.B.5. Carbide Production

Emission Sources	Sources Included	Method	Emission Factors
	Carbide Production	T1	D
Gasses Reported	CO_2		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No		

4.3.2.2 Methodological Issues

The methodological issues and emission factors of 2.B.5. Carbide Production is shown in Table SIC4.21 and Table SIC4.22 respectively.

Table SIC4.21 Methodological Issues of 2.B.5. Carbide Production

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Carbide production (2.B.5)	Carbide produced		Department of Mineral & Geoscience (JMG)

Table SIC4.22 Emission Factors of 2.B.5. Carbide Production

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Carbide production (2.B.5)	1.1 tonnes CO_2/ tonnes carbide produced											IPCC GLs (2006)

4.3.2.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.3.2.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.3.2.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.3.2.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.3.2.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.3.3 Petrochemical and Carbon Black (2.B.8.)

4.3.3.1 Category Description

The petrochemical and carbon black industries are vital to Malaysia's economy. Ethylene, a key olefin, is a fundamental building block in the petrochemical sector. This colourless gas with a slightly sweet odour is crucial for producing various plastics, such as polymers, polyvinyl chloride (PVC), ethylene dichloride, ethylene oxide, ethylbenzene, and acetaldehyde. In Malaysia, ethylene is widely used in manufacturing plastic products for both domestic consumption and export.

Ethylene oxide, a colourless and flammable gas with a faintly sweet odour, is produced by reacting ethylene with oxygen over a catalyst. It is essential for producing detergents, thickeners, solvents, plastics, and various organic chemicals such as ethylene glycol, ethanolamine, simple and complex glycols, polyglycol ethers, and other compounds. These products are widely used in Malaysia's chemical, pharmaceutical, and personal care industries.

Methanol, another critical petrochemical, is primarily utilized in paints, solvents, refrigerants, and disinfectants. The petrochemical plant in Labuan, Sabah, stands as the largest producer of methanol in Malaysia, supporting the nation's chemical manufacturing and export activities. Table SIC4.23 provides the overview of the emissions covered under this category.

Table SIC4.23 **Overview of Emissions Covered Under 2.B.8. Petrochemical and Carbon Black**

<table>
<tr><th>Emission Sources</th><th colspan="2">Sources Included</th><th>Method</th><th>Emission Factors</th></tr>
<tr><td rowspan="4"></td><td colspan="2">Methanol</td><td rowspan="4">T1</td><td>D</td></tr>
<tr><td rowspan="2">Ethylene</td><td>Ethane</td><td>D</td></tr>
<tr><td>Naphtha</td><td>D</td></tr>
<tr><td colspan="2">Ethylene Oxide</td><td>D</td></tr>
<tr><td>Gasses Reported</td><td colspan="4">CO_2, CH_4</td></tr>
<tr><td>Key Categories</td><td colspan="4">No</td></tr>
<tr><td>Coverage</td><td colspan="4">National</td></tr>
<tr><td>Major Improvements since last submission</td><td colspan="4">No</td></tr>
</table>

4.3.3.2 Methodological Issues

The methodological issues and emission factors of 2.B.8. Petrochemical and Carbon Black is shown in Table SIC4.24 and Table SIC4.25 respectively.

Table SIC4.24 Methodological Issues of 2.B.8. Petrochemical and Carbon Black

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Methanol (2.B.8.a)	Methanol production	Type of process: Combined steam reforming	PETRONAS
	Ethylene (2.B.8.b)	Ethylene production	Geographic adjustment factor of 130%	PETRONAS, Lotte Chemical Titan Holding Berhad
	Ethylene Oxide (2.B.8.d)	Ethylene oxide production	Oxygen process	PETRONAS

Table SIC4.25 Emission Factors of 2.B.8. Petrochemical and Carbon Black

Sub-Sector		Emission Factor											Data Source
		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Methanol (2.B.8.a)		0.6 tonne CO_2/tonne methanol	2.3 kg CH_4/tonnes of chemical										IPCC GLs (2006)
Ethylene (2.B.8.b)	Ethane	0.76 tonne CO_2/tonne ethylene	6 kg CH_4/tonnes of chemical										IPCC GLs (2006)
	Naphtha	1.73 tonne CO_2/tonne ethylene	3 kg CH_4/tonnes of chemical										
Ethylene Oxide (2.B.8.d)		0.663 tonne CO_2/tonne ethylene oxide	3 kg CH_4/tonnes of chemical										IPCC GLs (2006)

4.3.3.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.3.3.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.3.3.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.3.3.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.3.3.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.4 Metal Industry (CRT Category 2.C.)

4.4.1 Iron and Steel Production (2.C.1.)

4.4.1.1 Category Description

The iron and steel sector in Malaysia play a crucial role in supporting key applications, ranging from building materials to machinery and automotive components, which are essential for economic growth and infrastructure development. As of 2021, Malaysia has 27 companies involved in iron making, steel making, and steel rolling. The steel-making upstream plants employ both basic oxygen furnace (BOF) and electric-arc furnace (EAF) processes, with a production ratio of 77:23[16]. The sector continues to expand rapidly, with new expansions planned for existing plants and the introduction of new plants in East Malaysia by 2025[17].

[16] MISIF (2024)
[17] The Star Newspaper (2022)

During the initial stages of iron production, blast furnaces convert iron oxides into highly reduced products suitable for steelmaking, generating significant CO_2 emissions. Additional emissions are produced during the decarburization of pig iron in basic oxygen furnaces to produce steel. Once the molten steel is refined to meet specific composition and temperature requirements, it undergoes continuous casting to form steel bars. These bars are then shaped by rolling mills to produce various steel products necessary for Malaysia's industrial and construction sectors. Table SIC4.26 provides the overview of the emissions covered under this category.

Table SIC4.26 **Overview of Emissions Covered Under 2.C.1. Iron and Steel Production**

Emission Sources	Sources Included	Method	Emission Factors	
	Iron and Steel Production	T1	Electric Arc Furnace (EAF)	D
			Iron Production	D
			Sinter Production	D
			Coke Production	D
			Basic Oxygen Furnace (BOF)	D
Gasses Reported	CO_2, CH_4			
Key Categories	No			
Coverage	National			
Major Improvements since last submission	No			

4.4.1.2 Methodological Issues

The methodological issues and emission factors of 2.C.1. Iron and Steel Production is shown in Table SIC4.27 and Table SIC4.28 respectively.

Table SIC4.27 **Methodological Issues of 2.C.1. Iron and Steel Production**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Iron and steel production (2.C.1)	Amount of steel or iron production		Malaysian Iron & Steel Industry Federation (MISIF) Malaysian Steel Institute (MSI)

Table SIC4.28 **Emission Factors of 2.C.1. Iron and Steel Production**

Sub-Sector		Emission Factor											Data Source
		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Iron and steel production (2.C.1)	Electric Arc Furnace (EAF)	0.08 tonne CO_2/t.p											IPCC GLs (2006)
	Iron Production	1.35 tonne CO_2/t.p											IPCC GLs (2006)
	Sinter Production	0.2 tonne CO_2/t.p	0.07 kg CH_4/t.p										IPCC GLs (2006)
	Coke Production	0.56 tonne CO_2/t.p	0.1 kg CH_4/t.p										IPCC GLs (2006)
	Basic Oxygen Furnace (BOF)	1.46 tonne CO_2/t.p											IPCC GLs (2006)

* t.p. = tonne of production

4.4.1.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.4.1.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.4.1.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.4.1.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.4.1.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.4.2 Ferroalloys Production (2.C.2.)

4.4.2.1 Category Description

Ferroalloys production in Malaysia covers three plants located in Sarawak and encompasses silicon metal production, which is similar to the ferrosilicon process. This sector sees further expansion in terms of increased capacity within existing plants[18].

These ferroalloys play crucial roles in the Malaysian steel industry by enhancing steel's properties through deoxidation and alloying. They are integral in producing high-quality steel for infrastructure, automotive manufacturing, and machinery sectors in Malaysia. Additionally, silicon metal produced in Malaysia are found in applications such as aluminium alloys, silicones used in construction and automotive industries, and electronics manufacturing. The types of ferroalloys used in the production processes in Malaysia consists of ferrosilicon 75%, ferromanganese (7% C), ferromanganese (1% C) and silicomanganese. Table SIC4.29 provides the overview of the emissions covered under this category.

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[18] Natsuki K. (2017)

Table SIC4.29 Overview of Emissions Covered Under 2.C.2. Ferroalloys Production

Emission Sources	Sources Included	Method	Emission Factors	
	Ferroalloys Production	T1	Ferrosilicon 75%	D
			Ferromanganese (7% C)	D
			Ferromanganese (1% C)	D
			Silicomanganese	D
Gasses Reported	CO_2, CH_4			
Key Categories	Yes			
Coverage	National			
Major Improvements since last submission	No			

4.4.2.2 Methodological Issues

The methodological issues and emission factors of 2.C.2. Ferroalloys Production is shown in Table SIC4.30 and Table SIC4.31 respectively.

Table SIC4.30 Methodological Issues of 2.C.2. Ferroalloys Production

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Ferroalloys production (2.C.2)	Amount of ferroalloy production based on types		OM Material, Sakura Ferroalloys, Pertama Ferroalloys

Table SIC4.31 Emission Factors of 2.C.1. Iron and Steel Production

Sub-Sector		Emission Factor											Data Source
		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Ferro alloys production (2.C.2)	Ferrosilicon 75%	4 tonne CO_2/t.p.	1 kg CH_4/t.p.										IPCC GLs (2006)
	Ferromanganese (7% C)	1.3 tonne CO_2/t.p.											IPCC GLs (2006)
	Ferromanganese (1% C)	1.5 tonne CO_2/t.p.											IPCC GLs (2006)
	Silicomanganese	1.4 tonne CO_2/t.p.	1.2 kg CH_4/t.p.										IPCC GLs (2006)

* t.p. = tonne of production

4.4.2.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.4.2.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.4.2.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.4.2.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.4.2.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.4.3 Aluminium Production (2.C.3.)

4.4.3.1 Category Description

The applications of aluminium in Malaysia are diverse and pivotal to various industries. Aluminium is extensively used in the construction sector for building facades, roofing, and structural components due to its lightweight nature, corrosion resistance, and durability. In the automotive industry, aluminium is utilised for manufacturing vehicle bodies and parts, contributing to fuel efficiency and reducing vehicle weight. Moreover, aluminium finds applications in packaging, aerospace, and marine industries, highlighting its versatility and importance in Malaysia's industrial landscape.

Primary aluminium production which occurs in Sarawak, Malaysia follows a process involving the electrolytic reduction of alumina (Al_2O_3) which is also known as Centre Worked Prebake (CWPB). The aluminium industry in Malaysia is set for substantial growth, driven by rising demand both domestically and internationally[19].

Table SIC4.32 **Overview of Emissions Covered under 2.C.3. Aluminium Production**

Emission Sources	Sources Included	Method	Emission Factors
	Ammonia Production	T1	D
Gasses Reported	CO_2, CF_4, $C2F_6$		
Key Categories	Yes[20] (CF_4)		
Coverage	National		
Major Improvements since last submission	No		

[19] Protégé Associates (2024)
[20] The key category from the 2.C.3. Aluminium Production is CF_4 gas

4.4.3.2 Methodological Issues

The methodological issues and emission factors of 2.C.3. Aluminium Production is shown in Table SIC4.33 and Table SIC4.34 respectively.

Table SIC4.33 **Methodological Issues of 2.C.3. Aluminium Production**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Aluminium production (2.C.3)	Amount of aluminium production	Type of technology: prebake; type of technology: CWPB	Press Metal Group

Table SIC4.34 **Emission Factors of 2.C.3. Aluminium Production**

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Aluminium production (2.C.3)	1.6 tonne CO_2/tonne aluminium produced				0.4 kg CF_4/tonne aluminium produced; 0.04 kg C_2F_6/tonne aluminium produced							IPCC GLs (2006)

4.4.3.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.4.3.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.4.3.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.4.3.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.4.3.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.5 Non-Energy Products from Fuels and Solvent Use (CRT Category 2.D.)

4.5.1 Lubricant Use (2.D.1.)

4.5.1.1 Category Description

In Malaysia, lubricants are predominantly used in both industrial and transportation sectors. These lubricants are typically manufactured either at refineries through crude oil separation processes or at specialised petrochemical facilities. They encompass motor oils, industrial oils, and greases, each tailored to specific physical characteristics such as viscosity, which determine their suitability for various applications.

In industrial settings, lubricants are essential for machinery and equipment maintenance across manufacturing, mining, and construction industries, ensuring smooth operation and longevity of critical assets. In transportation, they are indispensable for engines, gears, and axles in vehicles ranging from cars to heavy-duty trucks, facilitating efficient performance and reducing wear and tear. Table SIC4.35 provides the overview of the emissions covered under this category.

Table SIC4.35 **Overview of Emissions Covered under 2.D.1. Lubricant Use**

Emission Sources	Sources Included	Method	Emission Factors
	Lubricant Use	T1	D
Gasses Reported	CO_2		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Newly reported sector		

4.5.1.2 Methodological Issues

The methodological issues and emission factors of 2.D.1. Lubricant Use is shown in Table SIC4.36 and Table SIC4.37 respectively.

Table SIC4.36 **Methodological Issues of 2.D.1. Lubricant Use**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Lubricant Use (2.D.1)	Lubricant consumption		Malaysia Energy Commission

Table SIC4.37 **Emission Factors of 2.D.1. Lubricant Use**

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	NO_x	CO	NMVOCs	SO_2	
Lubricant use (2.D.1)	20 kg C/GJ											IPCC GLs (2006)

4.5.1.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.5.1.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.5.1.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.5.1.6 Category-Specific Recalculations

This is a new sub-sector and the Time-Series have been added from 1990-2021 for completeness.

4.5.1.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.6 Electronics Industry (CRT Category 2.E.)

4.6.1 Integrated Circuit or Semiconductor (2.E.1.)

4.6.1.1 Category Description

An important subsector within the electronics industry in Malaysia encompassed the production of integrated circuits (IC) or semiconductors. This sector is vital for Malaysia's technological advancement, focusing on the wafer fabrication of semiconductor devices used in various applications such as telecommunications, consumer electronics, and automotive electronics.

The production processes involved the use of fluorinated compounds (FCs) such as CF_4, C_2F_6, C3F8, and others, which are essential but can potentially contribute to CF4 formation, a GHG. In accordance with the IPCC 2006 Guidelines, annual plant capacity utilization can be assumed to be 80% when country-specific capacity utilisation data are not available. Table SIC4.38 provides the overview of the emissions covered under this category.

Table SIC4.38 **Overview of Emissions Covered under 2.E.1. Integrated Circuit or Semiconductor**

Emission Sources	Sources Included	Method	Emission Factors
	Semiconductor Production	T1	D
Gasses Reported	CF_4, C_2F_6, CHF_3, C_3F_8, SF_6, NF_3		
Key Categories	Yes		
Coverage	National		
Major Improvements since last submission	Enhanced activity data values based on production capacity.		

4.6.1.2 Methodological Issues

The methodological issues and emission factors of 2.E.1. Integrated Circuit or Semiconductor is shown in Table SIC4.39 and Table SIC4.40 respectively.

Table SIC4.39 **Methodological Issues of 2.E.1. Integrated Circuit or Semiconductor**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Integrated Circuit or Semiconductor production (2.E.1)	Annual Manufacturing Design Capacity	Fraction of annual plant production capacity utilisation, fraction of 80%	Malaysian Investment Development Authority (MIDA)

Table SIC4.37 Emission Factors of 2.D.1. Lubricant Use

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	NF_3	SF_6	NO_x	CO	NMVOCs	SO_2	
Integrated Circuit or Semi-conductor (2.E.1)				0.04 kg FC/m² of silicon processed (CHF_3)	0.9 kg FC/m² of silicon processed (CF_4) 1 kg FC/m² of silicon processed (C_2F_6) 0.05 kg FC/m² of silicon processed (C_3F_8)	0.04 kg FC/m² of silicon processed	0.2 kg FC/m² of silicon processed					IPCC GLs (2006)

4.6.1.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.6.1.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.6.1.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.6.1.6 Category-Specific Recalculations

Enhanced the activity data was conducted from 2000-2011 to obtain the annual manufacturing design capacity. The previous reporting shows extrapolated total emissions.

4.6.1.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.6.2 Photovoltaics (2.E.3.)

4.6.2.1 Category Description

Malaysia is a major hub for photovoltaics (PV) manufacturing, with companies like First Solar, Q-Cells Malaysia and SunPower, among the major producers. Photovoltaic installations are widely utilised across various applications, including residential rooftops, commercial buildings, and large-scale solar farms. These applications see an increase in demand due to the popularity of solar energy as a form of RE.

Fluorinated gasses, particularly nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6), are used in the production of PV cells, especially in the manufacturing of silicon-based solar cells. In accordance with the IPCC 2006 Guidelines, annual plant capacity utilisation can be assumed to be 86% when country-specific capacity utilisation data are not available. Table SIC4.41 provides the overview of the emissions covered under this category.

Table SIC4.41 **Overview of Emissions Covered under 2.E.3. Photovoltaics**

Emission Sources	Sources Included	Method	Emission Factors
	Photovoltaics Production	T1	D
Gasses Reported	CF_4, C_2F_6		
Key Categories	Yes[20] (CF_4)		
Coverage	National		
Major Improvements since last submission	Enhanced activity data values based on production capacity.		

4.6.2.2 Methodological Issues

The methodological issues and emission factors of 2.E.3. Photovoltaics is shown in Table SIC4.42 and Table SIC4.43 respectively.

Table SIC4.42 Methodological Issues of 2.E.3. Photovoltaics

Choice of Method	Tier 1			
Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
	Photovoltaics (2.E.3)	Annual Manufacturing Design Capacity	Fraction of annual plant production capacity utilisation 86%	Malaysian Investment Development Authority (MIDA)

Table SIC4.43 Emission Factors of 2.E.1. Photovoltaics

Sub-Sector	Emission Factor										Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	NF_3	NO_x	CO	NMVOCs	SO_2	
Photovoltaics (2.E.3)					0.005 g FC/m^2 of substrate processed (CF_4); 0.0002 g FC/m^2 of substrate processed (C_2F_6)						IPCC GLs (2006)

4.6.2.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.6.2.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.6.2.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID

4.6.2.6 Category-Specific Recalculations

Enhanced the activity data was conducted from 2000-2011 to obtain the annual manufacturing design capacity. The previous reporting shows extrapolated total emissions.

4.6.2.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (CRT Category 2.F.)

4.7.1 Refrigeration and Air Conditioning – Mobile Air Conditioning (2.F.1.e.)

4.7.1.1 Category Description

Malaysia does not produce fluorinated gasses; however, the use of these hydrofluorocarbons is apparent in air conditioning. HFC-134a is used in majority of passenger vehicles, therefore, warranting the need to estimate the consumption in mobile air conditioning (MAC). The use of HFC-134a increased significantly, replacing chlorofluorocarbons (CFCs) in refrigeration and air-conditioning since year 1997.

As a signatory to the Montreal Protocol, Malaysia has phased out ozone-depleting substances (ODS). The primary halocarbon currently in use is HFC-134a, specifically for MAC in passenger vehicles. The inventory excludes emissions resulting from the disposal of vehicles and their components. It focuses solely on passenger cars (including taxi and hire) and non-commercial vehicles, within this specific segment. Table SIC4.44 provides the overview of the emissions covered under this category.

Table SIC4.44 Overview of Emissions Covered under 2.F.1.e. Mobile Air-Conditioning

Emission Sources	Sources Included	Method	Emission Factors
	Mobile Air-Conditioning	T2	D
Gasses Reported	HFCs		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No		

4.7.1.2 Methodological Issues

The methodological issues and emission factors of 2.F.1.e. Refrigeration and Air Conditioning is shown in Table SIC4.45 and Table SIC4.46 respectively.

Table SIC4.45 Methodological Issues of 2.F.1.e. Refrigeration and Air Conditioning – Mobile Air-Conditioning

Choice of Method	Tier 2			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Mobile Air-Conditioning (2.F.1.e.)	1) Amount of HFC/ PFC Charged into New Systems in Year t 2) Amount of HFC/ PFC Stocked in Existing Systems in Year t	1) Does not include emissions resulting from disposal. 2) Only passenger cars and non-commercial vehicles are included. 3) Assembly Losses of 0.5% 4) Annual Leakage Rate of 10%	Ministry of Transport (MoT)

Table SIC4.46 **Emission Factors of 2.F.1.e. Refrigeration and Air Conditioning – Mobile Air-Conditioning**

Sub-Sector	Emission Factor										Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	NF_3	NO_x	CO	NMVOCs	SO_2	
Refrigeration and Air-Conditioning (2.F.1)					Please refer to the footnote[21]						IPCC GLs (2006)

4.7.1.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.7.1.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.7.1.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.7.1.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.7.1.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

[21] The emissions for this category are calculated based on the applicable f-gas estimated annual leakage from the charging, in stock, during the assembly and operation activities/items.

4.8 Other Product Manufacture and Use (CRT Category 2.G.)

4.8.1 Electrical Equipment (2.G.1.)

4.8.1.1 Category Description

Sulphur Hexafluoride (SF_6) is primarily used in electrical equipment due to its superior insulating properties. This gas has replaced flammable oil in many types of electrical equipment such as switchgear and circuit breakers, enabling the construction of more compact substations, especially in densely populated urban areas. This shift has facilitated the growth of the use of SF_6 gas in electrical equipment among the utility providers in Malaysia. Despite its benefits, SF_6 is one of the most potent GHG, with a Global Warming Potential of 23,500 times greater than that of carbon dioxide.

The total emissions of SF_6 excluded the manufacturing emissions and equipment disposal emissions. This activity data was collected from three major utility providers in Malaysia. Table SIC4.47 provides the overview of the emissions covered under this category.

Table SIC4.47 **Overview of Emissions Covered under 2.G.1. Electrical Equipment**

Emission Sources	Sources Included	Method	Emission Factors
	Use of Electrical Equipment	T1	D
Gasses Reported	SF_6		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	Collected activity data of the missing gaps in the time series from stakeholders for completeness purposes.		

4.8.1.2 Methodological Issues

The methodological issues and emission factors of 2.G.1. Electrical Equipment is shown in Table SIC4.48 and Table SIC4.49 respectively.

Table SIC4.48 Methodological Issues of 2.G.1. Electrical Equipment

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Electrical Equipment (2.G.1.)	Nameplate capacity of installed equipment	Fraction per year of nameplate capacity of all equipment installed = 0.007 The total emissions of SF6 exclude the manufacturing emissions, equipment installation emissions and equipment disposal emissions.	Tenaga Nasional Berhad (TNB), Sabah Electricity Sdn Bhd (SESB), Sarawak Energy Berhad (SEB)

Table SIC4.49 Emission Factors of 2.G.1. Electrical Equipment

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	NF_3	SF_6	NO_x	CO	NMVOCs	SO_2	
Electrical Equipment (2.G.1)							0.007 of fraction SF_6					IPCC GLs (2006)

4.8.1.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.8.1.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.8.1.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.8.1.6 Category-Specific Recalculations

Collection of actual data from 1990-2017 was conducted from two stakeholders. However, the main stakeholder activity data was extrapolated/interpolated using recommended IPCC Guidelines methods.

4.8.1.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.8.2 Other Product Manufacture and Use – N2O from Product Uses (2.G.3.a.)

4.8.2.1 Category Description

In Malaysia, N_2O (nitrous oxide) is extensively used in both human and veterinary medicine. Supplied in steel cylinders with at least 98% purity, it serves as an anaesthetic and analgesic in medical settings, often as a carrier gas for other volatile anaesthetics. N_2O is employed for pain relief during surgical procedures, childbirth, and minor surgeries, and is also used in pre-mixed 50% N_2O and 50% oxygen mixtures for labour and short-duration painful procedures. In veterinary medicine, N_2O is administered similarly to its human applications, underscoring its vital role in Malaysia's healthcare system. Table SIC4.50 provides the overview of the emissions covered under this category.

Table SIC4.50 **Overview of Emissions Covered under 2.G.3.a. Other Product Manufacture and Use – N_2O from Product Uses**

Emission Sources	Sources Included	Method	Emission Factors
	N_2O from Product Use	T1	D
Gasses Reported	N_2O		
Key Categories	No		
Coverage	National		
Major Improvements since last submission	No		

4.8.2.2 Methodological Issues

The methodological issues and emission factors of 2.G.3.a. Other Product Manufacture and Use – N_2O from Product Uses is shown in Table SIC4.51 and Table SIC4.51 respectively.

Table SIC4.51 **Methodological Issues of 2.G.3.a. Other Product Manufacture and Use – N_2O from Product Uses**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	N_2O from Product Uses (2.G.3)	Quantity of N_2O Supplied in this Application Type in Year t		Gas supplier (Confidential)

Table SIC4.52 Emission Factors of 2.G.3.a. Other Product Manufacture and Use – N2O from Product Uses

Sub-Sector	Emission Factor											Data Source
	CO_2	CH_4	N_2O	HFCs	PFCs	NF_3	SF_6	NO_x	CO	NMVOCs	SO_2	
Electrical Equipment (2.G.1)			1 (fraction)									IPCC GLs (2006)

4.8.2.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Section IV of this BTR1 document.

4.8.2.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

4.8.2.5 Category-Specific QA/QC and Verification

Description for this source category is generally discussed in Sub-Chapter 1.5 of the NID.

4.8.2.6 Category-Specific Recalculations

There have been no recalculations to this category.

4.8.2.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC4.53.

4.9 Planned Sectoral Improvement

The planned sectoral improvements are described in Table SIC4.53.

Table SIC4.53 **Planned Industrial Processes and Product Use (IPPU) Sector Improvement**

Category	Planned Improvement	Description	Progress
Cross cutting	To address completeness of IPPU with estimates reported	Improve completeness for categories reported as "NE", etc Mapping of IPPU sector to justify/ assess/develop the completeness especially for the 2.F. and 2.G. sub-categories	NRES has engaged JICA to improve the F-gasses emissions estimation that contributes to the sectoral completeness through a Technical Cooperation Project. The output of the project is estimated to be reported as early as BTR2.
2.A.1. Cement Production	To develop country-specific emission factors	To develop country-specific emission factors for sub-sectors 2.A.1.	MITI is in the process of planning to develop higher tier EF for sub-sectors 2.A.1. and 2.C.1.
2.C.1. Iron and Steel Production	To develop country-specific emission factors	To develop country-specific emission factors for sub-sectors 2.C.1.	
2.E. Electronics Industry **– Semiconductor** **– Photovoltaics**	To improve time series	To enhance the time series consistency through completion or improvement of the AD.	NRES has engaged JICA to improve F-gasses emissions estimation through a Technical Cooperation Project. The output of the project is estimated to be reported as early as BTR2.
2.F.1.a. Stationary Air Conditioning (Anticipated as a relatively key category)	To collect activity data and complete time series	To develop the time series as it is planned to be a newly reported category .	

4.10 Uncertainty Assessment for Industrial Processes and Product Use (IPPU) Sector

The uncertainty in IPPU sector for 2005 stands at 7.82%. Table SIC4.54 shows the uncertainty analysis table.

The uncertainty in IPPU sector for year 2021 stands at 11.55%, while the trend uncertainty (based on year 2005) is 27.72%. Table SIC4.55 shows the uncertainty analysis table.

Table SIC4.54 Uncertainty for IPPU sector for 2005

CRT category			Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*
				(Gg CO_2 equivalent)	%	%	%	
2. Industrial processes and product use								
2.A. Mineral industry	2.A.1.	Cement production	CO_2	7,615.98	2.00%	8.00%	8.25%	0.00
	2.A.2.	Lime production	CO_2	239.24	8.00%	2.00%	8.25%	0.00
	2.A.3.	Glass production	CO_2	28.34	5.00%	10.00%	11.18%	0.00
	2.A.4.d.	Limestone and dolomite	CO_2	178.68	3.00%	5.00%	5.83%	0.00
2.B. Chemical industry	2.B.1.	Ammonia production	CO_2	988.52	5.00%	6.00%	7.81%	0.00
	2.B.2.	Nitric acid production	N_2O	193.05	2.00%	40.00%	40.05%	0.00
	2.B.5.	Carbide production	CO_2	49.49	5.00%	10.00%	11.18%	0.00
	2.B.8.	Petrochemicals and carbon black production	CO_2	2,633.90	5.00%	30.00%	30.41%	0.00
			CH_4	227.20	5.00%	60.00%	60.21%	0.00
2.C. Metal industry	2.C.1.	Iron and steel production	CO_2	1,367.98	10.00%	25.00%	26.93%	0.00
			CH_4	37.77	10.00%	25.00%	26.93%	0.00
	2.C.2.	Ferroalloys production	CO_2	0.00	5.00%	25.00%	25.50%	0.00
			CH4	0.00	5.00%	25.00%	25.50%	0.00
	2.C.3.	Aluminium production	CO_2	0.00	1.00%	10.00%	10.05%	0.00
			PFC	0.00	1.00%	10.00%	10.05%	0.00
2.D. Non-energy products from fuels and solvent use	2.D.1.	Lubricant use	CO_2	0.00	3.00%	5.00%	5.83%	0.00
2.E. Electronics industry	2.E.1.	Integrated circuit or semiconductor	PFC, HFC, SF_6, NH_3	8.90	10.00%	10.00%	14.14%	0.00
	2.E.3.	Photovoltaics	PFC	0.00	10.00%	10.00%	14.14%	0.00
2.F. Product uses as substitutes for ODS	2.F.1.e.	Mobile air-conditioning	HFC134a	435.76	10.00%	10.00%	14.14%	0.00
2.G. Other product manufacture and use	2.G.1.	Electrical Equipment	SF_6	15.28	10.00%	10.00%	14.14%	0.00
	2.G.3.a.	N_2O in Medical Applications	N_2O	19.87	10.00%	1.00%	10.05%	0.00
	Total			**14,039.96**				**0.01**
							Percentage uncertainty in total inventory	**7.82%**

Table SIC4.55 Uncertainty for Industrial Processes and Product Use (IPPU) sectors for 2021

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
2 Industrial processes and product Use													
2.A. Mineral industry	2.A.1. Cement production	CO_2	7,615.98	5,479.64	2.00%	8.00%	8.25%	0.00	1.03	0.39	0.08	0.01	0.01
	2.A.2. Lime production	CO_2	239.24	309.05	8.00%	2.00%	8.25%	0.00	0.02	0.02	0.00	0.00	0.00
	2.A.3. Glass production	CO_2	28.34	320.77	5.00%	10.00%	11.18%	0.00	0.02	0.02	0.00	0.00	0.00
	2.A.4.d. Limestone and dolomite	CO_2	178.68	648.44	3.00%	5.00%	5.83%	0.00	0.01	0.05	0.00	0.00	0.00
2.B. Chemical industry	2.B.1. Ammonia production	CO_2	988.52	1,499.21	5.00%	6.00%	7.81%	0.00	0.08	0.11	0.00	0.01	0.00
	2.B.2. Nitric acid production	N_2O	193.05	–	2.00%	40.00%	40.05%	–	0.04	–	0.01	–	0.00
	2.B.5. Carbide production	CO_2	49.49	187.00	5.00%	10.00%	11.18%	0.00	0.00	0.01	0.00	0.00	0.00
	2.B.8. Petrochemicals and carbon black production	CO_2 CH_4	2,633.90 227.20	4,029.45 365.29	5.00% 5.00%	30.00% 60.00%	30.41% 60.21%	0.00 0.00	0.21 0.02	0.29 0.03	0.06 0.01	0.02 0.00	0.00 0.00
2.C. Metal industry	2.C.1. Iron and steel production	CO_2 CH_4	1,367.98 37.77	14,945.92 17.29	10.00% 10.00%	25.00% 25.00%	26.93% 26.93%	0.01 0.00	0.81 0.01	1.06 0.00	0.20 0.00	0.15 0.00	0.06 0.00
	2.C.2. Ferroalloys production	CO_2 CH_4	0 0	1,436.27 15.01	5.00% 5.00%	25.00% 25.00%	25.50% 25.50%	0.00 0.00	0.10 0.00	0.10 0.00	0.03 0.00	0.01 0.00	0.00 0.00
	2.C.3. Aluminium production	CO_2 PFC	0 0	1,405.86 2,720.33	1.00% 1.00%	10.00% 10.00%	10.05% 10.05%	0.00 0.00	0.10 0.19	0.10 0.19	0.01 0.02	0.00 0.00	0.00 0.00

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
2.D. Non-energy products from fuels and solvent use	2.D.1. Lubricant use	CO_2	0	2.08	3.00%	5.00%	5.83%	0.00	0.00	0.00	0.00	0.00	0.00
2.E. Electronics industry	2.E.1. Integrated circuit or semiconductor	PFC, HFC, SF_6, NH_3	8.90	1,725.92	10.00%	10.00%	14.14%	0.00	0.12	0.12	0.01	0.02	0.00
	2.E.3. Photovoltaics	PFC	0	837.73	10.00%	10.00%	14.14%	0.00	0.06	0.06	0.01	0.01	0.00
2.F. Product uses as substitutes for ODS	2.F.1.e. Mobile air-conditioning	HFC134a	435.76	928.04	10.00%	10.00%	14.14%	0.00	0.02	0.07	0.00	0.01	0.00
2.G. Other product manufacture and use	2.G.1. Electrical Equipment	SF_6,	15.28	127.35	10.00%	10.00%	14.14%	0.00	0.01	0.01	0.00	0.00	0.00
	2.G.3.a. N_2O in Medical Applications	N_2O	19.87	27.70	10.00%	1.00%	10.05%	0.00	0.00	0.00	0.00	0.00	0.00
	Total		**14,039.96**	**37,028.35**				**0.01**					**0.08**
				Percentage uncertainty in total inventory				**11.55%**			**Trend Uncertainty**		**27.72%**

5
CHAPTER

AGRICULTURE (CRT SECTOR 3)

5.1 Overview of the Sector

The overview of the agriculture sector is shown in Table SIC5.1. The information includes gasses reported, major improvements undertaken, methodological tiers as well as emissions factor used within the sector.

Table SIC5.1 **Overview of the Agriculture Sector**

Emission Sources	**3.A.** Enteric Fermentation **3.B.** Manure Management **3.B.5.** Indirect N_2O Emissions **3.C.** Rice Cultivations **3.D.1.** Direct N_2O Emissions from managed soils **3.D.2.** Indirect N_2O Emissions from manure management **3.F.** Field Burning of Agricultural Residues **3.G.** Liming **3.H.** Urea Application
Gasses Reported	CO_2, CH_4, N_2O
Major improvements since last submission	**3.A.** **Enteric Fermentation** Improvement during estimation based on newer activity data and parameter on other cattle, poultry (chicken and ducks) and swine. **3.B.** **Manure Management** Improvements during estimation based on newer activity data on other cattle, poultry (chicken and ducks) and swine. **3.D.1.** **Direct N_2O Emissions from managed soils** Revised and improvement activity data obtained for FSN: N in synthetic fertilisers from time series to recent years. **3.G.** **Liming** Revised of activity data. Newer limestone data obtained from the stakeholder since year 2008 to recent years. **3.H.** **Urea Application** Revised of activity data from time series 1990 to recent years.

Sector		CO_2		CH_4		N_2O	
3. Agriculture		Method	EF	Method	EF	Method	EF
3.A.	**Enteric Fermentation**						
3.A.1.a.	Dairy cattle			T1	D		
3.A.1.b.	Non-dairy cattle			T1	CS		
3.A.2.	Sheep			T1	D		
3.A.3.	Swine			T1	D		
3.A.4.a.	Buffalo			T1	D		
3.A.4.d.	Goats			T1	D		
3.A.4.e.	Horses			T1	D		
3.B.	**Manure Management**						
3.B.1.a	Dairy cattle			T1	D	T1	D
3.B.1.b	Non-dairy cattle			T1	D	T1	D
3.B.2.	Sheep			T1	D	T1	D
3.B.3.	Swine			T1	D	T1	D
3.B.4.a.	Buffalo			T1	D	T1	D
3.B.4.d.	Goats			T1	D	T1	D
3.B.4.e.	Horses			T1	D	T1	D
3.B.4.g.	Poultry			T1	D	T1	D
3.B.5.	**Indirect N_2O Emissions**						
	Amount of manure nitrogen lost due to volatilisation of NH_3 and NO_x.					T1	D
	Leaching and runoff from manure management					T1	D
3.C.	**Rice Cultivations**						
	Rice Cultivations			T1	CS		
3.D.1.	**Direct N_2O Emissions from Managed Soils**						
	Anthropogenic N input types to estimate annual direct N_2O-N emissions produced from managed soils					T1	D

Sector		CO_2		CH_4		N_2O	
3. Agriculture		Method	EF	Method	EF	Method	EF
	Anthropogenic N input types to estimate annual direct N_2O-N emissions produced from flooded rice					T1	D
	Managed organic soils					T1	D
	Urine and dung inputs to grazed soils					T1	D
3.D.2.	**Indirect N_2O Emissions from Managed Soils**						
	N_2O from Atmospheric Deposition of N Volatilised from Managed Soils					T1	D
	N_2O from N leaching/ runoff from Managed Soils					T1	D
3.F.	**Field Burning of Agricultural Residues**						
	Field Burning of Agricultural Residues			T1	D	T1	D
3.G.	**Liming**						
	Limestone	T1	D				
3.H.	**Urea Application**						
	Urea Application	T1	D				

Trends of GHG Emissions from Agriculture Sector

In the agriculture sector, the Malaysia agriculture reports emissions from the following categories:

a. Enteric fermentation, (CH_4)
b. Manure management, (CH_4, N_2O)
c. Agricultural soils direct and indirect, N_2O, including synthetic fertiliser, manures and digestates applied to soils, urine and dung deposition during grazing, sewage sludge, mineralisation, crop residues, histosols (only direct)
d. Liming (CO_2)
e. Urea application (CO_2)
f. Rice cultivation (CH_4)

Total GHG emissions from the agriculture sectors in year 2021 amounted 7,310.04 Gg CO_2 eq. Figure SIC5.1 and Figure SIC5.2 demonstrates the contribution by gasses and subsectors within the agriculture sector, respectively. The highest contributor was from rice cultivation with 2,499.50 Gg CO_2 eq. (34.19%), followed by direct N_2O emissions from managed soils with 2,201.35 Gg CO_2 eq. (30.11%). Emissions from enteric fermentation contributed 1,247.65 Gg CO_2 eq. (17.07%), followed by indirect N_2O emissions from managed soils with 542.71 Gg CO_2 eq. (7.42%); urea application with 394.47 Gg CO_2 eq. (5.40%) and manure management with 287.84 Gg CO_2 eq. (3.94%); indirect N_2O emissions with 108.71 Gg CO_2 eq. (1.49%). Emission from liming (17.18 Gg CO_2 eq.) and Field Burning of Agricultural Residues (10.64 Gg CO_2 eq.) contributed less than 1% of the total emissions. Time series from 1990-2021 for agriculture sector is as shown in Figure SIC5.3.

Methane (CH_4)

The time series of CH_4 from year 1990 to 2021 shows a generally stagnant trend with slight fluctuations over time. In the agriculture sector, the largest contributor to CH_4 emissions was rice cultivation, which accounted for 57.69% in 1990, while enteric fermentation contributed 35.15%. By 2021, rice cultivation contributed 62.23% of CH_4 emissions, whereas enteric fermentation contributed 31.06%. The fluctuations in CH_4 emissions from rice cultivation were attributed to several factors. The reduction in emissions was due to the constant reduction in wetland and upland rice areas, especially in Sarawak. For instance, a reduction of 27,896 ha of rice cultivation areas was recorded in year 2019, largely due to a 26,165 ha decrease in Sarawak.

Nitrous oxide (N_2O)

Direct N_2O emissions showed an increasing trend throughout the year due to the increase in fertiliser consumption as well as changes in the Typical Average Animal Mass (TAM) values and livestock annual population based on number of animals produced annually (NAPA). N_2O emission peaked in year 2008 due to a high fertiliser consumption that year. Since 2001, emissions were relatively higher, in line with the government's policies to increase agriculture production for both domestic and export demands. The reduction in N_2O emissions from year 2019 onwards is due to the reduction in oil palm plantation areas, which consequently reduced fertiliser usage and the amount of crop residue produced.

Carbon dioxide (CO_2)

CO_2 emissions trend almost stagnant from year 1990 to 2021 due to insignificant changes in the use of urea and liming for agriculture activities. Compared to the base year 2005, the CO_2 emissions in year 2021 decreased by 16.5%, a trend driven by the reduction in urea consumption.

Figure SIC5.1 **Agriculture Contribution by Gasses (%) in 2021**

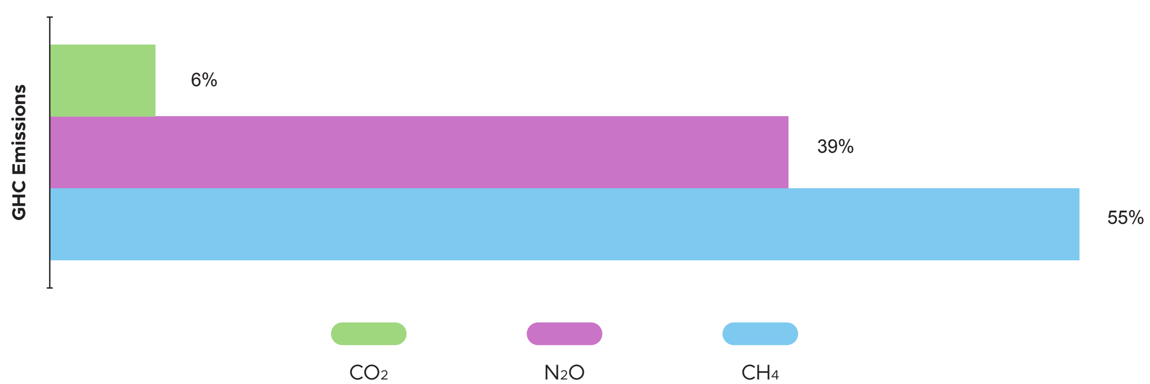


Figure SIC5.2 **Agriculture Contribution by Subsectors (%) in 2021**

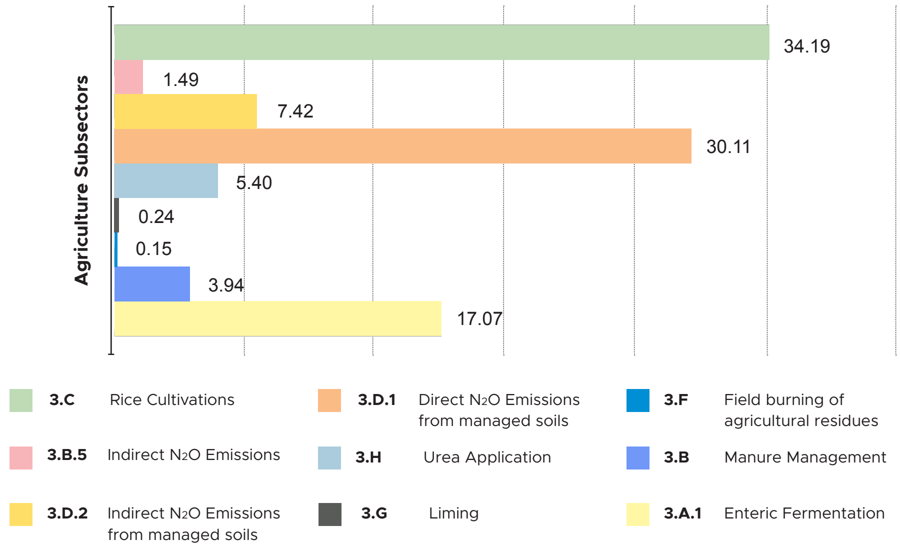
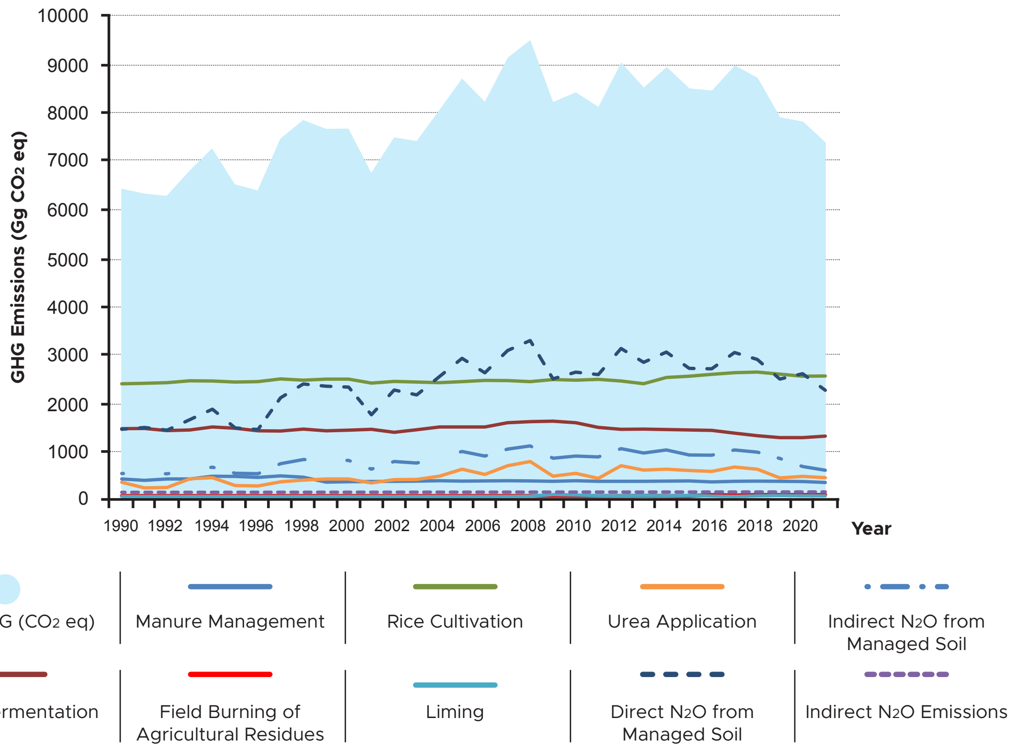


Figure SIC5.3 **Agriculture GHG Emission in Time Series 1990-2021**



Sectoral Summary

The sectoral summary of the agriculture sector is shown in Table SIC5.2 and Table SIC5.3.

Table SIC5.2 **Summary of GHG Emissions for Agriculture Sector in 2021**

Sub-sector	Gas	Emissions (Gg)	GWPs	CO_2 Equivalent (Gg)
		A	B	C= (A x B)
3.A. Enteric Fermentation	CH_4	44.5588	28	1,247.6452
3.B. Manure Management	CH_4 N_2O	9.3108 0.1024	28 265	260.7035 27.1358
3.B.5. Indirect N_2O Emissions	N_2O	0.4102	265	108.7090
3.C. Rice Cultivations	CH_4	89.2677	28	2,499.4968
3.D.1. Direct N_2O Emissions from managed soils	N_2O	8.3070	265	2,201.3540
3.D.2. Indirect N_2O Emissions from managed soils	N_2O	2.0480	265	542.7078
3.F. Field Burning of Agricultural Residues	CH_4 N_2O	0.3051 0.0079	28 265	8.5434 2.0963
3.G. Liming	CO_2	17.1801	1	17.1801
3.H. Urea Application	CO_2	394.4713	1	394.4713
			Total (Emissions)	**7,310.0432**

Table SIC5.3 **Sectoral Summary for Agriculture Sector in 2021**

GHG Source and Sink Categories		Latest Year Total: 2021 (Gg CO_2 eq.)	2005 - Latest Year Trend (2021) (%)	Recalculation
3.A.	**Enteric Fermentation**	1,247.6452	Decreased	New CSEF on other cattle Revise AD on certain years
3.B.	**Manure Management**	287.8393	Decreased	Changes on TAM (other cattle, swine) Revise AD based on NAPA (swine and poultry) Changes other cattle N2O EF to default value (1.0)
3.B.5.	**Indirect N_2O Emissions**	108.7090	Increased	Changes on NAPA (swine, poultry)
3.C.	**Rice Cultivations**	2,499.4968	Increased	
3.F.	**Field Burning of Agricultural Residues**	10.6396	Increase	
3.G.	**Liming**	17.1801	Decreased	Recalculation since 2008 (new AD)
3.H.	**Urea Application**	394.4713	Decreased	Revised on activity data
3.D.1.	**Direct N_2O Emissions from managed soils**	2,201.3540	Decreased	Revised on activity data
3.D.2.	**Indirect N_2O Emissions from managed soils**	542.7078	Decreased	

Sectoral Improvement Undertaken

The sectoral improvement undertaken of the agriculture sector is shown in Table SIC5.4 .

Table SIC5.4 **Sectoral Improvement Undertaken**

Sub-Category	Improvement	Description
3.A. Enteric Fermentation	New EF for the other cattle	A field survey found the industry dominated by KK crosses cattle with average value is 305.9 kg. Changes to nearest CSEF which is based on KK Elit breed to represent industry. New enteric CSEF is 51.35 kg CH4/animal/y.
3.B. Manure Management	Revised on the TAM (other cattle and swine) Revised live length (NAPA: on swine and poultry)	N_2O EF on other cattle manure management thus revised 1.24 to 1.0 (default value).
3.B.5. Indirect N_2O Emissions	Revised on the TAM (other cattle and swine) Revised live length (NAPA: on swine and poultry)	The changes of the TAM (other cattle and swine) and live length (NAPA: on swine and poultry) will result in recalculation on the emission in the whole time series.
3.C. Rice Cultivations		
3.D.1. Direct N_2O Emissions from managed soils	Revised FSN	Major changes in urea activity data and revised paddy cultivation area (2015 & 2016)
3.D.2. Indirect N_2O Emissions from managed soils	Revised and improvement activity data obtained for FSN: N in synthetic fertilisers from time series to recent years.	Revision of Indirect N_2O Emissions from managed soils in line with changes in synthetic fertilisers.
3.F. Field Burning of Agricultural Residues		
3.G. Liming	Improvement on the activity data completeness	Improvement of liming application data by data provider (KPKM)
3.H. Urea Application	Revised and improvement activity data obtained	Changes in urea activity data by data provider (PETRONAS)

5.2 Enteric Fermentation (CRT Category 3.A.)

5.2.1 Category Description

CH_4 in herbivores is produced as a by-product of enteric fermentation, a digestive process where micro-organisms break down carbohydrates into simple molecules that can be absorbed by the animal. This process is essential for the digestion of fibrous plant materials, which are a major component of herbivorous diets. The amount of methane released during enteric fermentation depends on various factors, including the animal's digestive system, age, weight, and the quality and quantity of feed consumed. These variables influence the efficiency of the fermentation process and, consequently, the volume of CH_4 produced.

Ruminant animals, such as cattle and sheep, are significant CH_4 producers due to their complex stomach systems designed to ferment large quantities of fibrous plant material. In contrast, non-ruminants like pigs and horses produce moderate amounts of CH_4 as their digestive systems are less specialised for fermentation. In Malaysia, livestock such as cattle and goats are among the prominent contributors to CH_4 emissions, largely due to the country's agricultural practices (smallholders, grazing, free-range, low-quality feed). The reliance on ruminants for meat and dairy production in Malaysia in addition to increasing demand underscores the importance of managing CH_4 emissions in the agricultural sector to mitigate environmental impact (Table SIC5.5).

Table SIC5.5 Overview of Removal/Emissions Covered Under 3.A. Enteric Fermentation

Emissions Source	Source Included	Methods	Emissions Factors
	3.A. Enteric fermentation		
	– Dairy Cattle	T1	D
	– Non-dairy cattle	T1	CSEF
	– Buffalo	T1	D
	– Sheep	T1	D
	– Goats	T1	D
	– Horses	T1	D
	– Swine	T1	D
Gasses Reported	CH_4		
Key Categories (KCA)	Yes		
Coverages	National		
Major Improvements since last submitted	Improvement during estimation based on newer activity data and parameter on other cattle, poultry (chicken and ducks) and swine. Improvement in AD involved on TAM of other cattle and its EF. There are changes on the beef cattle TAM. A recent study found that native KK crossbred breed with mature males and females weighs 369.8 kg and 242.0 kg, respectively. The average value of 305.9 kg is utilised for the estimation. New other cattle EF based on KK Elite cattle, which is 51.35 kg CH4/head/year will be used for emission estimation, replacing the previous value which is based on Brakmas cattle. Improvement in AD involved on TAM of swine. The swine market weight, previously at 105 kg is revised to 105.5 kg based on latest publication. In addition, the swine lifespan for production is 6.5 months following similar publication.		

5.2.2 Methodological Issues

The methodological issues and emission factors of 3.A Enteric Fermentation is shown in Table SIC5.6 and Table SIC5.7.

Table SIC5.6 **Methodological Issues of 3.A Enteric Fermentation**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Enteric Fermentation	Livestock population numbers	No dairy cows in Sarawak till 2018	Livestock Statistics (DVS); FAOSTAT

Table SIC5.7 **Emission Factors of 3.A Enteric Fermentation**

Sub-sector	Emission Factor			Data Source
	CO_2	CH_4	N_2O	
3.A. Enteric Fermentation (kg head^{-1} year^{-1})				
Dairy Cattle		68		IPCC GLs (2006)
Other Cattle		51.35		CSEF
Buffalo		55		IPCC GLs (2006)
Sheep		5		IPCC GLs (2006)
Goats		5		IPCC GLs (2006)
Camels				
Horses		18		IPCC GLs (2006)
Mules and Asses				
Swine		1		IPCC GLs (2006)
Poultry (Chicken)				IPCC GLs (2006)
Poultry (Ducks)				IPCC GLs (2006)
Other[1]				

5.2.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.2.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.2.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures, which is described in sub chapter 1.5 of the NID.

Data required for national GHG inventory is compiled through legislation by agencies and reported at national level. QC is undertaken for activity data by comparing the data against international databases and publications. The Sectoral Working Group (SWG) for agriculture checks and approves all the data dan emission factors. Check for consistency in data between categories and completeness are undertaken by the agriculture coordinating agency and discussed in the SWG meetings. Analysis of time series is also undertaken to ensure, input of values into the IPCC software is correct and the standard of data quality is maintained. Regular data compilation reviews are undertaken with data providers to ensure the correct use of data. Data is compiled into a database as archiving of information. The IPCC software is also another method for archiving of information.

5.2.6 Category-Specific Recalculations

The Malaysia livestock population was reviewed and shall follow updated statistical population provided by the DVS Putrajaya (Appendix 12.5: livestock activity data). The beef cattle TAM used in the previous BUR4 was 425.0 kg which is over-estimated comparing to weight acquired from a recent field survey. Based on the survey, KK crosses represented 75% of beef cattle population in Peninsular Malaysia with males weighing 369.8 kg and females 242.0 kg, and average value of 305.9 kg[22]. A CSEF for enteric CH_4 emission of 51.35 kg CH_4/animal/y based on KK Elit breed is utilised for the estimation which would closely represent the industry.

[22] (Mohd Saufi B.* A. A., 2023)

The swine market weight is revised to 105.5 kg following later published journal[23, 24]. Swine annual productions length are around 6.5 months following similar publication. Recalculation was carried out for the whole time period of 1990-2021.

5.2.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

5.3 Manure Management (CRT Category 3.B.)

5.3.1 Category Description

CH_4 is produced from the anaerobic decomposition of manure in the absence of oxygen, which typically occurs in confined livestock operations such as dairy farms, beef feedlots, and swine or poultry farms. In Malaysia, where intensive livestock farming is common, these conditions are prevalent in large-scale cattle, swine, and poultry operations, often utilising liquid-based manure management systems that facilitate CH_4 production.

N_2O emissions from manure occur both directly and indirectly in pasture-based systems and confined areas, as seen in Malaysia's diverse livestock management practices. Direct N_2O emissions are produced through nitrification, an oxygen-dependent process that convert ammonia nitrogen to nitrates (NO_3^-), while anaerobic conditions lead to denitrification, converting NO_3^- and nitrites to N_2O and nitrogen gas (N_2). In Malaysia, these emissions are influenced by factors such as the nitrogen and carbon content of the manure, storage duration, and the specific treatment methods used in local livestock farming (refer Table SIC5.8).

[23] (Moktir Singh Gardir Singh and Rachel Wai Jing Fong, 2014)
[24] (Michelle-Fong, 2018)

Table SIC5.8 Overview of Removal/Emissions Covered Under 3.B Manure management

Emissions Source	Source Included	Methods	Emissions Factors
	3.B. Manure management – Dairy Cattle – Non-dairy cattle – Buffalo – Sheep – Goats – Horses – Swine – Poultry (chicken and ducks)	 T1 T1 T1 T1 T1 T1 T1 T1	 D D D D D D D D
Gasses Reported	CH_4, N_2O		
Key Categories (KCA)	Yes		
Coverages	National		
Major Improvements since last submitted	Improvements during estimation based on newer activity data on other cattle, poultry (chicken and ducks) and swine. There are changes on the average annual population data for poultry (chickens and ducks) and swine. Population data will be based on NAPA value rather than the total annual population reported, which is used in previous reporting. This aligns with the IPCC software requirements. The average annual population also resulted in more accurate emission estimation in poultry and swine number. Changes on the TAM value as per 3.A.1 (Enteric Fermentation) sub activity thus the emission estimations are recalculated. New EF for manure management from other cattle (beef) will be used, which is 1.0 (IPCC default value) replacing the previous value of 1.24 to avoid over-estimation of emission.		

5.2.3 Methodological Issues

The methodological issues and emission factors of 3.B Manure Management is shown in Table SIC5.9 and Table SIC5.10.

Table SIC5.9 Methodological Issues of 3.B Manure management

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Manure Management	Animal population	Proportions of the animal waste management system	Livestock Statistics
		Fractions of Manure, Waste Management Systems		Expert Judgment

Table SIC5.10 Emission Factors of 3.B Manure management

Sub-sector	Emission Factor			Data Source
	CO_2	CH_4	N_2O	
3.B. Manure Management (kg head^{-1} year^{-1})				
Dairy Cattle		31		IPCC GLs (2006)
Other Cattle		1.0		IPCC GLs (2006)
Buffalo		2		IPCC GLs (2006)
Sheep		0.2		IPCC GLs (2006)
Goats		0.22		IPCC GLs (2006)
Horses		2.19		IPCC GLs (2006)
Mules and Asses				
Swine		7		IPCC GLs (2006)
All animal above solid storage			0.005	IPCC GLs (2006)
Uncovered lagoon (N_2O only)			0.000	IPCC GLs (2006)
Poultry (Chicken)		0.02		IPCC GLs (2006)
Poultry (Ducks)		0.02		IPCC GLs (2006)
Poultry manure solid storage			0.005	IPCC GLs (2006)
Poultry manure with and without litter			0.001	IPCC GLs (2006)

5.3.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.3.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.3.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A category earlier.

5.3.6 Category-Specific Recalculations

Similar updated activity data utilised in the estimation of enteric CH_4 emissions is applied in the estimation of N_2O emission for animal waste. The typical animal mass utilised is updated to 305.9 kg. Changes in the TAM will lead to an overestimation of N_2O emissions. Therefore, it is necessary to adjust the N_2O EF for the cattle to IPCC's default value of 1.0, from the previous 1.24. The market weight of swine has been revised to 105.5 kg following more recent publications[25, 26]. Swine annual productions cycle lasts around 6.5 months. Recalculation was carried out in the whole time period from 1990-2021.

5.3.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

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[25] (Moktir Singh Gardir Singh and Rachel Wai Jing Fong, 2014)
[26] (Michelle-Fong, 2018)

5.4 Indirect N_2O Emissions (CRT Category 3.B.5.)

5.4.1 Category Description

In Malaysia, indirect GHG emissions primarily result from the volatilisation of nitrogen in the forms of NH_3 and nitrogen oxides (NOx). The fraction of excreted organic N that is mineralised to ammonia nitrogen during manure collection and storage largely depends on the duration of storage and, to a lesser extent, temperature. Simple organic nitrogen compounds, such as urea from mammals and uric acid from poultry, are rapidly mineralised to ammonia nitrogen. This ammonia nitrogen is highly volatile and easily diffuses into the surrounding air, contributing to indirect emissions.

Nitrogen losses commence at the point of excretion in animal housing facilities and other production areas such as milking parlours. These losses persist through on-site management in storage and treatment systems, commonly referred to as manure management systems. Additionally, nitrogen is lost through runoff and leaching into soils from the solid storage of manure in outdoor areas, feedlots, and grazing pastures (Table SIC5.11).

Table SIC5.11 Overview of Removal/Emissions Covered Under 3.B.5 Indirect N_2O

Emissions Source	Source Included	Methods	Emissions Factors
	3.B.5. Indirect N_2O Emissions – Amount of manure nitrogen lost due to volatilisation of NH_3 and Nox. – Leaching and runoff from manure management	 T1 T1	 D D
Gasses Reported	N_2O		
Key Categories (KCA)	No		
Coverages	National		
Major Improvements since last submitted	No major improvements have been made to emissions from this category.		

5.4.2 Methodological Issues

The methodological issues and emission factors of 3.B.5. Indirect N_2O Emissions is shown in Table SIC5.12 and Table SIC5.13.

Table SIC5.12 **Methodological Issues of 3.B.5. Indirect N_2O Emissions**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Indirect N_2O Emissions	Animal population	Experts' judgements were used to identify the manure management systems for indirect N_2O emissions which are poultry manure with litter, poultry manure without litter, solid storage and uncovered anaerobic lagoon.	Livestock Statistics
		Fractions of Manure, Waste Management Systems		Expert Judgment

Table SIC5.13 **Emission Factors of 3.B.5. Indirect N_2O Emissions**

Sub-sector	Emission Factor			Data Source
	CO_2	CH_4	N_2O	
3.B.5. Indirect N_2O emissions [kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$]				
Poultry Manure with and without Litter			0.01	IPCC GLs (2006)
Solid Storage (Buffalo, Dairy Cows, Goats, Other Cattle, Sheep, Swine)			0.01	IPCC GLs (2006)
Uncovered Anaerobic Lagoon Dairy (Cows, Other Cattle, Swine)			0.01	IPCC GLs (2006)

5.4.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.4.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.4.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A. category earlier.

5.4.6 Category-Specific Recalculations

Recalculation conducted due to changes of the other cattle TAM, Swine and the changes on the number of animals produced in a year (NAPA: swine and poultry).

5.4.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

5.5 Rice Cultivations (CRT Category 3.C.)

5.5.1 Category Description

In flooded conditions, such as wetlands and paddy rice fields, decomposing organic matter releases significant amounts of CH_4 into the atmosphere as in Table SIC5.14. This is particularly notable in countries with extensive rice cultivation. Although CH_4 is generally emitted from all flooded soils, the net soil carbon stocks can vary based on management practices and environmental factors. In well-drained soils, CH_4 is consumed by methanotrophic bacteria. In flooded rice fields, CH_4 is produced through anaerobic decomposition and escapes via air bubbles and rice plants. The emissions depend on factors such as rice species, harvest frequency, soil type, temperature, irrigation, and fertiliser use.

In Malaysia, rice is planted in two main seasons: the main season and the off-season, allowing for two annual harvests. About 64% of the rice is cultivated in designated granary areas under completely flooded conditions, facilitated by an efficient system of canals and irrigation managed by government agencies. Meanwhile, 27% of the rice is grown in non-granary areas, which rely on simpler irrigation systems, rain-fed conditions, and river water, with the rate of CH_4 emissions is determined at 27%. Additionally, 8% of the rice is cultivated in upland areas in Sabah and Sarawak regions without any irrigation, relying entirely on rainwater.

Table SIC5.14 **Overview of Removal/Emissions Covered Under 3.C Rice Cultivations**

Emissions Source	Source Included	Methods	Emissions Factors
	3.C. Rice Cultivations	T1	CSEF (regional)
Gasses Reported	CH_4		
Key Categories (KCA)	Yes		
Coverages	National		
Major Improvements since last submitted	No major improvements have been made to emissions from this category.		

5.5.2 Methodological Issues

The methodological issues and emission factors of 3.C. Rice Cultivations is shown in Table SIC5.15 and Table SIC5.16.

Table SIC5.15 **Methodological Issues of 3.C. Rice Cultivations**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Rice Cultivations	Annual rice production areas	- Annual rainfed area = annual planted non-granary area - Planted area in Sabah/Sarawak for wet season = 100% of the parcel area - All rice in irrigated areas is under continuous flooding and no intermittent drainage (single or multiple aeration) - There is no drought-prone and deep-water rice in Malaysia	Agrofood Statistics 2020, MAFS; Document provided by DOA, 2022.

Table SIC5.16 **Emission Factors of 3.C. Rice Cultivations**

Sub-sector	Emission Factor			Data Source
	CO_2	CH_4	N_2O	
3.C Rice cultivations (kg CH4 ha^{-1} day^{-1})				
Irrigated (Granary)		1.6		CSEF (Regional)
Rainfed (Non-granary)		1.6		CSEF (Regional)
Upland		1.6		CSEF (Regional)

5.5.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.5.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.5.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A. category earlier.

5.5.6 Category-Specific Recalculations

No recalculations have been made to emissions from this category.

5.5.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

5.6 Direct N_2O Emissions from Managed Soils (CRT Category 3.D.1.)

5.6.1 Category Description

N_2O is naturally produced in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of NH_4^+ to NO_3^-, while denitrification is the anaerobic microbial reduction of NO_3^- to nitrogen gas (N_2). N_2O acts as a gaseous intermediate in the reaction sequence of denitrification and as a by-product of nitrification that escapes from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in these reactions is the availability of inorganic N in the soil. N_2O emissions of resulting from anthropogenic N inputs or N mineralisation occur through both a direct pathway and two indirect pathways. The direct pathway involves emissions directly from the soils to which the N is added or released. The two indirect pathways are as follows:

i. Following the volatilisation of ammonia (NH_3) and nitrogen oxides (NO_2) from managed soils, fossil fuel combustion, and biomass burning, and the subsequent redeposition of these gasses and their products (NH_4^+ and NO_3^-) to soils and waters.
ii. After the leaching and runoff of N, mainly as NO_3^-, from managed soils.

This understanding aligns with the definitions and guidelines provided in Chapter 1, Section 1.1 of Volume 4: Agriculture, Forestry and Other Land Use, as outlined in the 2006 IPCC Guidelines for National GHG Inventories. In the context of Malaysia, direct N_2O emissions from managed soils were the primary contributors to GHGs emissions in the agricultural sector, totalling 3,736.73 Gg CO_2 eq. in 2019 (Table SIC5.17).

Table SIC5.17 **Overview of Removal/Emissions Covered Under 3.D.1. Direct N_2O Emissions from Managed Soils**

Emissions Source	Source Included	Methods	Emissions Factors
	3.D.1. Direct N_2O Emissions from Managed Soils		
	– FSN: N in synthetic fertilisers	T1	D
	– FON: N in animal manure, compost, sewage sludge and other.	T1	D
	– FCR: N in crop residues	T1	D
	– Managed organic soils	T1	D
Gasses Reported	N_2O		
Key Categories (KCA)	Yes		
Coverages	National		
Major Improvements since last submitted	Revised and improvement activity data obtained for FSN: N in synthetic fertilisers from time series to recent years.		

5.6.2 Methodological Issues

The methodological issues and emission factors of 3.C.4. direct N_2O emissions from managed soil is shown in Table SIC5.18 and Table SIC5.19.

Table SIC5.18 **Methodological Issues of 3.D.1. Direct N_2O Emissions from Managed Soils**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Direct N_2O Emissions from Managed soil	Annual amount of import and export for different types of-N-based fertilisers	Data are based on the consumption of nitrogenous fertiliser in the country. Calculations of consumption of total nitrogenous fertiliser under managed soil were based on production + import – export	Document provided by KPKM, 2023
		Annual amount of urea production	Synthetic fertiliser usage for flooded rice was calculated based on flooded paddy hectarage multiply by 104 kg N FCR (flooded rice): N in crop residue for flooded rice was calculated for rice straw based on total above and below-ground biomass with 0.7% N content basis for below-ground and 0.4% N content for above ground	The document provided by PETRONAS, 2024
		Annual amount of Oil palm trunk (OPT) and Oil Palm Fronds (OPF) & Empty Fruit Bunches (EFB)	FCR (managed soil): Other crop residue involved were oil palm trunk (OPT), oil palm frond (OPF) and empty fruit bunch (EFB). 50% of OPF and OPT were removed from the plantation and are not calculated as part of FCR	Malaysia Oil Palm Statistics 2015; Official Portal of Malaysian Palm Oil Board
		Amount of Rice Straw	FCR (flooded rice): N in crop residue for flooded rice was calculated for rice straw based on total above and below-ground biomass with 0.7% N content basis for below-ground and 0.4% N content for above ground	Paddy Statistics Expert Judgment
		Fractions of Manure, Waste Management Systems	Expert judgement determined that 40% of manure is applied as animal feed but the actual is 0% as following animal feed act. The actual 40% were considered as others (no 'others' option in the inventory format) which remained untreated/ unprocessed on the floor, with a minor percentage being burned, dumped as is, or other unknown activities which not listed	

Table SIC5.19 **Emission Factors of 3.D.1. Direct N_2O Emissions from Managed Soils**

Sub-sector	Emission Factor			Data Source
	CO_2	CH_4	N_2O	
3.D.1. Direct N_2O emissions from Managed Soils [kg N2O-N (kg N input)$^{-1}$]				
Anthropogenic N input types to estimate annual direct N_2O-N emissions produced from managed soils			0.01	IPCC GLs (2006)
Synthetic fertilisers animal manure, compost, sewage sludge			0.01	IPCC GLs (2006)
Crop residues			0.01	IPCC GLs (2006)
Changes to land use or management			0.01	IPCC GLs (2006)
Anthropogenic N input types to estimate annual direct N_2O-N emissions produced from flooded rice				IPCC GLs (2006)
Synthetic fertilisers			0.003	IPCC GLs (2006)
Animal manure, compost, sewage sludge			0.003	IPCC GLs (2006)
Crop residues			0.003	IPCC GLs (2006)
Changes to land use or management			0.003	IPCC GLs (2006)
Managed organic soils Oil Palm (Organic Soils) [drained/managed organic soils]			1.2	IPCC GLs (2006)
Urine and dung inputs to grazed soils				
CPP			0.02	IPCC GLs (2006)
SO			0.01	IPCC GLs (2006)

5.6.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.6.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.6.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A. category earlier.

5.6.6 Category-Specific Recalculations

No recalculations have been made to emissions from this category.No recalculations have been made to emissions from this category.

5.6.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).Chapter).

5.7 Indirect N_2O Emissions from Managed Soils (CRT Category 3.D.2.)

5.7.1 Category Description

The second pathway contributing to Malaysia's GHG emissions as show in Table SIC5.20 involves the leaching and runoff of N from synthetic and organic fertiliser applications, crop residues, and the mineralisation of nitrogen associated with soil carbon (C) loss in mineral and drained/managed organic soils due to land-use changes or management practices. Additionally, urine and dung deposition from grazing animals contributes to this pathway. Nitrogen in inorganic forms, mainly NO_3, can bypass biological retention mechanisms in the soil/vegetation system through overland water flow (runoff) or flow through soil macropores or pipe drains. When nitrate is present in the soil in excess of biological demand, such as under cattle urine patches, the excess leaches through the soil profile. This leached nitrate undergoes nitrification and denitrification processes, which convert some NH_4^+ and NO_3^- into N_2O, a potent GHG. This may take place in the groundwater below the land to which the N was applied, or in riparian zones receiving drain or runoff water, or in the ditches, streams, rivers and estuaries (and their sediments) into which the land drainage water eventually flows.

Table SIC5.20 Overview of Removal/Emissions Covered Under 3.D.2. Indirect N_2O Emissions from Managed Soils

Emissions Source	Source Included	Methods	Emissions Factors
	3.D.2. Indirect N_2O Emissions from managed soils – N Volatilised from managed soils. – N leaching/runoff from managed soils	 T1 T1	 D D
Gasses Reported	N_2O		
Key Categories (KCA)	No		
Coverages	National		
Major Improvements since last submitted	No major improvements have been made to emissions from this category		

5.7.2 Methodological Issues

The methodological issues and emission factors of 3.C.5. Indirect N_2O Emissions from Managed Soil is shown in Table SIC5.21 and Table SIC5.22.

Table SIC5.21 Methodological Issues 3.D.2. Indirect N_2O Emissions from Managed Soils

Choice of Method	Tier 1				
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**	
	Indirect N_2O Emissions from managed soils	Same as Direct Manure Management	N_2O emissions are obtained by calculating N input. N_2O emissions estimated based on deposition of N volatilisation, leaching and runoff from managed soil	Same as Direct Manure Management	

Table SIC5.22 **Emission Factors of 3.C.5. Indirect N_2O Emissions from Managed Soils**

Sub-sector	Emission Factor			Data Source
	CO_2	CH_4	N_2O	
3.D.2 Indirect N_2O emissions from Managed Soils (kg N_2O-N) (kg NH_3-N + NO_x-N volatilized)$^{-1}$				
N_2O from Atmospheric Deposition of N Volatilised from Managed Soils			0.01	IPCC GLs (2006)
N_2O from N leaching/runoff from Managed Soils			0.008	IPCC GLs (2006)

5.7.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.7.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.7.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A. category earlier.

5.7.6 Category-Specific Recalculations

No recalculations have been made to emissions from this category.

5.7.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

5.8 Field Burning of Agricultural Residues (CRT Category 2.F.)

5.7.1 Category Description

Biomass burning, including human-initiated and natural fires, involves the combustion of living and dead vegetation. It releases non-CO_2 emissions such as CH_4, CO, NOx, and N_2O, particularly from the burning agricultural residues, which vary by country and crop management. CO_4 emissions from biomass burning are not reported, as the carbon released is assumed to be reabsorbed by new vegetation in the next growing season.

In current agricultural practices, biomass burning is reported from rice production and is limited to approximately 10% of granary areas. After harvest, the majority of rice farmers incorporate rice straw into the soil. Other crops do not involve biomass burning and instead use alternative residue management methods (Table SIC5.23).

Table SIC5.23 Overview of Removal/Emissions Covered Under 3.F Field Burning of Agricultural Residues

Emissions Source	Source Included	Methods	Emissions Factors
	3.F Field Burning of Agricultural Residues	T1	D
Gasses Reported	CH_4, N_2O, CO, NOx		
Key Categories (KCA)	No		
Coverages	National		
Major Improvements since last submitted	No major improvements have been made to emissions from this category		

5.8.2 Methodological Issues

The methodological issues and emission factors of 3.F. Field Burning of Agricultural Residues is shown in Table SIC5.24: Methodological Issues of 3.F. Field Burning of Agricultural Residues and Table SIC5.25.

Table SIC5.24 **Methodological Issues of 3.F. Field Burning of Agricultural Residues**

Choice of Method	Tier 1			
Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
	Field Burning of Agricultural Residues	Fraction of area burnt in paddy fields	Burning practices only on paddy fields at a proportion 10% of irrigated granary area during the dry season Agricultural residues were burnt completely (Combustion factor = 1)	Agrofood Statistics 2020, MAFS; Document provided by DOA, 2022.

Table SIC5.25 **Emissions Factors of 3.F. Field Burning of Agricultural Residues**

Sub-sector	Emission Factor						Data Source
	CO_2	CH_4	N_2O	CO	NOx	C	
3.F. Field Burning of Agricultural Residues [g GHG (kg dm burnt)$^{-1}$]		2.7	0.07	9.2	2,5		IPCC GLs (2006)

5.8.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.8.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.8.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A. category earlier.

5.8.6 Category-Specific Recalculations

No recalculations have been made to emissions from this category.

5.8.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

5.9 Liming (CRT Category 3.G.)

5.9.1 Category Description

Liming is a common practice aimed at reducing soil acidity and promoting plant growth in managed environments, particularly in agricultural lands and managed forests. The addition of carbonates such as calcic limestone ($CaCO_3$) or dolomite ($CaMg\ (CO_3)_2$) to soils during the liming processes results in the release of CO_2 as the carbonates dissolve and release bicarbonate ($2HCO_3^-$), which subsequently decomposes into CO_2 and water (H2O) (Table SIC5.26). Lime plays a crucial role in agriculture by maintaining optimal soil pH levels, a critical factor influencing the availability and uptake of essential nutrients by crops[27]. Moreover, incorporating lime into soil has been proven beneficial in improving soil structure, enhancing water-holding capacity, and fostering microbial activity. These improvements collectively contribute to enhanced plant growth and productivity. The strategic use of lime in agriculture holds significant potential for achieving sustainable agricultural goals by enhancing soil health, increasing crop yields, and ultimately bolstering food production[28].

[27] (Jamilah, 2010, January 1)
[28] (Zainol F. A., 2021)

Table SIC5.26 **Overview of Removal/Emissions Covered Under 3.G. Liming**

Emissions Source	Source Included	Methods	Emissions Factors
	3.G. Liming Limestone	T1 T1	D D
Gasses Reported	CO_2		
Key Categories (KCA)	No		
Coverages	National		
Major Improvements since last submitted	Revised of activity data. Newer limestone data obtained from the stakeholder since 2008 to recent years.		

5.9.2 Methodological Issues

The methodological issues and emission factors of 3.G. liming is shown in Table SIC5.27 and Table SIC5.28.

Table SIC5.27 **Methodological Issues of 3.G. Liming**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Liming	Annual amount of subsidised lime for paddy	New data from the KPKM shows a revision starting from the year 2008. The subsidy scheme for liming was applied to paddy crops, and there are no records indicating that it was purchased or used directly by farmers.	Document provided by KPKM, 2024.

Table SIC5.28 **Emission Factors of 3.G. Liming**

Sub-sector		Emission Factor			Data Source
		CO_2	CH_4	N_2O	
3.G.	Liming				
	Limestone [tonnes of C (tonne of limestone)-1]	0.12			IPCC GLs (2006)

5.9.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.9.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.9.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A. category earlier.

5.9.6 Category-Specific Recalculations

A latest activity data obtained from the year 2008. A recalculation was made to all AD year obtained.

5.9.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

5.10 Urea Application (CRT Category 3.H.)

5.10.1 Category Description

Urea (Table SIC5.29) is indispensable in Malaysian agriculture for its high nitrogen content, which crucial for enhancing crop productivity[29]. Despite its agricultural benefits, the application of urea raises significant environmental concerns, particularly regarding GHG emissions. In 2019, Malaysia reported emissions of 389.89 Gg CO_2 eq. from urea application.

These emissions are compounded by substantial nitrogen losses, typically ranging from 50% to 70%, due to volatilisation and leaching following application. When urea is applied to soils during fertilisation, it releases CO_2 that was sequestered during its industrial production. Upon interaction with water and urease enzymes, urea ($CO(NH_2)_2$) is converted into ammonium (NH_4^+), hydroxyl ion (OH^-), and bicarbonate (HCO_3^-). Similar to the soil's response to lime addition, bicarbonate further breaks down into CO_2 and water. This emission category is significant due to the atmospheric CO_2 originally removed during urea manufacturing; a factor assessed within the IPPU Sector.

Table SIC5.29 **Overview of Removal/Emissions Covered Under 3.H. Urea Application**

Emissions Source	Source Included	Methods	Emissions Factors
	3.H. Urea Application	T1	D
Gasses Reported	CO_2		
Key Categories (KCA)	No		
Coverages	National		
Major Improvements since last submitted	Revised of activity data from time series 1990 to recent years.		

[29] (Pawar, A., Chauhan, M R., Mod, P., & Wade, G. , 2017)

5.10.2 Methodological Issues

The methodological issues and emission factors of 3.H. urea application is shown in Table SIC5.30 and Table SIC5.31.

Table SIC5.30 **Methodological Issues of 3.G. Liming**

Choice of Method	Tier 1			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Urea application	Annual amount of import and export for urea	Consumptions of urea are based on the total import and production minus the export amount	Harmonised system data
		Annual amount of urea production		The document provided by PETRONAS, 2022

Table SIC5.31 **Emission Factors of 3.H. Urea Application**

Sub-sector	Emission Factor			Data Source
	CO_2	CH_4	N_2O	
3.H. Urea application [tonnes of C (tonne of urea)$^{-1}$]	0.12			IPCC GLs (2006)

5.10.3 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in Sub-Chapter 1.9 of the NID.

5.10.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 of the NID.

5.10.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures as described in in the QA/QC process of the 3.A. category earlier

5.10.6 Category-Specific Recalculations

The latest activity data obtained from PETRONAS includes changes in certain production years. A recalculation was made for all activity data years obtained.

5.10.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Table SIC5.32: Planned Improvements for the Agriculture Sector (in the last sub-chapter of Agriculture Chapter).

5.11 Category Specific Plan Improvements

The category specific plan improvements of agriculture sectors are shown in Table SIC5.32.

Table SIC5.32 **Planned Improvements for the Agriculture Sector**

Category	Improvement	Description Improvement	Progress
Cross Cutting	Address completeness of agriculture subcategories with estimates reported	Improve completeness of reporting pools in mandatory categories currently reported as NE.	Work is in progress
Livestock	Other cattle enteric fermentation GHG estimation	There is a need to shift the other cattle to simplified Tier 2 for more accurate estimation.	In progress require capacity building
	Other cattle EF	The improvement in local other cattle emission factor which more representative to national industry practices.	In progress
	Improvement in poultry sub-categories	Suggestion to breakdown poultry (chicken and ducks) to broiler and layer.	In progress with AD collection and QC
	Additional AD	Additional of other livestock if possible, such as “Deer”.	In progress with AD collection and QC
Rice Cultivation	New EF	The current project able to address the EF and improve the accuracy with the data availability.	In progress
	Cultivation period	Review the emissions based on the rice cultivation period. Rice cultivation period can be reduced from 120 days to 110 days due to the new varieties introduced having shorter maturity periods.	Require expert judgement

5.12 Uncertainty Assessment for Agriculture Sector

The uncertainty in agriculture sector for year 2005 stands at 59.48%. Table SIC5.33 shows the uncertainty analysis table.

Table SIC5.33 **Uncertainty for Agriculture Sector for 2005**

CRT category		Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
			(Gg CO_2 equivalent)	%	%	%	
3. Agriculture							
3.A. Enteric fermentation		CH_4	1,626.37	13.23%	97.47%	98.36%	0.02
3.B. Manure management		CH_4 N_2O	567.61 86.07	15.00% 15.00%	93.81% 141.42%	95.00% 142.21%	0.00 0.00
3.B.5. Indirect N_2O emissions		N_2O	406.01	16.58%	20.00%	25.98%	0.00
3.C. Rice cultivations		CH_4	2,372.38	10.00%	62.50%	63.29%	0.02
3.D. Agricultural soils	3.D.1 Direct N_2O Emissions from managed soils	N_2O	3,425.87	113.58%	112.85%	160.11%	0.29
	3.D.2. Indirect N_2O Emissions from managed soils	N_2O	1,054.48	90.88%	21.08%	93.29%	0.01
3.F. Field burning of agricultural residues		CH_4 N_2O	17.85 5.29	10.00% 10.00%	0.00% 0.00%	10.00% 10.00%	0.00 0.00
3.G. Liming		CO_2	0.00	50.00%	50.00%	70.71%	0.00
3.H. Urea application		CO_2	575.07	50.00%	50.00%	70.71%	0.00
		Total	**10,136.99**				**0.35**
					Percentage uncertainty in total inventory		**59.48%**

The uncertainty in agriculture sector for year 2021 stands at 56.12%, while the trend uncertainty (based on 2005) is 36.40%. Table SIC5.34 shows the uncertainty analysis table.

Table SIC5.34 **Uncertainty for Agriculture Sector for 2021**

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
3. Agriculture													
3.A. **Enteric Fermentation**		CH_4	1,626.37	1,247.65	13.23%	97.47%	98.36%	0.03	0.01	0.12	0.01	0.02	0.00
3.B. **Manure Management**		CH_4 N_2O	567.61 86.07	260.70 27.14	15.00% 15.00%	93.81% 141.42%	95.00% 142.21%	0.00 0.00	0.01 0.00	0.03 0.00	0.01 0.00	0.01 0.00	0.00 0.00
3.B.5. **Indirect N_2O emissions**		N_2O	406.01	108.71	16.58%	20.00%	25.98%	0.00	0.02	0.01	0.00	0.00	0.00
3.C. **Rice cultivations**		CH_4	2,372.38	2,499.50	10.00%	62.50%	63.29%	0.05	0.08	0.25	0.05	0.03	0.00
3.D. **Agricultural soils**	3.D.1 Direct N_2O Emissions from managed soils	N_2O	3,425.87	2,201.35	113.58%	112.85%	160.11%	0.23	0.03	0.22	0.03	0.35	0.12
	3.D.2. Indirect N_2O Emissions from managed soils	N_2O	1,054.48	542.71	90.88%	21.08%	93.29%	0.00	0.02	0.05	0.00	0.07	0.00
3.F. **Field burning of agricultural residues**		CH_4 N_2O	17.85 5.29	8.54 2.10	10.00% 10.00%	0.00% 0.00%	10.00% 10.00%	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
3.G. Liming		CO_2	0.00	17.18	50.00%	50.00%	70.71%	0.00	0.00	0.00	0.00	0.00	0.00
3.H. Urea application		CO_2	575.07	394.47	50.00%	50.00%	70.71%	0.00	0.00	0.04	0.00	0.03	0.00
Total			**10,136.99**	**7,310.04**				**0.31**					**0.13**
							Percentage uncertainty in total inventory	**56.12%**				**Trend Uncertainty**	**36.40%**

6
CHAPTER

LAND USE, LAND-USE CHANGE AND FORESTRY (CRT SECTOR 4)

6.1 Overview of the Sector

The overview of the Land-Use, Land-Use Change and Forestry (LULUCF) sector is shown in Table SIC6.1.

Table SIC6.1 Overview of the LULUCF Sector

Emission/ Removal Sources	**4.A.1.** Forest Land Remaining Forest Land **4.B.1.** Cropland Remaining Cropland **4.C.1.** Grassland Remaining Grassland **4.D.1.** Wetland Remaining Wetlands **4.E.1.** Settlement Remaining Settlement **4.(I).** Direct and indirect N_2O emissions from N inputs to managed soils **4.(II).** Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils) **4.(III).** Total for all land-use categories (Direct and indirect nitrous oxide (N_2O) emissions from nitrogen (N) mineralisation/immobilisation associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils) **4.(IV).** Total for all land-use categories (Biomass burning)
Gasses Reported	CO_2, CH_4, N_2O
Major improvements since last submission	**4.A.1. Forest Land Remaining Forest Land** Revised activity data from 2015 onwards, updated emission factors for the inland and fallow forests, and inclusion of rewetting in the forest. **4.B.1. Cropland Remaining Cropland** Introduced the new Tier 2 direct CO_2 EFs for cropland on drained organic soils, using new Tier 1 and 2 EFs for indirect (fluvial export in drainage ditches) DOC, inclusion of below-ground biomass and emissions from drained peatlands from other peatlands and revised the growth rates for cocoa, rubber and oil palm. **4.D.1. Wetland Remaining Wetlands** Improvements during estimation based on newer category - Flooded land remaining flooded land. **4.E.1. Settlement Remaining Settlement** Updated activity data and emission factors for forest and cropland.

This chapter provides an assessment of the GHG emissions and removals resulting from land use, land-use change and forestry in Malaysia. The LULUCF sector deals with GHG emissions associated with land use and their management practices for the carbon stored primarily in vegetation. IPCC 2006 Guidelines and 2013 Wetland Supplement were used to calculate the emissions and removals. The land used categories covered in this report are Forest Land, Cropland, Grassland, Wetlands, and Settlements. This assessment includes emissions and removals of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) from forest wildfires, CO_2, CH_4 and N_2O from drained peat swamp forest and peatland. Removals of carbon dioxide are presented as negative quantities. The IPCC software was updated, which also impacted the calculations.

The GHG emissions and removals from Forest Land Remaining Forest Land are reported for all forest ecosystem carbon (C) pools: aboveground biomass, belowground biomass, non-carbon dioxide (non-CO_2) emissions from forest fires and drained organic soil. Emissions and removals from Land Converted to Forest Land are included for aboveground biomass and belowground biomass. Carbon stock change in peat swamp and mangrove forests are included under forest land.

Emissions and removals are reported for Cropland Remaining Cropland and Land Converted to Cropland. Changes in carbon stocks in perennial crops, rubber, oil palm, and cocoa are estimated while a Tier 1 approach is applied for the other perennial crops like fruit trees. Emissions and removals from cropland cultivated in peatlands are also included in this chapter. For the subcategories of Forest Land Converted to Cropland, the changes in aboveground and belowground biomass C stocks are also reported.

During the reporting period, grassland emissions are from draining peatlands in animal husbandry areas. However, there is no change in grassland carbon stocks.

Emissions from Wetlands Remaining Wetlands are reported for the first time. Seasonally flooded wetlands are not explicitly considered in reporting unless modified by human activity. Estimating emissions from flooded land remaining flooded land is a new activity reported. However, the C stock change for the Forest Land converted to Wetlands has been included in the harvest amount in Forest Land Remaining Forest Land.

The change of C stocks from Settlements Remaining Settlements is not reported in this chapter. The reported GHG emissions and removals from Land Converted to Settlements. It includes changes in C stocks in aboveground biomass and belowground biomass due to land use to settlements.

6.1.1 Trends in emissions and removals

The LULUCF sector is the only sector within the national GHG inventory that reports both sources and sinks. The net sink is provided by removals from carbon stock gains in above and belowground biomass exceeding emissions from carbon stock losses and GHG emissions from LULUCF activities. Following the inclusion of emissions from the drainage of organic soils, CH_4 and N_2O make a greater contribution to net LULUCF emissions.

The LULUCF sector covers emissions and removals of direct and indirect GHGs under five categories, of which Forest Land and Cropland are net sinks, Grassland and Wetlands are net sources. Forest Land and Cropland converted to Settlements are net sources.

LULUCF emissions by category for 2021 are shown in Table SIC6.2 with changes against the base year of 2005. The net total sinks increased when compared against 2005. The increase in sinks is contributed by the measures put in place during the COVID-19 pandemic. The reduction in direct N_2O emissions from drained organic soils is contributed primarily due to the shift in crops within the peatlands where a lower emission factor is used.

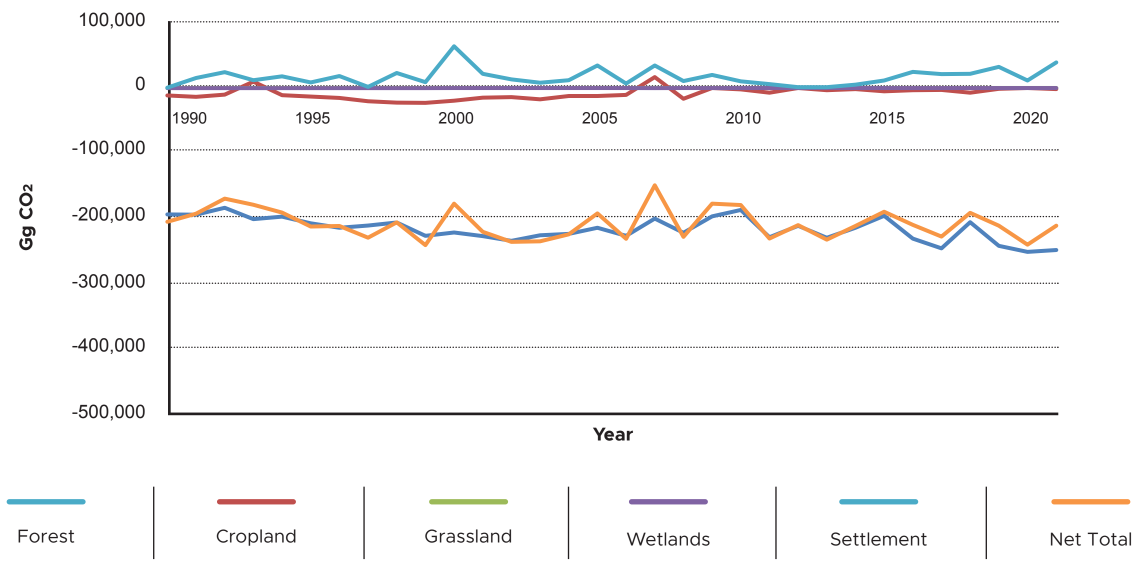
Table SIC6.2 LULUCF Emissions by Categories for 2021

Categories	Gg CO_2 eq.	
	2005	2021
4.A.1. Forest Land Remaining Forest Land	- 214,453.8053	-248,823.4818
4.B.1. Cropland Remaining Cropland	-12,561.0963	-278.0354
4.C.1. Grassland Remaining Grassland	105.0764	105.0764
4.D.1. Wetland Remaining Wetlands	0.4475	0.6500
4.E.1. Settlement Remaining Settlement	34334.9985	34,795.5142
4.(I). Direct and indirect N_2O emissions from N inputs to managed soils	0	0
4.(II). Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)	33.6508	358.0520
4.(III). Total for all land-use categories (Direct and indirect nitrous oxide (N_2O) emissions from nitrogen (N) mineralisation/immobilisation associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	1809.1550	1,552.6350
4.(IV). Total for all land-use categories (Biomass burning)	13.8323	3.4234
Total	**-190,717.7411**	**-212,284.3294**

The trend in total emissions and removals from 1990-2021 is shown in Figure SIC6.1. Overall, the net total sinks have stabilised.

However, in the last ten years, land use change both from forest and cropland has increased significantly. This is primarily due to increased urbanisation, particularly in other parts of the country, where gaps in economic development are being addressed by the government. The underlying trend of declining emissions from LULUCF since year 1990 has been mainly driven by the decline in emissions from forest land conversions to other land uses and the increase in removals through forest regrowth on previously cleared land as well as, putting in place a maximum cap for harvesting from natural forest from year 2006 onwards. Besides, the Third National Agricultural Policy (NAP3) focussed on improving yields in cropland and no expansion from the forest. The government also introduced the Central Forest Spine and Heart of Borneo projects from year 2009. These projects aim to develop corridors and connectivity between forests so that the resilience of forests can be improved while trying to reduce wildlife-human conflicts. Additionally, it also helps in the biodiversity gene flow and conservation efforts.

Figure SIC6.1 **Time Series for the LULUCF Sector (1990-2021)**



The share of emissions per sub-category has changed significantly between the base year and the current year. One of the principal drivers of change in carbon fluxes across Malaysian land use relates to losses and gains in woody biomass. The loss of woody biomass is mainly reported under three classifications: *Forest Land Remaining Forest Land, Cropland Remaining Cropland and Forest Land and Cropland Converted to Settlement, Grassland and Wetlands*.

Temporary losses of woody biomass on forest land are reported under the *Forest Land Remaining Forest Land* classification. Biomass losses are accounted for from harvesting through Sustainable Forest Management (SFM) and wildfires. Most wildfires in Malaysia are small without significant loss in biomass. A regeneration of forest following a harvest or fire event is reported under *Forest Land Remaining Forest Land* as no change in land use has occurred.

Increase in forest land are reported under *Land Converted to Forest Land*. These changes include forest regrowth on land previously cleared for other uses and the regeneration of forests from natural seed sources, which was previously not considered as forest.

In Cropland, the trend for planting is subjected to commodity prices. In the early 1990s, rubber and cocoa were the major commodity crops planted and were replaced with oil palm when the price dropped significantly. The increase and loss of woody biomass in Cropland are due to growth and harvest. The increase in woody biomass is due to an increase in productive areas within Cropland. The food crop planting area remains somewhat the same and is undertaken by small-scale farmers except for rice cultivation. Details on rice cultivation can be referenced under the Agriculture Sector.

Emissions from the settlement are closely linked to the 5-year development plans implemented by the Government. From 1990 onwards, as part of the diversification of the economy, manufacturing, and service centres were established throughout the country. This resulted in increased deforestation and cropland conversion. In the last six years, the development of infrastructure in the Borneo states has been the focus.

6.1.1.1 Forest land

Forest land converted to cropland occurred mostly in the 1970s and 1980s when the large-scale forest was opened for organized smallholders' oil palm and rubber plantations through the Federal Land Development Authority (FELDA), Federal Land Consolidation and Rehabilitation Authority (FELCRA), etc schemes. Post-1990, through the NAP3 (1992-2010), where the emphasis was to increase the productivity of croplands and no expansion from forest land.

Forest land reduced from post-1990 is primarily due to the urbanisation in Malaysia. With an emphasis on balancing development and forest land, expansion occurred primarily from abandoned cropland where natural regeneration of forest occurred and subsequently gazetted as forest. The implementation of Central Forest Spine and Heart of Borneo contributed to an increase in forest areas where some unused areas with natural regeneration were gazetted as forest reserves.

The updated IPCC software has also changed the estimates. The total removals in a year are determined primarily by the movement of forest between the categories. Inland forests converted to plantations or fallow forests would entail a reduction in removals. The large sinks in 2002 are due to no net shift between Inland forests and fallow forests or plantation forests. The same pattern is also noted from year 2019 onwards.

The variation in the net sink is driven primarily due to reduced harvesting. In year 2004, the government approved a maximum cutting limit of 85cm3/ha for natural forests with the implementation from year 2006 onwards. The total timber extraction for a 5-year period is fixed and monitored annually. Additionally logging moratoriums were implemented in some forests. This has contributed to the increase in sinks in the *Forest Land Remaining Forest Land*. The harvest in year 2020 and 2021 significantly reduced due to the measures put in place during the pandemic.

Rewetting of peat swamp forest was undertaken as early as 2008. Rewetting of peat swamp forest has reduced forest fire incidence as shown in the pictures below. In this report, a total of 1,200 ha of rewetting of peat swamp forest is reported and emissions are estimated.

Figure SIC6.2 Total Emissions (Gg CO_2) from Forest Land (1990-2021)

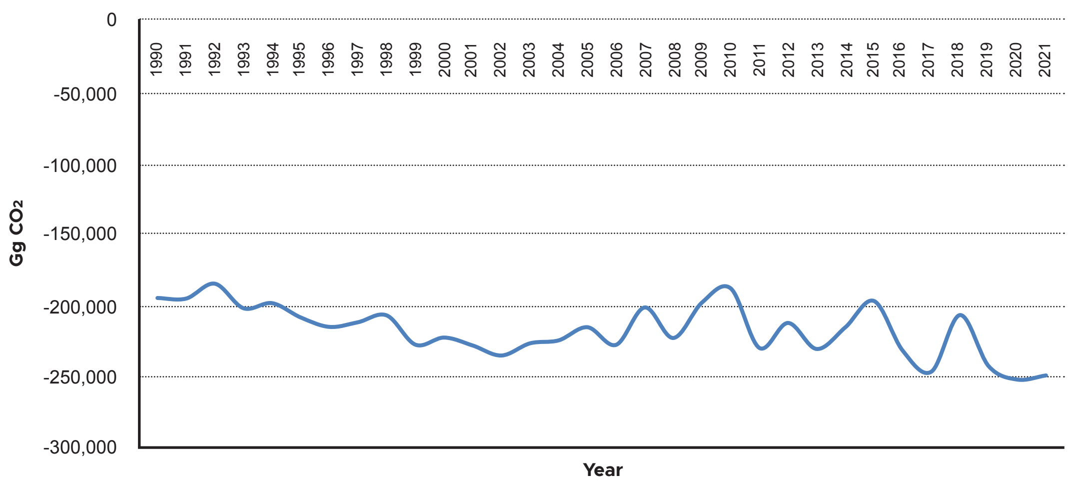


Figure SIC6.3 Rewetting Activity in Peat Swamp Forest Involving Multiple Stakeholders

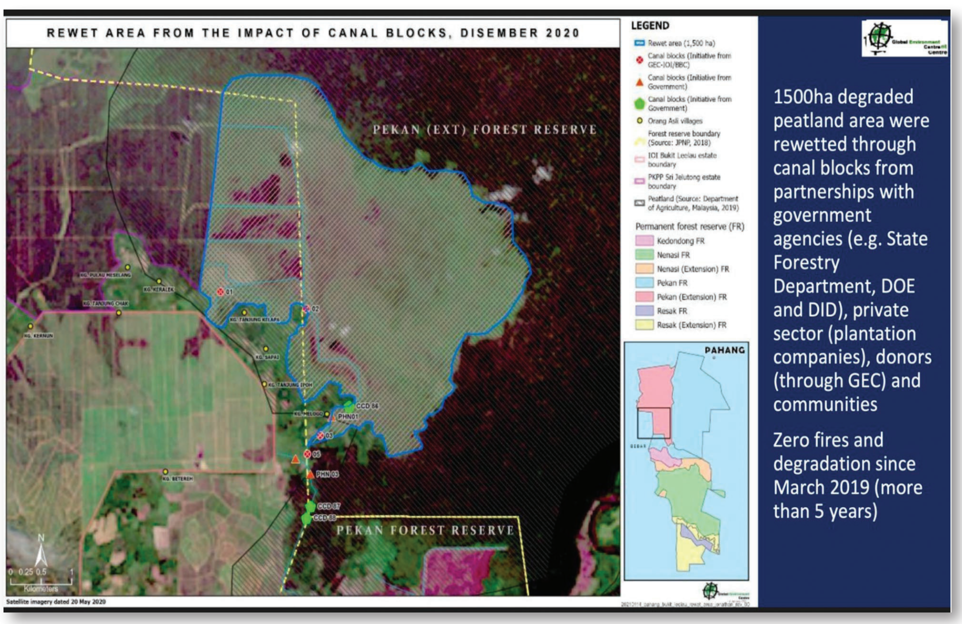


Photo credit: Pahang State Forestry Department and GEC

Figure SIC6.4 **Peat Swamp Forest was Affected by Fires in 2012 and the Recovery Post-Canal Blocking**

Photo credit: Selangor State Forestry Department

6.1.1.2 Cropland

The smallholder sector continues to experience problems of low productivity and uneconomic size of holdings. Labour shortages and low commodity prices have further led to substantial idle agricultural land and abandoned holdings. It is estimated that there are about 400,000 ha of idle agricultural land and about 420,000 ha of abandoned rubber land in the country. In addition, land for agricultural activities is becoming more limited owing to conversion for other uses such as industrial, residential and urban uses.

The overriding objective of NAP3 is the maximisation of income through the optimal utilisation of resources in the sector. This includes maximising agriculture's contribution to national income and export earnings as well as maximising the income of producers through exporting value-added products rather than raw materials. These policies are continued in the later policies as well. In year 2019, the government issued a policy of capping the total oil palm planted area to 6.5 million ha and no new planting in peatlands. From year 2020 onwards, the oil palm cultivation area has been reduced due to increased costs and labour shortages.

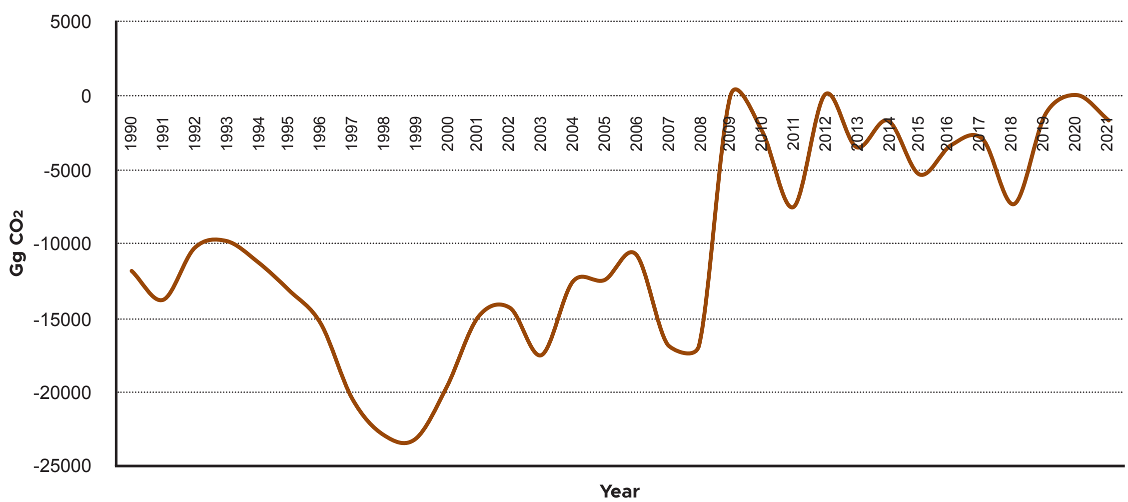
For Cropland, total removals are dependent on productivity and commodity price. The National Commodities Policy outlined a strategic approach that focussed on enhancing productivity and limiting land expansion into forest areas. There have been updates in the methodology for estimating GHG emissions and removals from Cropland, resulting in some changes explained below.

The largest crop planted in Malaysia is oil palm representing 5.74 mil ha followed by rubber,1.14 mil ha. The recent trend indicates oil palm cultivation is on a decline affected by labour shortage as well as conversion to settlement. Rubber on the other hand was on a decline from 1990-2011 primarily due to low prices, conversion to oil palm and settlement as well as abandonment.

The emission trend from cropland is linked to patterns of expansion as well as the price of the commodity. When oil palm expansion occurred in rubber, there was a downward trend in removals while an upward trend was when the expansion was from unmanaged or cocoa plantations. Cocoa plantations were on a downward trend until recently. Rubber cultivation was on a decline from 1990 to 2011 and a gradual increase in the planted area was reported from 2011 to 2020. On the other hand, oil palm cultivation reduced from year 2020 onwards.

The change in removal trends from year 2009 onwards is due to larger areas of replanting with 2020 being a net source. On the whole, emissions from Cropland are on a downward trend driven by labour shortage and the reduction in oil palm cultivation in the recent years (Figure SIC6.5).

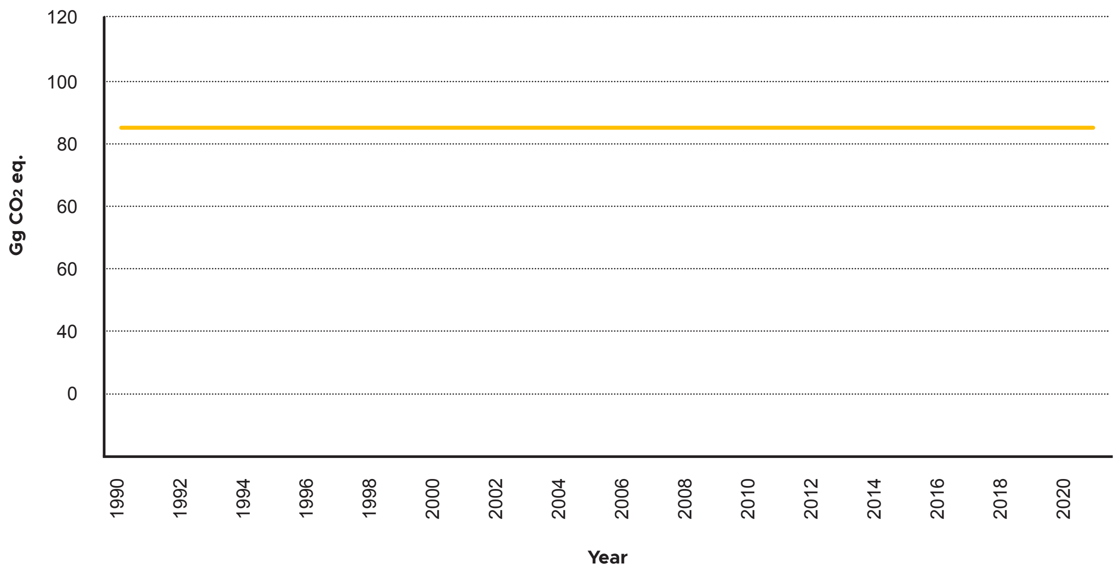
Figure SIC6.5 **Total Emissions (Gg CO_2) from Cropland (1990-2021)**



6.1.1.3 Grassland

The Tier 1 approach is used for grasslands, assuming no net gain or loss in biomass. Since grassland is defined as pasture land animal husbandry, the focus also restricts the scope of carbon stock estimation to areas specifically managed for grazing. Consequently, the emission trends remain at zero. However, there is a small area of community farmland in peatland. The area was drained.

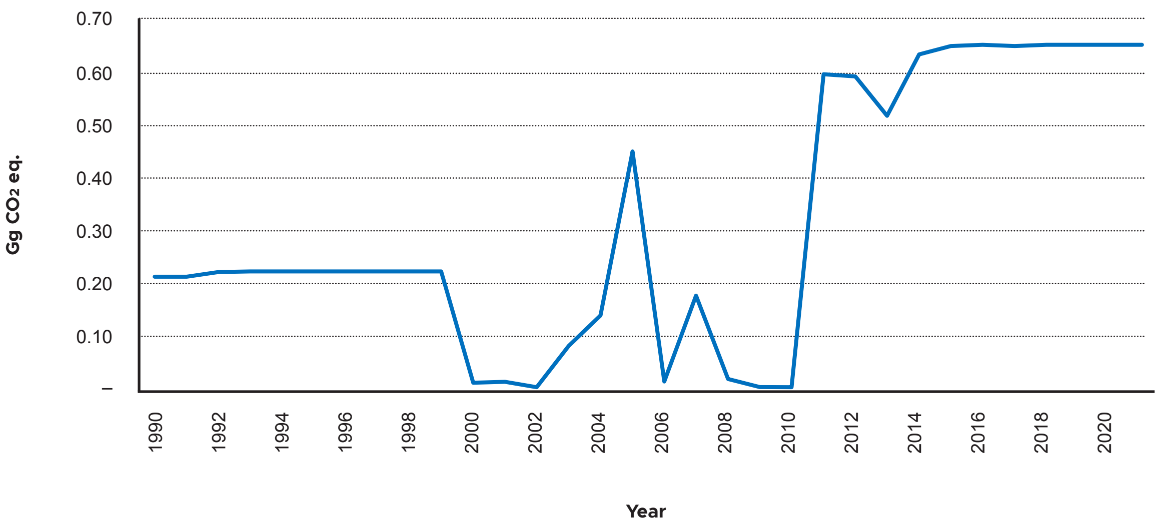
Figure SIC6.6 **Total Emissions (Gg CO_2 eq.) from Grassland (1990-2021)**



6.1.1.4 Wetlands

Emissions and removals are from flooded lands or peat extraction in the 2006 IPCC Guidelines. However, peat extraction activity does not occur in Malaysia. Flooded lands are defined as water bodies where human activities have altered the surface area covered by water, typically through water level regulation. Methane emissions from flooded land remaining flooded were estimated and shown in Figure SIC6.7. Emissions are linked to the age (10 years) from the operation of dams.

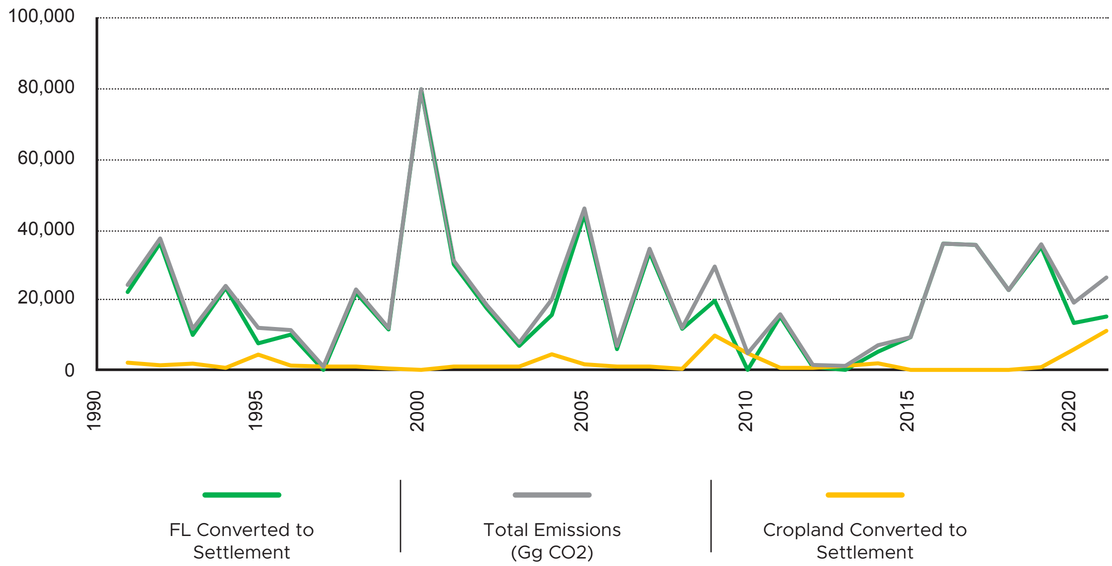
Figure SIC6.7 **Total Emissions (Gg CO_2 eq.) from Wetlands (1990-2021)**



6.1.1.5 Settlement

The settlement encompasses emissions and removals from Forest Land and Cropland that have been converted into Settlements. For Settlement Remaining Settlement, Tier 1 approach is used to assess annual carbon stocks. Under this method, it is conservatively assumed that any increase in biomass carbon stocks due to growth is fully offset by reductions caused by removals (such as harvest, pruning, and clipping) from both living and dead biomass (e.g., broken branches). Consequently, emissions resulting from land conversion, specifically, forest and cropland into settlements are taken into account. Currently, the expansion of built areas is expanding rapidly outside the Klang Valley conurbation as well. Construction activities were impacted during the Pandemic, but it picked up in the later part of 2021.

Figure SIC6.8 **Total Emissions (Gg CO_2 eq.) from Settlement (1990-2021)**



6.1.2 Direct N_2O emissions from managed soils

The emissions from direct N_2O from drained peatlands is reported here. Emissions from manure management and fertiliser application are reported under agriculture sector.

6.1.3 Time series and consistency summary of recalculation of the overall sector

The overall recalculation undertaken in this report is shown in Table SIC6.3. The time series from 1990 to 2021 is provided as in CRT (Table 10s1). To ensure consistency of the time series, recalculations are made from 1990 onwards when there is an improvement in activity data/emission factors or the IPCC software.

Table SIC6.3 Overall Trends and Recalculation for the LULUCF Sector

GHG Source and Sink Categories	Latest Year Total	2005 Latest Year Trend	Recalculation (remarks and justification)
Total LULUCF			
4.A. Forest Land	248,823.4818	Stabilised	– IPCC software updated – Activity data emission factors updated – DOC from drained peat swamp forest – Rewetting from 2016 onwards
4.B. Cropland	-1753.8213	Decrease	– Emission factors updated. – Update in IPCC software which includes below-ground biomass and DOC in organic soils. More categories of cultivation in organic soil included
4.C. Grassland	105.0764	No change	– Update in activity data
4.D. Wetlands	0.65	Marginal increase	– Included CH_4 emissions from flooded land remaining flooded land
4.E. Settlements	38,978.5614	Increase	– Update in emission factors and activity data

6.1.4 Current improvement (including to ensure completeness) undertaken in the overall sector

Overall improvement made since the last report (BUR4) is shown in Table SIC6.4. To ensure the completeness of the assessment, Malaysia has included emissions from all organic soils that are drained and cultivated. Additionally, emissions from flooded land and hydro dams are also included in this current report.

Table SIC6.4 **Sectoral Improvement Since the Last Submission for the LULUCF Sector**

Sub-Category	Improvement	Description
4.A. Forest Land	Emission factor Drained peat swamp forest Rewetting of peat swamp forest	– Update in activity data from 2015 – Emission factors updated – Inclusion of DOC in drained peatlands and rewetting – CO_2 and CH_4 emissions from rewetted peat swamp forest
4.B. Cropland	Carbon pool Emissions from drained peatlands	– Inclusion of drained peatland in cropland – Emission factors updated – Below-ground biomass is included – Inclusion of DOC in drained peatlands
4.C. Grassland	Emissions from drained peatlands	– Emissions from drained peatlands
4.D. Wetlands	Emissions from flooded land remaining flooded land	– Inclusion of CH_4 emissions from flooded land remaining flooded land
4.E. Settlements	None	– Update in activity data and emission factors

6.2 Land-Use Definitions and The Land Representation Approach(es) Used and Their Correspondence to The Land Use, Land-Use Change and Forestry Categories (E.G. Land Use and Land-Use Change Matrix)

6.2.1 Malaysia's Land Area and Administration

Malaysia has a land area of 33.065 million ha, separated by the South China Sea into two regions, Peninsular Malaysia and Borneo's East Malaysia. Malaysia has an equatorial climate that is generally uniform daily temperature variation throughout the year. The total land area consists of forest, 54.4%, cropland 34.4% and grassland, wetlands and settlements making the remaining 11.2%.

The land administration structure in Malaysia demarcates the power to manage land to the State Authority as land is a state matter under the Federal Constitution of Malaysia. Land administration and land law practices are based on the Torrens system introduced by the British. Under the Torrens System, the Register is everything. Hence, the legal entity of a forest is through the State gazette while land titles are given for other land use. The National Forestry Act, 1984 (NFA) for Peninsular Malaysia, the Forest Enactment,1968 for Sabah and the Forests Ordinance (Cap.126) for Sarawak allow State Authorities by notification in the *Gazette*, to declare any area as permanent reserved forest.

6.2.2 Land definition

The managed land definition follows the general definition provided in the IPCC 2006 Guidelines. However additional elaboration is provided to reflect national circumstances. Based on the following definitions, most lands in Malaysia are classified as managed:

i. Managed Land: Land is considered managed if direct human intervention has influenced its condition. Direct intervention occurs mostly in areas accessible to human activity and includes altering or maintaining the condition of the land to produce commercial or non-commercial products or services; to serve as transportation corridors or locations for buildings, landfills, or other developed areas for commercial or non-commercial purposes; to extract resources or facilitate the acquisition of resources; or to provide social functions for personal, community, or societal objectives where these areas are readily accessible to society.

ii. Unmanaged Land: All other land is considered unmanaged. Unmanaged land largely comprised of areas that had been abandoned by land owners or land earmarked for development pre-independence but yet to be developed. Unmanaged land is also re-classified as managed over time if anthropogenic activity is introduced into the area based on the definition of managed land.

For Malaysia, all areas are assigned to one of the LULUCF land use categories (Forest Land, Cropland, Grassland, Wetland, and Settlements). Most land use is considered to be managed when estimating removals and emissions from LULUCF. Lands are designated as managed based on the definition provided earlier in this section. The following criteria are used to apply the definition in an analysis of managed land:

i. Forest land, Cropland, Grassland, Wetlands and Settlements are designated as managed;
ii. All Forest Land including protected areas and state parks are considered managed unless specified otherwise;
iii. All Grassland are considered managed at a county scale as they are grazing livestock in the country;
iv. Abandoned agricultural land is considered unmanaged land until the land owner returns to utilise the land; and
v. Ex-shifting cultivation and Native Customary Land is considered as abandoned agricultural land (managed/unmanaged).

IPCC has categorised land use into six broad categories. They are forest, cropland, grassland, wetlands, agriculture and other land. Each land-use category is further subdivided into land remaining in that category (e.g., Forest Land Remaining Forest Land) and land converted from one category to another (e.g., Forest Land converted to Cropland). The definitions of land-use categories incorporate land cover type, land use, or a combination of the two. Malaysia used both land cover and land use in defining its land use categories. GHG emissions and removals are determined for each specific land use.

The six broad land-use categories described below form the basis for estimating and reporting GHG emissions and removals from land use and land-use conversions. The land uses are considered as top-level categories for representing all land-use areas, with sub-categories describing special circumstances significant to emissions estimation, and where data are available. The categories (and sub-categories) are intended to be identified through the use of Approaches for representing land-use area data described in subsequent sections:

i. Forest Land: All areas are managed under the National Forestry Act and State Forestry Enactment. Malaysia's forest definition is Land (or land) spanning more than 0.5 ha with trees higher than 5 m at maturity and a canopy cover of more than 30%;

ii. Cropland: This category includes agricultural land, rice fields, and commodity crops. Annuals and perennial crops are included in this category;

iii. Grassland: Pastureland and animal husbandry are considered under grassland. Temporary abandoned land covered with grasses or shrubs are not considered as grassland but cropland. No land use maps are available for grassland;

iv. Wetlands: This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland, or Settlements categories. It includes natural rivers and lakes as unmanaged sub-divisions. In Malaysia, rivers, lakes, and dams are considered wetlands; and

v. Settlements: This category includes all developed land, including transportation infrastructure, human settlements of any size, industrial areas, graveyards, mining land, and poultry farms unless they are already included under other categories. No land use maps are available for settlement.

6.2.3 Land Representation

A national land-use representation system that is consistent and complete, both temporally and spatially, is needed to assess land use and land-use change status and the associated GHG emissions and removals over the Inventory time series. Land can be categorized into five groups: alienated land (registered title), mining land (mining leases), reserved land (land reserved for public purpose under Section 62 of the National Land Code (NLC), forest reserve (land gazette under the National Forestry Act 1984) and state land (all land in the state, other than above mentioned). Agriculture land and settlement are often alienated land with a registered title. Malaysia's land use has been grouped into the IPCC categories of forest cover, cropland, grasslands, wetlands, and settlements.

The descriptions of land use follow the framework of:

i. Land-use category – is reported as land remaining in a land-use category (i.e., remaining in the same use throughout the inventory timeseries).
ii. Land-use change category – is reported as land converted to a new land-use category (representing a change in land use).

iii. Land-use categories and sub-categories have been further stratified on the basis of land-use practices and bio-physical characteristics in order to create more homogeneous spatial units that may be used for emissions estimation.

iv. Land use transition – changes in land use within the 20-years period is considered land use in transition. The 20-years interval is taken as a default length of the transition period for carbon stock changes following land-use change. The actual length of the transition period depends on the land use change of a particular country or region and may differ from 20 years.

6.2.4 Land Use Data and Sources

Three national datasets are used to track land management and are used as the basis to classify land areas into the IPCC land use and land-use change categories. The three primary datasets are the Ministry of Natural Resources and Environmental Sustainability (NRES), the Ministry of Plantation and Commodity (KPK) and the Ministry of Agriculture and Food Security (KPKM). The forest and commodity data are collected from the forest gazette and license application, while the other cropland data are collected through periodic surveys, geospatial imagery, and production data. Additionally, information on other land use was also obtained from other sectoral agencies, namely the Departments of Agriculture and Plan Malaysia. Some lands can be classified into one or more categories due to multiple uses that meet the criteria of more than one definition. In cases like this, the land use category will be based on the Land Registry. Table SIC6.5 gives an overview of the land use in Malaysia and data sources.

All of Malaysia's land has a gazette or title deposited in a Land Registry managed by the District Land Office. One of the long-term improvements in the activity data for land use is to collect information from the Land Registry, especially for settlement. This will take considerable effort and resources.

Table SIC6.5 Data Source for LULUCF

Category	Data source	Explanation	Total area (mil ha) in 2021
Forest land	Ministry of Natural Resources and Sustainability	Forest land by categories and type	17.979
Cropland	Ministry of Plantation and Commodity (KPK), and Ministry of Agriculture and Food Security (KPKM)	Commodity crops; cocoa, oil palm, rubber, kenaf, and tobacco Other cropland Included managed and unmanaged cropland	11.355
Grassland	Ministry of Agriculture and Food Security (KPKM) Department of Veterinary Services and Department of Agriculture	Pasture land and animal husbandry	0.276
Wetlands	ICI-LC Tenaga National Berhad, Sabah Electricity Sdn Bhd and Sarawak Energy Berhad	Historical data from ICI-LC Current expansion from hydro and irrigation dams are obtained from Energy companies	0.585
Settlements	ICI_LC, state governments and Plan Malaysia Land cover maps ICI-LC	Urban, sub-urban areas Infrastructure like roads etc	2.870

6.3 Country-Specific Approaches

6.3.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Malaysia used Approach 2 for its land representation. Approach 2 tracks land use conversions between categories but are not spatially explicit. It provides an assessment of both the net losses or gains in the area of specific land-use categories and what these conversions represent (i.e., changes both from and to a category), it is still only tracking those changes without spatially explicit location data, often based on national boundaries. For some categories of land use and especially for historical land use change, Bayesian analysis was undertaken, where a posterior distribution of land use is based on observed data.

IPCC (2006) outlines that a country can choose either an approach or a mix of approaches to track land use change according to their national circumstances. For this analysis, Malaysia used Approach 2 for its land representation. Approach 2 is used to represent the land use area data and tracks land use conversions between categories but is not spatially explicit. It provides an assessment of both the net losses or gains in the area of specific land-use categories and what these conversions represent (i.e., changes both from and to a category), it is still only tracking those changes without spatially explicit location data, often based on national boundaries.

Tracking land-use conversions in this manner will normally require the estimation of initial and final land-use categories for all conversion types, as well as the total area of unchanged land by category. The final result of this approach can be presented as a non-spatially explicit land use conversion matrix. The matrix form is a compact format for representing the areas that have come under different conversions between all possible land-use categories. Land use and land use change matric for 2021 are shown in Table SIC6.6.

Land use change is tracked by the respective agencies and the Land and Survey Department, who manages the national land registry.

Table SIC6.6 Land Use and Land Use Change Matrix for 2021 (ha)

	Forest (Managed)	Cropland	Grassland	Wetlands	Settlements	Final Area
Forest (Managed)	16,979,103					16,979,103
Cropland		11,354,931				11,354,931
Grassland			276,000			276,000
Wetlands				585,443		585,443
Settlements	66,496	65,784			2,723,938	2,869,936
Initial area	17,045,599	11,420,714	276,000	585,443	2,737,656	32,065,412
Net change (Final-Initial area)	66,214	65,784	0	0	131,998	

Consultations with data providers were undertaken and checked for consistency and accuracy of activity data to ensure there are no gaps or overlaps that would lead to double counting of the land information. Most information is obtained through the national reporting processes. For forest data, the Forest Departments will document and track the data and report to the Ministry. For commodity crops, data is collected through the licenses issued. The other categories are collected via the agencies.

Methodology and Time-Series consistency

All emissions and removals estimates are calculated using methods in the 2006 IPCC Guidelines for National GHG Inventories (2006 IPCC Guidelines), and 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories: Wetlands. The IPCC Inventory Software version 2.93 was used to generate the GHG inventory estimates. It also provides a good archiving system for the LULUCF sector.

Additionally, the calculated emissions and removals in each year are presented commonly in line with the reporting guidelines for the reporting of inventories under the Paris Agreement. This chapter follows a common format and explains the application of methods used to calculate emissions and removals.

Methods to estimate GHG emissions and removals in the LULUCF sector are similar; (gain-loss) for all the types of land use of which Forest Land (4.A.) Cropland (4.B.), Grasslands (4.C.), Wetlands (4.D.), Settlements (4.E.) and (Figure 6.1) as well as direct N_2O emissions. Malaysia does not report any emissions or removals from the Other Land (4.F.) and Harvested Wood Products (4.G.) category.

Table SIC6.7 **Methodological Tiers by Category, and Coverage of Pools for the LULUCF Sector**

		CO_2		CH_4		N_2O	
		Method	EF	Method	EF	Method	EF
4.	**LULUCF**						
4.A.1.	Forest Land Remaining Forest Land	T2	CS, D	T1	D	T1	D
4.B.1.	Cropland Remaining Cropland	T1	CS			T1	D
4.C.1.	Grassland Remaining Grassland	T1					
4.D.1.	Wetland Remaining Wetlands	T1	D				
4.E.1.	Settlement Remaining Settlement	T1	CS, D				
4.F.1.	Other Land Remaining Other Land						
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land[30]							
3.C.1	Biomass Burning in Forest Land[30]	T1	D	T1	D	T1	D
3.C.2	Liming[30]						
3.C.3	Urea Application[30]						
3.C.4	Direct N_2O Emissions from Managed Soils[30]					T1	D
3.C.5	Indirect N_2O Emissions from Managed Soils[30]						

The emissions and removals of CO_2 are based on changes in carbon stocks. They are estimated for each land-use category (including both land remaining in a land-use category as well as land converted to another land use). Lands are treated as remaining in the same category (e.g., cropland remaining cropland) if a land-use change has not occurred, consistent with the IPCC 2006 guidelines. Otherwise, the land is classified in a land-use change category based on the current use and most recent use before conversion to the current use (e.g., cropland converted to forest land).

Carbon pools in natural ecosystems can be divided into the following five storage pools (IPCC 2006):

i. Aboveground biomass, which includes all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage. This category includes live understory.
ii. Belowground biomass, which includes all living biomass of coarse living roots greater than 2 mm diameter.
iii. Dead wood, which includes all non-living woody biomass either standing, lying on the ground (but not including litter), or in the soil.
iv. Litter, which includes all duff, humus, and fine woody debris above the mineral soil as well as woody fragments with diameters of up to 7.5 cm.
v. Soil organic carbon (SOC), including all organic material in the soil to a depth of 1 meter but excluding the coarse roots of the belowground pools. Organic (e.g., peat and muck) soils have a minimum of 30% percent organic matter by mass and develop under poorly drained conditions of wetlands. All other soils are classified as mineral soil types and typically have relatively low amounts of organic matter, with low activity. Mangroves are considered high-activity soil.

Table SIC6.8 **Carbon Pools Assessed in the Current Inventory**

Carbon pools	Forest	Cropland	Grassland	Wetlands	Settlements
Above ground biomass	√	√	T1	√	√
Below ground biomass	√	√	T1	√	√
Deadwood	T1	T1	T1	T1	
Litter	T1	T1	T1	T1	
Soil organic carbon	T1	T1	T1	T1	

6.3.2 Information on approaches used for natural disturbances

In Malaysia, open burning is strictly prohibited under the provisions of Sections 29A (1) and 29A (2) of the Environmental Quality Act 1974. These regulations explicitly state that no person shall allow or cause open burning on any premises, including land. However, wildfire occurrences are infrequent in Malaysia's forests and are primarily associated with El Niño events. During a strong El Niño event, less than 0.1% of the forest area is affected by wildfire. To estimate carbon loss resulting from wildfires, a standardized approach outlined in the IPCC 2006 guidelines is used.

6.3.3 Information on approaches used for reporting harvested wood products (HWP)

Malaysia is studying the most suitable approach and data requirement to estimate emissions from HWP.

6.4 Forest Land (CRT Category 4.A.)

6.4.1 Description

Forest is managed based on the category of gazette and forest types. There are 3 types of forest, Inland, Peat swamp and Mangrove. Forest plantation is another category. Some areas have naturally regenerated following past activities and now being considered as fallow forest. Forest gazetted under Permanent Reserved Forest is managed under SFM, where low-impact logging is implemented. These forests are certified under the Malaysian Forest Certification Scheme (MTCS) or Forest Stewardship Council (FSC). To date, a total of 6.74 mil ha of forest have been certified. While Protected Areas are managed for the conservation of flora and fauna dan national/state parks. Hence, emissions and removals from the forests are considered based on the management activities undertaken. Table SIC6.9 provides an overview of emissions and removals covered under forest.

Table SIC6.9 **Overview of Removal/Emissions Covered Under Forest**

Emissions Source	Source Included	Methods	Emissions Factors
	Carbon stock change in forest land	Gain -loss method	NFI and publications IPCC default
	Non-CO_2 emissions from wildfires	Stock change	IPCC default
	Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils	NA	
	Emissions and removals from drainage and other management of organic and mineral soils	On-site and off-site emissions	IPCC default
	Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralisation/immobilisation associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	NA	
Gasses Reported	CO_2, CH_4, N_2O, CO, NOx		
Coverages	National		
Key Categories (KCA)	Yes (4.A.1 Forest land remaining forest land)		
Major Improvements since last submission	a. Activity data updated from year 2015 onwards b. Emission factors for the inland forest and fallow forest updated dan drained peatland c. New category for CO_2 off-site emission factors from drained peatland d. New category, CH_4 emissions from drained peatlands e. Inclusion of rewetting in forest		

6.4.2 Methodological issues

The emissions and removals of GHG are based on changes in carbon stocks within the land use category. They are estimated for each land-use category (including both land remaining in a land-use category as well as land converted to another land use). The Gain-Loss method is used to estimate the emissions and removals from forest land remaining forest land. When there is an expansion of land use, the stock difference is used for the year in which the expansion occurred. Detailed methodologies used are shown in Table SIC6.10.

Table SIC6.10 **Description of Methodologies for Forest Land**

Choice of Method	Tier 1: Gain-Loss Method and Stock Difference			
Activity Data	**Category**	**Parameter of Activity Data**	**Assumption**	**Data Source**
Forest land remaining forest land				
Average annual increment in biomass Equation 2.10	– Totally Protected Area – Inland Forest – Peat Swamp Forest – Mangrove – Forest plantation – Fallow Forest – Degraded Peat Swamp Forest – Unmanaged forest	Total area of forest as shown in the Category column Total land converted to forest land	1. The average transfer rate into dead organic matter (dead wood and litter) and soil are equal to the average transfer rate out of dead organic matter so that the net stock change is zero. 2. No fertilizers applied in the forest or if applied, it is calculated as the national urea used under 3C	NRES Department Data
Annual carbon loss due to biomass removals Equation 2.12	Biomass loss from harvest	Total volume removal		KPK
Annual decrease in carbon stocks due to biomass loss Equation 2.14	Biomass loss from disturbance - forest fires	Total biomass loss	26% of biomass burnt	Department data
Annual carbon loss from drained organic soils – Annual on-site CO_2-C emissions/ removals from drained organic soil Equation 2.3 (2013 Wetland Supl) – Annual off-site CO_2 emissions due to DOC loss from drained organic soil Equations 2.4 and 2.5	Drained and rewetting of peat swamp forest	Total area (ha)		GEC Malaysia Forestry Department

Mangrove data is affected by high tide and low tide. Hence, an average value of 441,000 ha. Malaysia has used the T1 approach to estimate emissions and removals from the SOC, litter and dead wood. Efforts are ongoing to develop country-specific emission factors and preliminary findings in Table SIC6.11 and Table SIC6.12. The annual increment is between 0.03 -1.77 tC/h/year. For, leaf litter production, the current findings are between 3- 5t/ha/year.[30, 31]

Table SIC6.11 **Preliminary Findings on Changes in SOC in Forest Land**

Forest type	Location	Dominant Species	Reference Soil C stocks	Soil C stocks (tC ha^{-1})	Difference (t2-t1)	Annual soil C stock changes
Inland	Chikus Forest Reserve	Dipterocarpaceae	22.5	93.21	40	1.77
	Hutan Batu Kapal	Dipterocarpaceae	18.0	62.30	40	1.1
	Hutan Simpan Bukit Lagong	Dipterocarpaceae	22.5	36.37	34	0.41
	Hutan Simpan Bukit Lagong	Dipterocarpaceae	22.5	35.70	35	0.38
	Kenaboi Forest Reserve – Rehabilitated Forest Plot	*Shorea leprosula, Shorea ovalis & Shorea acuminata*	18.0	28.90	36	0.30
	Kenaboi Forest Reserve – Degraded Forest Plot	*Shorea leprosula, Shorea ovalis & Shorea acuminata*	18.0	18.90	36	0.03
	Berembun Forest Reserve – Unlogged Forest Plots	*Dipterocarpus spp. & Shorea spp.*	21.0	34.12	36	0.36

30 Saner et al 2012
31 Yamashita et al (2003)

Table SIC6.12 **Emission Factors for Forest Land**

Category	Emission Factor					Data Source
	CO_2	CH_4	N_2O	CO	NOx	
Inland Forest	9.1 t C/ha					NFI; Banin et al (2016)
Peat	9.1 t C/ha					
TPA	4.3 t C/ha					
Mangrove	11 t C/ha					Ong 1992 Goessens et al (2014)
Fallow Inland Forest	5.7 t C/ha					Kenzo et al (2010)
Degraded peat swamp	4.3 t C/ha					Roland et al (2012)
Drained PSF	5.2 Kg CO_2- C/ha/year	4.9 Kg CH_4/ ha/year	2.4 Kg N_2O-N/ ha/year			2013 Wetland Supplement
Forest Plantation	5.0 t C/ha					IPCC 2006GL
Forest fires	1580 g/kg	6.8 g/kg	0.2 g/kg	104 g/kg	1.6 g/kg	IPCC 2006GL

6.4.3 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment, which is described in sub-chapter 1.6 of the NID.

Data collected for forest land is from the gazettement of forests. Land survey has its own uncertainty. Additionally, some of the gazettes order dates as early as 1900. This has provided some difficulties in estimating some of the forest areas. Work is ongoing to update the forest area. Emission factors are mostly derived from the National Forest Inventory and publications. Uncertainties are estimated accordingly. Factors affecting the uncertainty of data is primarily associated with old data in the Land Registry.

The fluctuation in the forest data is due to two reasons, firstly the delayed replacement of forest due to deforestation and secondly some of the forest has to be re-gazetted as community conservation area or native land when claims are approved. This has contributed to the fluctuation of removals and emissions in forest land.

6.4.4 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in sub-chapter 1.9 of the NID.

6.4.5 ategory-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures, which is described in sub-chapter 1.5 of the NID.

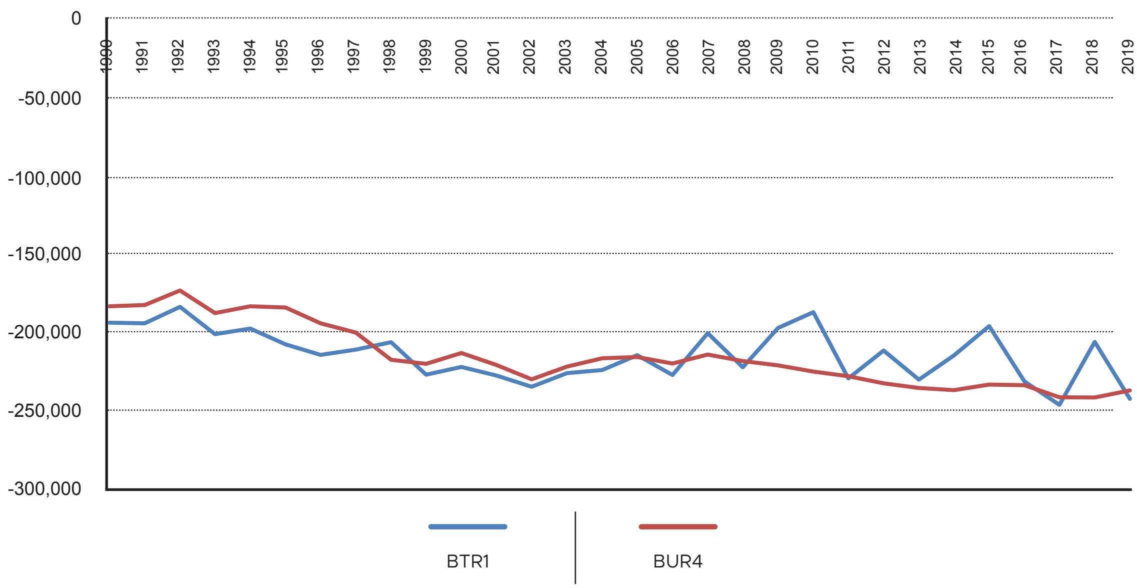
General quality control procedures were used in data collection and performing calculations to estimate carbon stocks. For example, the carbon datasets, which include inventory variables such as areas, volumes and/or biomass, were compared with published literature.

Data required for national GHG inventory is compiled through legislation by agencies and reported at national level. QC is undertaken for activity data by comparing the data against international databases and publications. The Sectoral Working Group (SWG) for LULUCF checks and approves all the data dan emission factors. Check for consistency in data between categories and completeness are undertaken by the LULUCF coordinating agency and discussed in the SWG meetings. Analysis of time series is also undertaken to ensure, input of values into the IPCC software is correct and the standard of data quality is maintained. Regular data compilation reviews are undertaken with data providers to ensure the correct use of data. Data is compiled into a database as archiving of information. The IPCC software is also another method for archiving of information.

6.4.6 Category-Specific Recalculations

The calculation was undertaken due to changes as shown in Table SIC6.3. The difference in values between BUR4 and the current report is about 1% (Figure SIC6.9). For 2002, the huge difference is due to the improvement in the IPCC software, where more fallow forest was moved to Inland Forest. This difference is contributed by the update in emission factors and activity data. Emission factors for fallow, plantation, peat swamp and inland forests were updated. Additionally, there were some updates in the forest figures from year 2018 for plantation forests and year 2015 for peat swamp forests. The forest fire area was also updated from year 2015.

Figure SIC6.9 **Comparison of the net total for forest emissions estimated between BUR4 and BTR1**



6.4.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Section 6.9.

6.5 Category Cropland (CRT Category 4.B.)

6.5.1 Description

While palm oil remained dominant, efforts were made to diversify crops, including expanding cocoa cultivation. The government emphasised sustainable practices, addressing environmental concerns through certification programs for palm oil plantations. Oil palm cultivation continued to reduce in year 2021 while rubber lost 2,000 ha. On the other hand, cocoa had a marginal increase of 270 ha. Table SIC6.13 provides the overview of emissions and removals covered under Cropland.

Table SIC6.13 **Overview of removal/emissions covered under Cropland**

Emissions Source	Source Included	Methods	Emissions Factors
	Carbon stock change in cropland	Gain -loss method	Publications
	Non-CO_2 emissions from cropland	IE	
	Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils	NA	
	Emissions and removals from drainage and other management of organic and mineral soils	On-site and off-site emissions	IPCC GLs (2006)
	Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralisation/immobilisation associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	IE	
Gasses Reported	CO_2, CH_4, N_2O		
Coverages	National		
Key Categories (KCA)	Yes (4.B.1 Cropland remaining cropland)		
Major Improvements since last submission	a. New direct CO_2 EFs for cropland on drained organic soils. b. New category for CO_2 off site emission factors from drained peatlands c. New category, CH_4 emissions from drained peatlands d. Inclusion of below-ground biomass and e. Revision of growth rates for cocoa and oil palm		

6.5.2 Methodological issues

The emissions and removals of GHG are based on changes in carbon stocks within land use category. They are estimated for each land-use category (including both land remaining in a land-use category as well as land converted to another land use). The Gain-Loss method is used to estimate the emissions and removals from cropland remaining cropland and stock change for crop changes within cropland and between land use. Description of methodologies by categories used are shown in Table SIC6.14 and emission factor used for Cropland in Table SIC6.15.

Table SIC6.14 Description of Methodologies for Cropland

Choice of Method	Tier 1: Gain-Loss Method and Stock Difference			
Activity Data	**Category**	**Parameter of Activity Data**	**Assumption**	**Data Source**
Cropland land remaining cropland				
Average annual increment in biomass Equation 2.10	– Cocoa – Oil palm – Rubber – Annual crops – Other perineal crops – Other crops in peatlands – Abandoned peatland – Unmanaged cropland	Total area of cultivation as shown in the Category column Total land converted to cropland land	1. For other crops, the Tier 1 approach was applied; incremental gains from growth are offset by losses from natural mortality, pruning or other losses 2. The average transfer rate into dead organic matter (dead wood and litter) and soil are equal to the average transfer rate out of dead organic matter, so that the net stock change is zero. 3. For mineral soil, no tillage occurred	KPK, KPKM Department Data Department Data
Annual carbon loss due to biomass removals Equation 2.12	Biomass loss from harvest	Total area		Department Report
Annual carbon loss from drained organic soils – Annual on-site CO_2-C emissions/ removals from drained organic soil Equation 2.3 (2013 Wetland Supl) – Annual off-site CO_2 emissions due to DOC loss from drained organic soil Equations 2.4 and 2.5	Drained organic soils	Total area (ha)		Publication GEC Malaysia
Land converted to cropland				
Average annual increment in biomass – Total biomass in each category and the difference Equations 2.8	– Cocoa – Oil palm – Rubber – Annual crops – Other perineal crops – Other crops in peatlands – Abandoned peatland – Unmanaged cropland	Total area increased in the reporting year	1. For mineral soil, no tillage occurred	Publications

Table SIC6.15 Emission Factors used for Cropland

Category	Emission Factor					Data Source
	CO_2	CH_4	N_2O	CO	NOx	
Cocoa	2.16 Roots: 0.2					Swisscontact (2021)
Oil palm	1.79 Roots: 0.27					Kho et al (2016)
Rubber	2.08 Roots: 0.20					Yew & Nasaruddin (2002)
Drained peatland – oil palm	1st rotation 11.43 t C/ha					Manning et al 2012
	Second rotation 7.5 t C/ha					Henson 2003
	DOC 0.8208					2013 IPCC Wetland Supl
		7 kg CH_4/ha/year	1.2 kg N_2O-N/ha/year			2013 IPCC Wetland Supl
Drained peatland – other crops	1.5 t C/ha DOC 0.8208	7 kg CH_4/ha/year	3.3 kg N_2O-N/ha/year			2013 IPCC Wetland Supl

6.5.3 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment, which is described in sub-chapter 1.6 of the NID.

6.5.4 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in sub-chapter 1.9 of the NID.

6.5.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures, which is described in sub-chapter 1.5 of the NID.

General quality control procedures were used in data collection and performing calculations to estimate carbon stocks. For example, the carbon datasets, which include inventory variables such as areas, volumes and/or biomass, were compared with published literature.

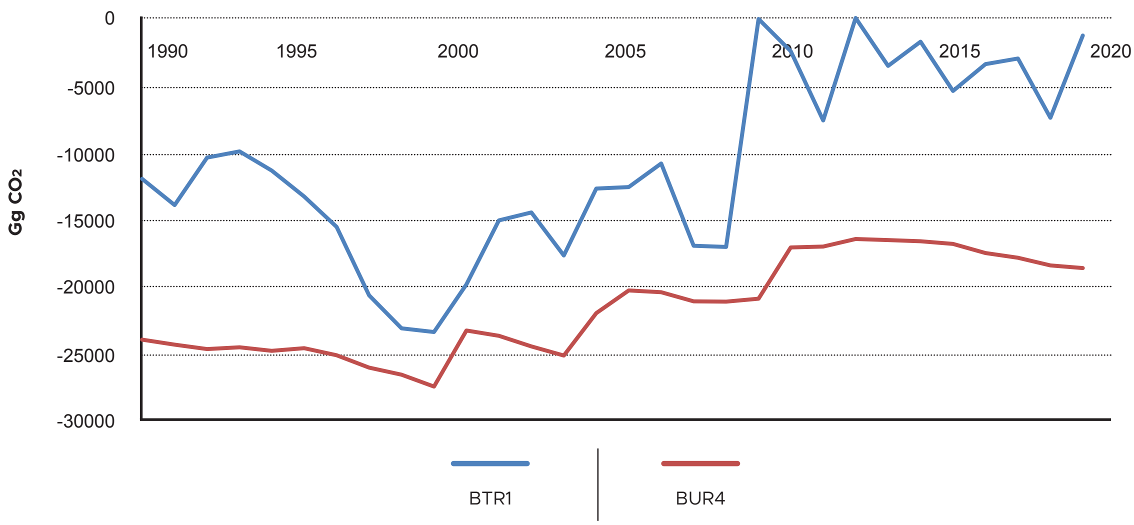
Data required for national GHG inventory is compiled through legislation by agencies and reported at the national level. QC is undertaken for activity data by comparing the data against international databases and publications. The SWG for LULUCF checks and approves all the data and emission factors. Check for consistency in data between categories and completeness is undertaken by the LULUCF coordinating agency and discussed in the SWG meetings. Analysis of time series is also undertaken to ensure, the input of values into the IPCC software is correct and the standard of data quality is maintained. Regular data compilation reviews are undertaken with data providers to ensure the correct use of data. Data is compiled into a database as archiving of information. The IPCC software is also another method for archiving of information.

6.5.6 Category-Specific Recalculations

Recalculations were carried out due to several improvements in the IPCC software; stock change option to estimate changes within cropland (abrupt); the inclusion of belowground biomass; and off-site DOC in peatlands included. In addition, the emission factors for cocoa and oil palm were also updated. Oil palm's net accumulation rate was updated to reflect:

i. The selection of oil palm clones for increased yield potential; and
ii. Efficient resource utilisation offers a promising avenue for sustainable intensification.

Figure SIC6.10 **Comparison of the net total for cropland emissions estimated between BUR4 and BTR1**



6.5.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Section 6.9.

6.6 Category Grassland (CRT Category 4.C.)

6.6.1 Description

Grassland is crucial for livestock production and maintaining. In Malaysia, the management of pasture land, often referred to as Sustainable Grazing Land Management (SGLM), is essential to prevent land degradation, support food security, human well-being, and may contribute to climate change mitigation and adaptation. Hence, emissions and removals from the forests are considered based on the management activities undertaken. Table SIC6.16 provided the overview of emissions and removals covered under the grassland.

Table SIC6.16 Overview of Removals and Emissions Covered Under Grassland

Emissions Source	Source Included	Methods	Emissions Factors
	Carbon stock change	Gain – loss method	Publications
	Non-CO_2 emissions		
	Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils	IE	
	Emissions and removals from drainage and other management of organic and mineral soils	Default	IPCC defaults
	Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	NA/IE	IPCC default
Gasses Reported	CO_2, CH_4 and N_2O		
Coverages	National		
Key Categories (KCA)	No		
Major Improvements since last submission	No		

6.6.2 Methodological issues

The emissions and removals of GHG are based on changes in carbon stocks within the land use category. They are estimated for each land-use category (including both land remaining in a land-use category as well as land converted to another land use). Gain-Loss method is used to estimate the emissions and removals from grassland. Description of methodologies by categories used are shown in Table SIC6.17. Additionally, about 2100 ha of grassland is in peatland. It is primarily for water buffalos and for them to soak in water. Emissions from drained peatland is estimated.

Table SIC6.17 Description of Methodologies for Grassland

Choice of Method	Tier 1: Gain Loss Method			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Pasture land	Total land area	T1 assumption; gains = loss	KPKM
	Drained peatland	Total grassland in peatlands and drained	Shallow peat and shallow drained. Primarily for buffaloes.	DVS

Table SIC6.18 Emission Factors Used for Grassland

Category	Emission Factor					Data Source
	CO_2	CH_4	N_2O	CO	NOx	
Emissions from drained peatland	9.6 t C/ha		1.57 kg N_2O-N/ha/year			2013 IPCC Wetland Supplement

6.6.3 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment, which is described in sub-chapter 1.6 of the NID.

6.5.4 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in sub-chapter 1.9 of the NID.

6.6.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures, which is described in sub-chapter 1.5 of the NID.

General quality control procedures were used in data collection and performing calculations to estimate carbon stocks. For example, the carbon datasets, which include inventory variables such as areas, volumes and/or biomass, were compared with published literatures.

Data required for national GHG inventory is compiled by agencies. QC is undertaken for activity data by comparing the data against international databases and publications. The SWG for LULUCF checks and approves all the data dan emission factors. Check for consistency in data between categories and completeness are undertaken by the LULUCF coordinating agency and discussed in the SWG meetings. Analysis of time series is also undertaken to ensure, the input of values into the IPCC software is correct and the standard of data quality is maintained. Regular data compilation reviews are undertaken with data providers to ensure the correct use of data. Data is compiled into a database as archiving of information. The IPCC software is also another method for archiving of information.

6.6.6 Category-Specific Recalculations

Not applicable.

6.6.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Section 6.9.

6.7 Category Wetlands (CRT Category 4.D.)

6.7.1 Description

Peat extraction activity does not occur in Malaysia and hence is not accounted. Emissions and removals from peatlands are covered under forest land and cropland. See the section on 6.5 Category Cropland (CRT 4.B) for details.

Wetlands expansion in Malaysia has primarily been for the construction of hydro-electricity dams. Between 1990-2021, eleven hydroelectricity dams were constructed. GHG emissions associated with biomass loss prior to flooding are included in the harvest in the forest category. All biomass is cleared prior to flooding the area. Hence, emissions and removals from the forests are considered based on the management activities undertaken (Table SIC6.19).

Table SIC6.19 **Overview of removals and emissions covered under Wetlands**

Emissions Source	Source Included	Methods	Emissions Factors
	Managed peatlands	NO	
	Carbon stock change in flooded land	IE (forest land)	
	CH_4 emissions from flooded land remaining flood land	Diffusive emissions	IPCC default
Gasses Reported	CH_4		
Coverages	National		
Key Categories (KCA)	No		
Major Improvements since last submission	Flooded land remaining flooded land is a new category estimated.		

6.7.2 Methodological issues

Wetlands like peatlands and mangroves are covered in forest and cropland. No peat extraction activities are undertaken in Malaysia. Biomass loss from forest-converted wetlands, in particular hydro dams, are included in the harvest in forest land. Additionally, rice paddy, which is cultivated through land flooding, falls under the category of Agriculture.

For flooded land remaining flooded land, CO_2 emissions from hydroelectric dams were estimated using default emissions factors that were calculated outside the IPCC software. CO_2 emission from diffusion (Tier 1) is calculated using the Level 1 equation. The default assumption in the 2006 Guidelines is that CO_2 and CH_4 emissions are limited to the first 10 years after the flooding took place, and any subsequent emissions of CO_2 come from carbon entering the reservoir from other land areas (e.g., upstream agriculture). Hence, hydroelectricity dams constructed and operated within the reporting period are considered and limited to the first 10 years after flooding.

Table SIC6.20 Description of methodologies for Wetlands

Choice of Method	Tier 1: Gain Loss Method			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
CH_4 emissions from flooded land	Flooded land remaining flooded land	Total surface area of wetlands	Diffusive CH_4 emissions occurred in the first 10 years after flooding of the dams.	TNB; SESB, SEB

Table SIC6.18 Emission Factors Used for Grassland

Category	Emission Factor					Data Source
	CO_2	CH_4	N_2O	CO	NOx	
Flooded land remaining flooded land – Averaged daily diffusive emissions		0.63 kg CH_4 ha^{-1} day^{-1}				2006 IPCC GL

6.7.3 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment, which is described in sub-chapter 1.6 of the NID.

6.7.4 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in in sub-chapter 1.9 of the NID.

6.7.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures, which is described in in sub-chapter 1.5 of the NID.

Data required for national GHG inventory is compiled by agencies. QC is undertaken for activity data by comparing the data against international databases and publications. The SWG for LULUCF checks and approves all the data dan emission factors. Check for consistency in data between categories and completeness are undertaken by the LULUCF coordinating agency and discussed in the SWG meetings. Analysis of time series is also undertaken to ensure, input of values into the IPCC software is correct and the standard of data quality is maintained. Regular data compilation reviews are undertaken with data providers to ensure the correct use of data. Data is compiled into a database as archiving of information. The IPCC software is also another method for archiving of information.

6.7.6 Category-Specific Recalculations

Not applicable.

6.7.7 Category-Specific Planned Improvements

This source category is covered by the sectoral planned improvements, which is described in Section 6.9.

6.8 Category Settlements (CRT Category 4.E.)

6.7.1 Description

Settlement data were collected from departmental reports and verified during stakeholder consultations. International data was used to obtain historical data (CCI-LC) pre-2015. Data on settlement expansion is obtained through the de-gazettement of previous land use. Data collection for settlement poses a lot of challenges, especially in villages where crops area also planted in the compound of the house. Secondly, temporary licenses are also given to communities to plant crops under the transmission line, while the land is considered a settlement.

The trend of converting cropland to residential and commercial areas thus creating an economic activity within the area while creating new conurbation. The East Malaysian states in Borneo are also developing new hubs for renewable energy, ecotourism and other economic activities.

Table SIC6.22 Overview of removals and emissions covered under Settlement

Emissions Source	Source Included	Methods	Emissions Factors
	Settlement remaining Settlement	Gain – loss	
	FL converted to Settlement	Stock difference	NFI Kenzo et al 2010
	Cropland converted to Settlement	Stock difference	Kho et. al. (2016)
Gasses Reported	CO_2		
Coverages	National		
Key Categories (KCA)	Yes		
Major Improvements since last submission	1. Update in activity data 2. Update in emission factors for forest and cropland		

6.8.2 Methodological issues

Table SIC6.23 Description of Methodologies for Settlements

Choice of Method	Tier 1: Gain Loss Method			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Settlement remaining settlement	To total tree canopy or trees in urban or periurban areas	Tier 1 approach; incremental gains from growth are offset by losses from natural mortality, pruning or other losses.	Plan Malaysia Sabah agencies UPEN Sarawak, CCI-LC
	Forestland converted to settlement	Total forest area converted to settlement	All biomass is cleared at conversion	Forestry Dept
	Cropland converted to settlement	To cropland converted to settlement	All biomass is cleared at conversion	Remote sensing data, Development Plans and Developers Annual Reports

Table SIC6.24 Emission Factors Used for Settlements

Category	Emission Factor					Data Source
	CO_2	CH_4	N_2O	CO	NOx	
Inland forest	94.5 t C/ha		1.57 kg N_2O-N/ha/year			NFI
Peat swamp forest	99. t C/ha					
Fallow forest	45.8 t C/ha					Kenzo et al (2010)
Rubber	60.4 t C/ha					Yew & Nasarudin (2002)
Oil palm	37.6 t C/ha					Kho et al (2016)

6.8.3 Uncertainty Assessment and Time-Series Consistency

Uncertainty assessment for the LULUCF sector was undertaken using IPCC Approach 1, propagations of error method. Activity data for land use is derived from land registry which hold land survey data.
For Forest Land, data is derived from national statistics and the uncertainty is 15% based on the survey methods while the emission factors uncertainty was obtained from the NFI and calculated as 32%. The combined uncertainty is 35%.

For Cropland, the data is also derived from national statistics and the uncertainty is 25% and for emission factors. The uncertainty is from the land survey and also the accuracy of native customary land.

6.8.4 Description of Any Flexibility Applied

This source category is covered by the general flexibility, which is described in sub-chapter 1.6 of the NID.

6.8.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures, which is described in sub-chapter 1.9 of the NID.

Data required for national GHG inventory is compiled by relevant agencies. QC is undertaken for activity data by comparing the data against international databases and publications. The SWG for LULUCF checks and approves all the data dan emission factors. Check for consistency in data between categories and completeness are undertaken by the LULUCF coordinating agency and discussed in the SWG meetings. Analysis of time series is also undertaken to ensure, input of values into the IPCC software is correct and the standard of data quality is maintained. Regular data compilation reviews are undertaken with data providers to ensure the correct use of data. Data is compiled into a database as archiving of information. The IPCC software is also another method for archiving information.

6.8.6 Category-Specific Recalculations

Recalculations were carried out for settlement as follows:

i. Settlement: The changes in values are contributed from the changes in values in oil palm carbon stocks. This has been explained in cropland.

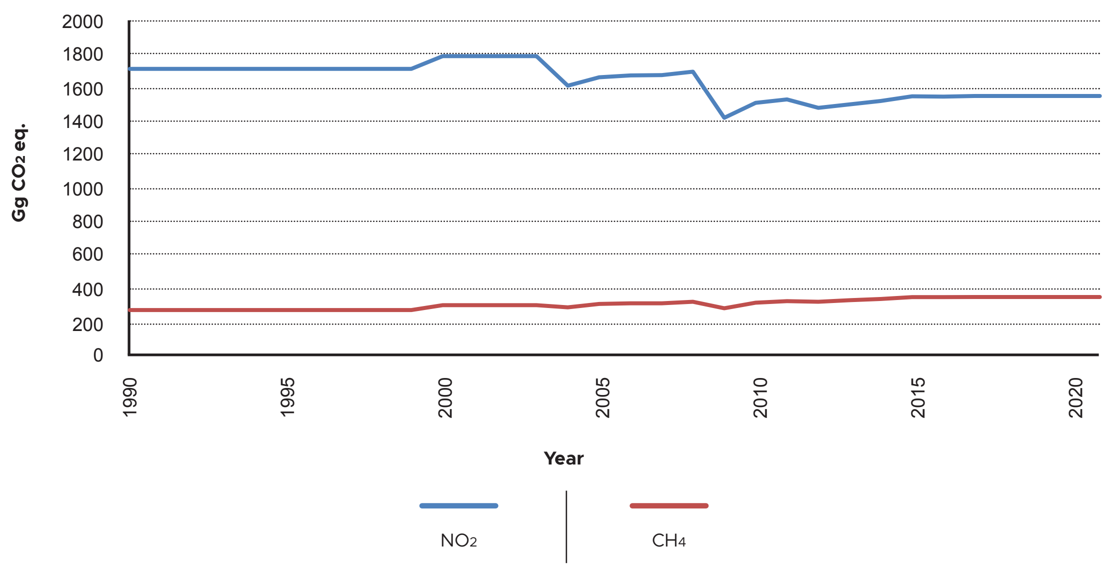
4.(II). Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)

Rewetting had been untaken since year 2008 and emissions from rewetting is reported from year 2016. The total area rewet is 1,200 ha and the emission was 1.8638 Gg CO_2 eq.

4.(III). Total for all land-use categories (Direct and indirect nitrous oxide (N_2O) emissions from nitrogen (N) mineralisation/immobilisation associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)

This category included here is emissions from drained peatlands which was previously reported under agriculture sector.

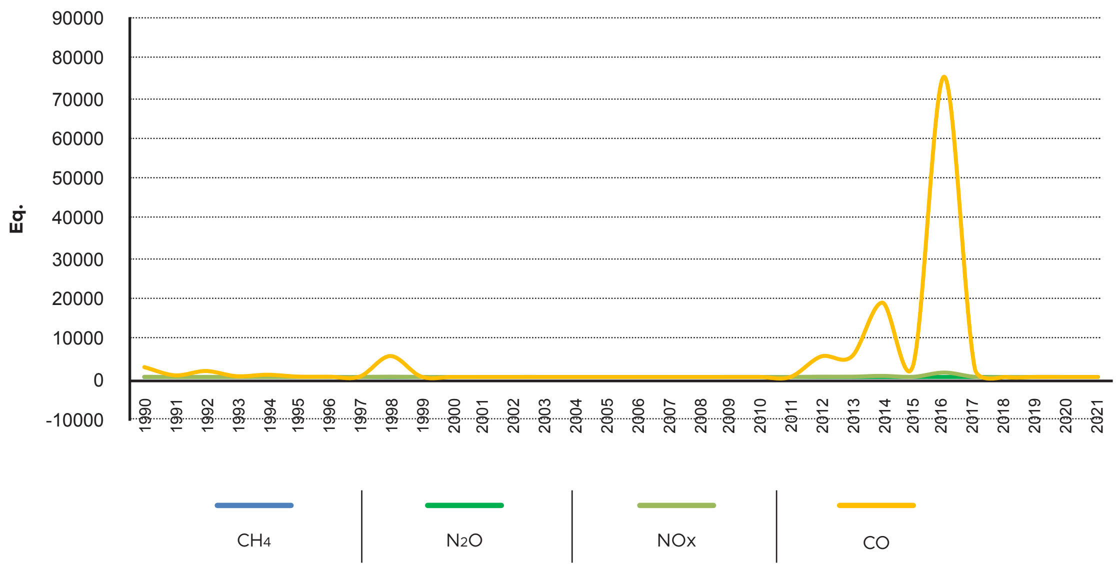
Figure SIC6.11 **Emissions from drained peatlands**



4.(IV). Total for all land-use categories (Biomass burning)

Emissions from wildfires are shown in Figure SIC6.12. The highest emissions from wildfires occurred in 2016, where about 21,000 ha of forest has fire incidence.

Figure SIC6.12 **Emissions from wildfires**



6.9 Category-Specific Planned Improvements

6.7.1 Description

Planned improvements include continuous refinement and improvement of activity data, emission factors and transparency in reporting.

For the LULUCF sector, the changes of land use activities are very dynamic in meeting development for rural communities and country's economic growth. These changes require continuous assessment of land use and land use change, especially for pre-2010 which is still ongoing. Malaysia may update its land use and land use change data once this exercise is completed. Assessment includes abandoned cropland, land use change transitions and alienated land. Malaysia is also improving its data collection and verification processes to reduce the reporting period gap in the national statistics. This could potentially take some time.

Planned improvement in developing country-specific emission factors for soil organic carbon and dead organic matter in forests is ongoing. The project has been delayed due to the lockdowns and has only started in year 2022. Weather conditions further delayed the data collection. Malaysia is also reviewing its approach taken to estimate biomass loss due to forest fires. Forest fires occur primarily during the El Niño years.

Malaysia plans to review its peatlands status, especially for those that have been cultivated and drained for more than 50 years. Once the assessment is completed, Malaysia may review the emission factors used. Efforts are being made to develop updated country-specific emission factors for oil palm in peatlands. Detailed improvement plan is shown in Table SIC6.25.

Table SIC6.25 **Category-Specific Planned Improvements**

Category	Improvement	Description	Progress
Cross-cutting	Address completeness of LULUCF subcategories with estimates reported	Improve completeness of reporting pools in mandatory categories currently reported as N.E	Work is in progress
Cross-cutting	Develop a plan and time frame for estimating and reporting uncertainties for all LULUCF categories	Malaysia has provided uncertainty analysis for the LULUCF categories. However, improvement is required on the estimates.	
General	Improvement of activity data	Large areas of abandoned land due to labour shortage need to be assessed for consistency.	
General	Drained peatlands	Improved understanding on drained peatlands or if they are ditches in forest and other crops in peatland.	
General: Land Transition	Revise and improve the consistency and completeness of land transition matrix	Data analysis on to improve the consistency and completeness of land use transition is ongoing	
General	Emission factors	Improvement/updating of emission factors where necessary	
Forest land	HWP	Baseline data/parameters are being collected	Work is in progress
Forest land	Harvest	Disaggregation of data between PRF and State Land Forest	

Category	Improvement	Description	Progress
Forest land	Biomass burning from wildfires	Fraction of biomass loss	Data collection and analysis ongoing
Forest land	Unmanaged cropland converted to forest land	Improvement in assessment of carbon stocks in unmanaged cropland	
Forest land	Forest land converted to wetlands and settlement	Improvement in data analysis especially for data prior to 2015 in some regions	
Cropland	Activity data	Develop a method to ensure consistency in tracking crop especially amongst farmers	
Cropland	Soil carbon	Explore the use of the Bayesian approach to estimate the soil carbon stocks	
Cropland	Emissions from drained peatlands	Data collection from peatlands drained more than 50 years.	Data collection and analysis ongoing
Wetlands	Improve estimates for flooded land remaining flooded land	Explore the use of 2019 Refinement	
Settlement	Settlement remaining settlement	Methodological approach to estimate emissions and removals from Settlement	
Settlement	Forest and crop land converted to Settlement	Explore the use of Bayesian approach to estimate the soil carbon stocks	

The equations used are:

2006 IPCC Guidelines

A. Equation 2.10 – Average annual increment in biomass
B. Equation 2.12 – Annual carbon loss of wood removals
C. Equation 2.14 – Annual carbon losses in biomass to disturbance
D. Equation 2.16 – Initial change in biomass carbon stocks on land converted to another land category
E. Equation 11.1 – Direct N_2O emissions from managed soils (only covers emissions from managed organic soils)
F. Equation 3A.1 – CH_4 emissions from flooded land

2013 Wetlands Supplementary

G. Equation 2.3 – Annual on-site CO_2-C emissions/removals from drained organic soil
H. Equation 2.4 – Annual off-site CO_2 emissions due to DOC loss from drained organic soil
I. Equation 2.5 – Emissions factor for annual CO_2 emissions due to DOC export from drained organic soils
J. Equation 3.3 – CO_2-C emissions/removals from rewetted organic soil
K. Equation 3.4 – Annual on-site CO_2-C emissions/removals from rewetted organic matter
L. Equation 3.5 – Annual off-site CO_2 emissions due to DOC loss from rewetted organic soil
M. Equation 3.7 – CH_4-C emissions/removals from rewetted organic soil
N. Equation 3.8 – Annual CH_4-C emissions from rewetted organic soil

6.10 Uncertainty Assessment for LULUCF Sector

The uncertainty in agriculture sector for year 2005 stands at 59.48%. Table SIC5.33 shows the uncertainty analysis table.

Table SIC5.33 **The uncertainty in LULUCF sector for year 2005 stands at 38.25% (Table SIC6.26)**

CRT category		Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
			(Gg CO_2 equivalent)	%	%	%	
4.	**LULUCF**						
4.A.	Forest land	CO_2	(214,453.80)	32.00%	10.00%	33.53%	0.14
4.B.	Cropland	CO_2	(12,561.10)	20.00%	20.00%	28.28%	0.00
4.C.	Grassland	CO_2	105.08	25.00%	71.00%	75.27%	0.00
4.D.	Wetland	CO_2	0.45	71.00%	71.00%	100.41%	0.00
4.E.	Settlement	CO_2	34,335.00	22.50%	26.00%	34.38%	0.00
4.(II)	Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)	CH_4	33.65	32.00%	10.00%	33.53%	0.00
4.(I)	Direct and indirect N2O emissions from N inputs to managed soils	N_2O	0.00	32.00%	10.00%	33.53%	0.00
4.(III)	Total for all land-use categories (Direct and indirect nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	N_2O	1,809.16	32.00%	10.00%	33.53%	0.00
4(IV).	Total for all land-use categories (Biomass Burning)	CH_4	13.83	32.00%	10.00%	33.53%	0.00
	Total		**(190,717.74)**				**0.15**
				Percentage uncertainty in total inventory			**38.25%**

The uncertainty in LULUCF sector for year 2021 stands at 39.70%, while the trend uncertainty (base year 2005) is 59.35% (Table SIC6.27).

Table SIC6.27 **Uncertainty for LULUCF Sector for 2021**

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
4.	LULUCF												
4.A.	Forest land	CO_2	(214,453.80)	(248,823.48)	32.00%	10.00%	33.53%	0.15	0.05	1.30	0.01	0.59	0.35
4.B.	Cropland	CO_2	(12,561.10)	(278.04)	20.00%	20.00%	28.28%	0.00	0.07	0.00	0.01	0.00	0.00
4.C.	Grassland	CO_2	105.08	105.08	25.00%	71.00%	75.27%	0.00	0.00	0.00	0.00	0.00	0.00
4.D.	Wetland	CO_2	0.45	0.65	71.00%	71.00%	100.41%	0.00	0.00	0.00	0.00	0.00	0.00
4.E.	Settlement	CO_2	34,335.00	34,795.51	22.50%	26.00%	34.38%	0.00	0.02	0.18	0.00	0.06	0.00
4.(II)	Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)	CH_4	33.65	359.89	32.00%	10.00%	33.53%	0.00	0.00	0.00	0.00	0.00	0.00
4.(I)	Direct and indirect N_2O emissions from N inputs to managed soils	N_2O	0.00	0.00	32.00%	10.00%	33.53%	0.00	0.00	0.00	0.00	0.00	0.00
4.(III)	Total for all land-use categories (Direct and indirect nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	N_2O	1,809.16	1,552.64	32.00%	10.00%	33.53%	0.00	0.00	0.01	0.00	0.00	0.00
4(IV).	Total for all land-use categories (Biomass Burning)	CH_4	13.83	3.42	32.00%	10.00%	33.53%	0.00	0.00	0.00	0.00	0.00	0.00
Total			**(190,717.74)**	**(212,284.33)**				**0.16**					**0.35**
				Percentage uncertainty in total inventory				**39.70%**		**Trend Uncertainty**			**59.35%**

7
CHAPTER

WASTE (CRT SECTOR 5)

7.1 Overview of the Sector

The overview of the waste sector is demonstrated in Table SIC7.1. The information includes gasses reported, major improvements undertaken, methodological tiers as well as emission factors used within the sector.

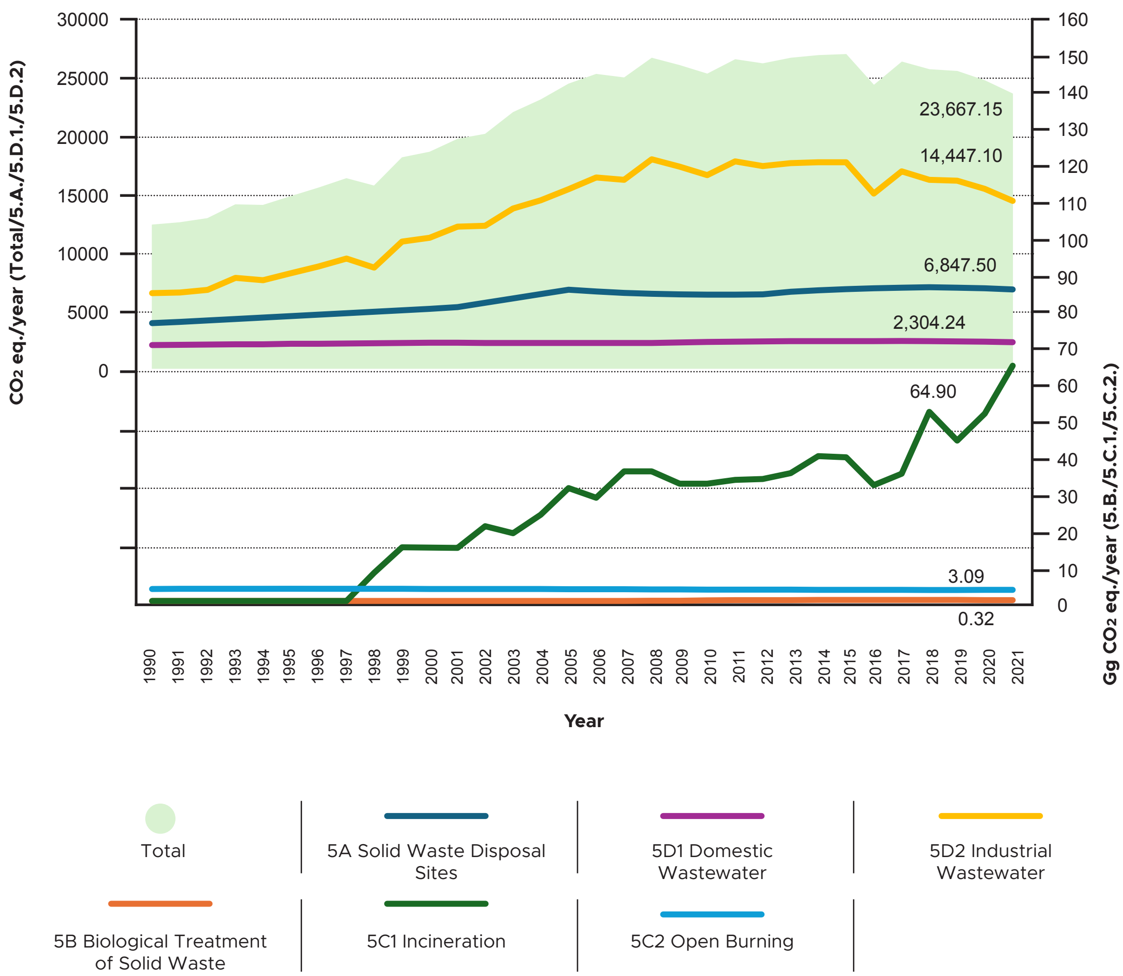
Table SIC7.1 **Overview of the Waste Sector**

Emission Sources Included	5.A. Solid Waste Disposal 5.B. Biological Treatment of Solid Waste 5.C. Incineration and Open Burning of Solid Waste 5.D. Wastewater Treatment and Discharge					
Gasses Reported	CO_2, CH_4, N_2O					
Major improvements since last submission	Revised estimates for 5A, solid waste disposal, based upon improved data.					
Sector	**CO_2**		**CH_4**		**N_2O**	
5. Waste	**Method**	**EF**	**Method**	**EF**	**Method**	**EF**
5.A. Solid Waste Disposal Sites			T1	D		
5.B. Biological Treatment of Solid Waste			T1	D	T1	D
5.C. Incineration and Open Burning of Waste						
5.C.1 Incineration	T2a	D	T2a	D	T2a	D
5.C.2 Open Burning	T1	D	T1	D	T1	D
5.D. Wastewater Treatment and Discharge						
5.D.1 Domestic Wastewater			T1	D	T1	D
5.D.2 Industrial Wastewater						
POME Methane Emission			T2	CS		
Rubber			T1	D		
Petroleum Refineries			T1	D		
Pulp & Paper			T1	D		
Meat & Poultry			T1	D		

Trends of GHG Emissions from the Waste Sector

Total emissions in 2021 from the waste sector stood at 23,667.15 Gg CO_2 eq. as shown in Figure SIC7.1. Emissions consist of CO_2, N_2O and CH_4 from waste incineration; CH_4 from solid waste disposal on land, and CH_4 and N_2O from wastewater handling and biological treatment of solid waste.

Figure SIC7.1 **Emissions Time Series from Waste Sector**



The highest emissions were from industrial wastewater treatment and discharge at 14,447.10 Gg CO_2 eq. (61.0%), followed by solid waste disposal sites at 6,847.50 Gg CO_2 eq. (29.0%) and 2,304.241 Gg CO_2 eq. (10.0%) from domestic wastewater treatment and discharge. Overall emissions from the waste sector have decreased by 8% since year 2019. The activities leading to GHG emissions reduction was mostly from industrial wastewater treatment and discharge due to the implementation of methane recovery systems in the palm oil industry. The biogas capturing activities were subjected to mandatory requirement for two categories of mills since year 2014: new constructed mills and mills requesting for throughput expansion. This mandate has contributed to an increased uptake of sustainable practices across the industry, including methane recovery projects. This is inline with the Malaysian Sustainable Palm Oil (MSPO) Scheme, which became mandatory on 31st December 2019 and effective on 1st January 2020. These initiatives align with Malaysia's strategy to fulfil the globally-recognised Environmental, Social and Governance (ESG) requirements and the Sustainable Development Goals (SDGs), positioning the Country as a responsible leader in palm oil production.

Figure SIC7.2 and Figure SIC7.3 demonstrates the contribution by gasses and subsectors within the waste sector, respectively.

Figure SIC7.2 **Waste Sector Contribution by Gasses (%) in 2021 (in Gg CO_2 eq.)**

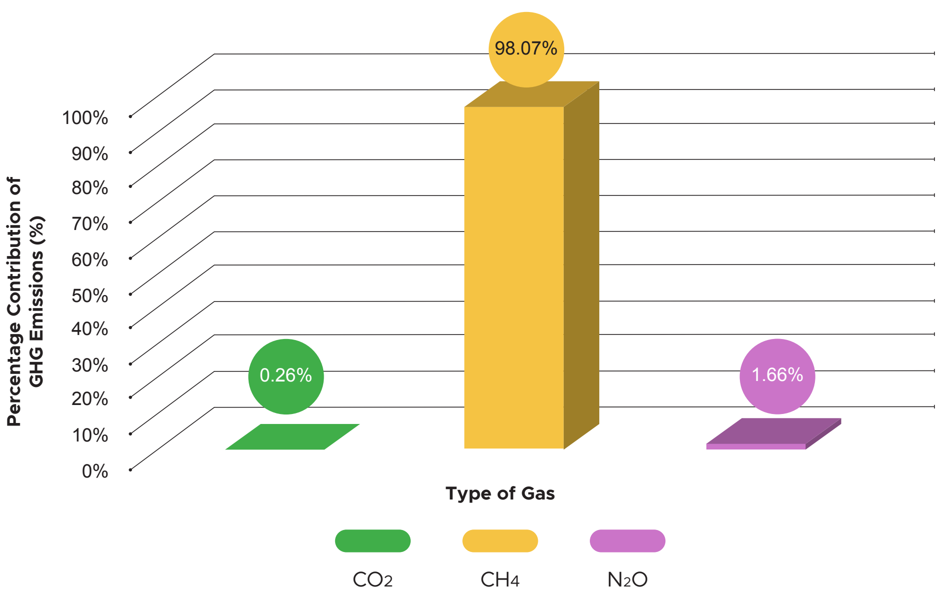
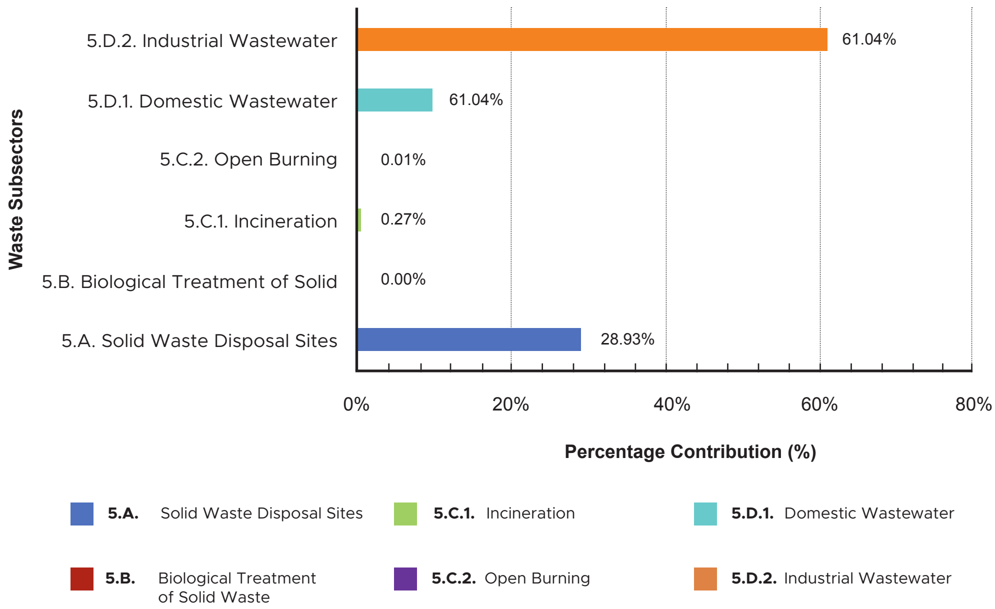


Figure SIC7.3 Waste Sector Contribution by Subsectors (%) in 2021



Sectoral Summary

Table SIC2.2 provides the summary of GHG emissions in 2021 for the waste sector. There are four (4) main categories under the sector, namely the Solid Waste Disposal Sites (5.A.), Biological Treatment of Solid Waste (5.B.), Incineration and Open Burning of Waste (5.C.) and Wastewater Treatment and Discharge (5.D.). Total emissions including the non-CO_2 gasses are estimated at 23,667.15 Gg CO_2 eq.

Table SIC7.2 Summary of GHG Emissions for the Waste Sector in 2021

Sub-sector	Gas	Emissions (Gg)	GWPs	CO_2 eq. (Gg)
		A	B	C= (A x B)
5.A. Solid Waste Disposal Sites	CH_4	244.5535	28	6,847.4969
5.B. Biological Treatment of Solid Waste	CH_4 N_2O	0.0072 0.0004	28 265	0.2019 0.1147
5.C. Incineration and Open Burning of Waste				
5.C.1. Incineration	CO_2 N_2O	61.7744 0.0118	1 265	61.7744 3.1225
5.C.2. Open Burning	N_2O CH_4 N_2O	0.7061 0.0779 0.0008	1 28 265	0.7061 2.1823 0.2049
5.D. Wastewater Treatment and Discharge				
5.D.1. Domestic Wastewater	CH_4 N_2O	68.3712 1.4711	28 265	1,914.3940 389.8479
5.D.2. Industrial Wastewater				
POME Methane Emission	CH_4	510.8298	28	14,303.2349
Rubber	CH_4	2.9557	28	82.7609
Petroleum Refineries	CH_4	0.0002	28	0.0044
Pulp & Paper	CH_4	1.0992	28	30.7779
Meat & Poultry	CH_4	1.0830	28	30.3229
			Total (Emissions)	**23,667.1466**

A sectoral summary of the emissions trend is demonstrated in Table SIC7.3 below.

Table SIC7.3 **Summary of Trends for the Waste Sector in 2021**

GHG Source and Sink Categories		Latest Year Total: 2021 (Gg CO_2 eq.)	2005 - Latest Year Trend (2021)	Description
5.A.	**Solid Waste Disposal**	6,847.50	Increase	The increase of Malaysia's population Economic growth Lifestyle change
5.B.	**Biological Treatment of Solid Waste**	0.31	An increase up to 2019, a decrease from 2019 to 2021	Prior to 2019: Active participation from the industry during CDM commencement 2019 onwards: Closure of composting plants as the activity is not economically viable.
5.C.	**Incineration and open burning of waste**	Incineration: 65.29 Open Burning: 2.89	Incineration: Increase Open Burning: Decrease	5.C.1. Regulation have been put in place 5.C.2. Decrease in rural population
5.D.	**Wastewater treatment and discharge**	Domestic: 2,304.24	Domestic: 2005-2016: Increase 2017-2021: Decrease	5.D.1. 2005-2021: Increasing trend due to population and economic growth. It is also might be due to enhancement of activity data for Sarawak. 2017 - 2021: Decreasing trend might be due to the extrapolation of activity data for Sabah based on available actual data 2016.
		Industrial: 14,447.10	Industrial: Decrease	5.D.2.: Methane recovery system (biogas capture) has increased.
5.E.	**Other**			

Sectoral Improvement Undertaken

The sectoral improvement undertaken of the waste sector is shown in Table SIC7.4.

Table SIC7.4 **Sectoral Improvement Undertaken**

Sub-Category		Improvement	Description
5.A.	**Solid Waste Disposal**	Refinement in activity data for categorisation of solid waste disposal site	SWDS Classification referred to The Technical Guideline for Sanitary Landfill, Design & Operation Level 1: Unmanaged shallow (<5m waste) Level 2: Managed well-active aeration Level 3: Managed well-semi aerobic Level 4: Managed well-semi aerobic
5.B.	**Biological Treatment of Solid Waste**	NIL	NIL
5.C.	**Incineration and open burning of waste**	NIL	NIL
5.D.	**Wastewater treatment and discharge**	NIL	NIL
5.E.	**Other**		

Emission from Solid Waste Disposal Sites

The increase in CH_4 emissions from solid waste disposal is attributed to population growth and the corresponding rise in the volume of waste sent to landfills. Nevertheless, between 2001 and 2005, CH_4 emissions rose significantly, primarily due to improvements in the waste per capita value, as detailed in Table SIC 7.7.

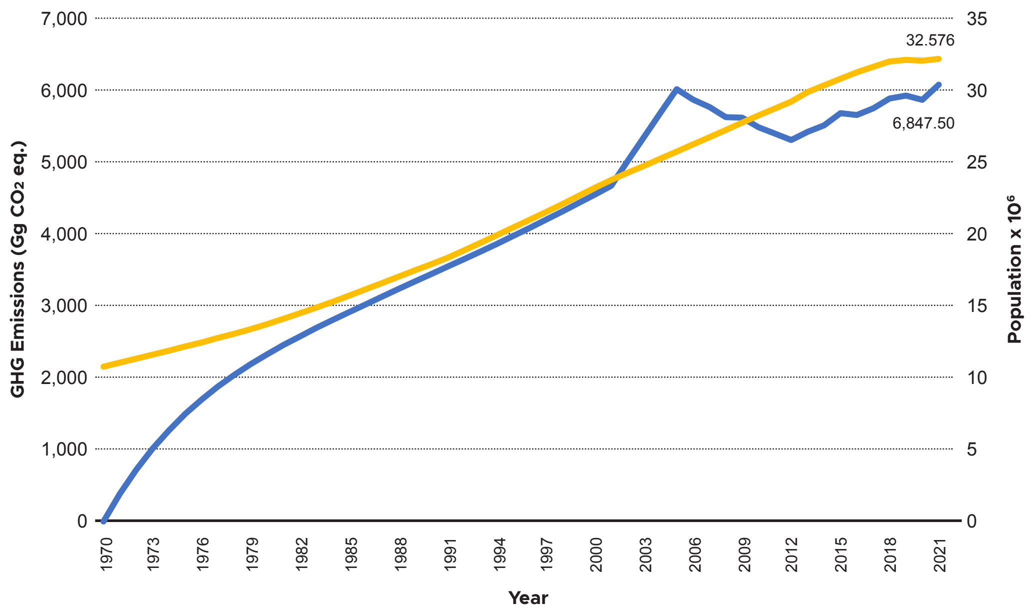
However, emissions began to decline thereafter, driven by advancements in landfill categorisation. From 1970 to 2004, calculations of GHG emissions were based on the uncategorized Methane Correction Factor (MCF) using the IPCC default of 0.6. Starting in year 2005, SWDS were categorised as unmanaged shallow and managed semi-aerobic, following the establishment of the National Solid Waste Management Department (JPSPN), which facilitated more accurate emissions estimations.

Due to the current scenario in Malaysia, landfilling remains the predominant approach to dispose of solid waste, regardless of being the lowest preference in the waste management hierarchy. Landfill was shown to be the greatest source of GHG emissions, contributing more than three-quarters of total emissions associated with waste management.

Based on a study by JICA (2006), 96% of wastes were sent to SWDS and the remaining 4% was sent for intermediate treatment and recycling. Then, in year 2012 onwards data provided by JPSPN (2013), show 90% of waste generated were sent to SWDS and 10% was recycled. Currently, in 2021, 69% of waste disposed of in Malaysia is landfilled. The total number of landfill sites in Malaysia in 2021 is 137 sites. Specifically, there were 116 open dumpsites in Malaysia and 21 were sanitary landfills. Generally, when MSW is first deposited in a landfill, it undergoes an aerobic (with oxygen) decomposition stage when little methane is generated. Then, typically within less than one-year, anaerobic conditions are established, and methane-producing bacteria begin to decompose the waste and generate methane. It is therefore of utmost importance to tackle landfill gas emission.

Reduction of methane emission in the solid waste disposal is a challenge where every sector has a role to play and that can be partly solved by following the waste hierarchy with more recycling and the complementary development of energy recovery for non-recyclable waste. Proper gas monitoring was not done in most landfills which the emission trend, pattern and impact remains untold. Understanding CH_4 and CO_2 concentration trends will positively help in spatial variation of landfill emissions in Malaysia.

Figure SIC7.4 **Solid Waste Disposal Sites CH_4 Emissions for 1990-2021**

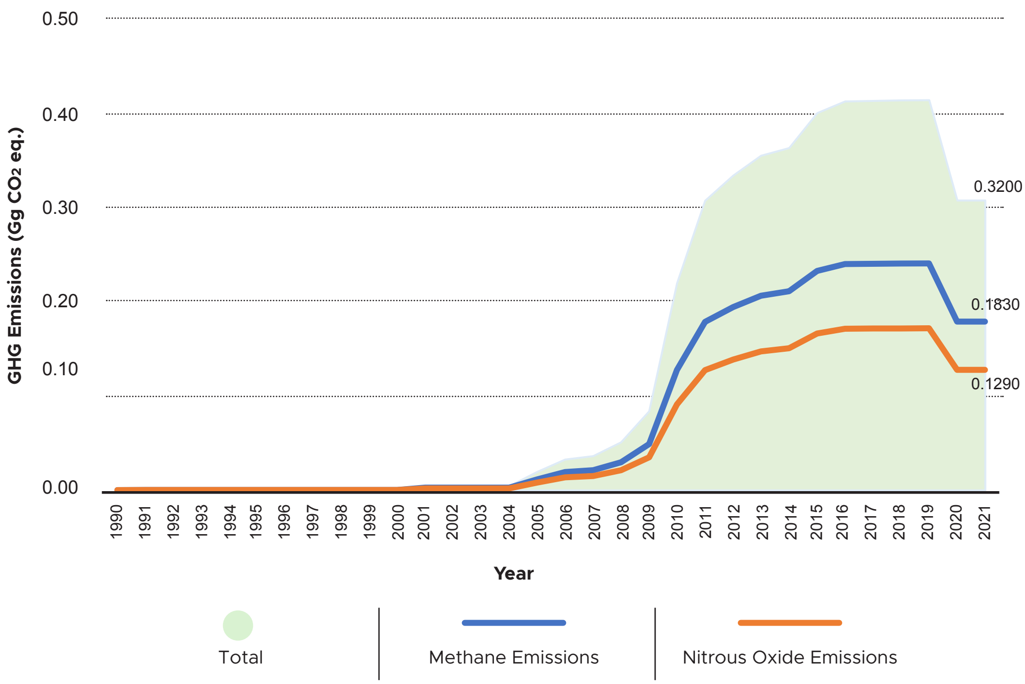


Emission from Biological Treatment of Solid Waste

The trend for biological treatment of EFB via composting has increased since the activity started in 1991. Basically, the trend for GHG emissions as shown in Figure SIC7.5 is correlated to the increased development of composting plants at palm oil mills starting in 2004. The tremendous increment of composting plants (year 2009-2011) might be due to the active participation from the industry during the CDM commencement period before post-Kyoto. In year 2021, the estimated CH_4 and N_2O emissions were 0.18 Gg CO2 eq. and 0.13 Gg CO2 eq., respectively. This figure contributes to 0.31 Gg CO_2 eq. from the biological treatment of solid waste.

From the findings, the composting of EFB generated about 0.02 (year 2005) to 0.31 Gg CO_2 eq. (year 2021). This large increment is due to the increased number of composting plants from five (5) (year 2005) to 55 (year 2021). The biological treatment of solid waste is found to be the lowest category source in emitting GHG in the waste sector.

Figure SIC7.5 **Biological Treatment of Solid Waste GHG Emissions for 1990-2021**



Emission from Incineration and Open Burning

The general trend for incineration of scheduled waste (hazardous waste, clinical waste, and fossil liquid waste) is increasing since the activity started in year 1998. However, there are small fluctuations in the estimation (i.e., 1-3 Gg CO_2 eq./year) which are contributed by several factors. Despite the increasing amount of scheduled waste produced from the industries, the availability of proven technology in scheduled waste recovery process and the introduction of the Environmental Quality (Scheduled Wastes) Regulation 2005 that allow them to opt for scheduled waste recovery process instead of the incineration process.

While the estimation trend for open burning of waste seems constant over the span of 31 years, there is a slight decrease which is mainly due to urbanization, stringent law enforcement and also the improvement of solid waste management in Malaysia. It is expected that the open burning emission will continue to decrease.

The estimation trend for indirect emission follows the GHG emission trend because it is associated with the activity data values.

Figure SIC7.6 **Incineration GHG Emissions from 1990-2021**

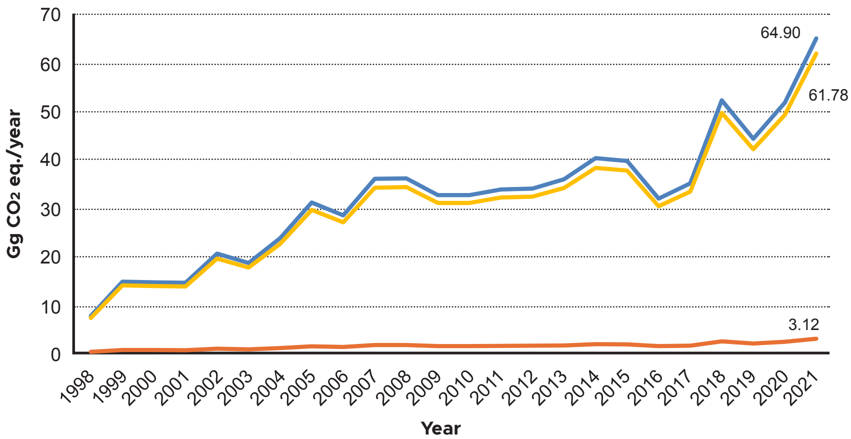


Figure SIC7.7 **Open Burning GHG Emissions from 1990-2021**

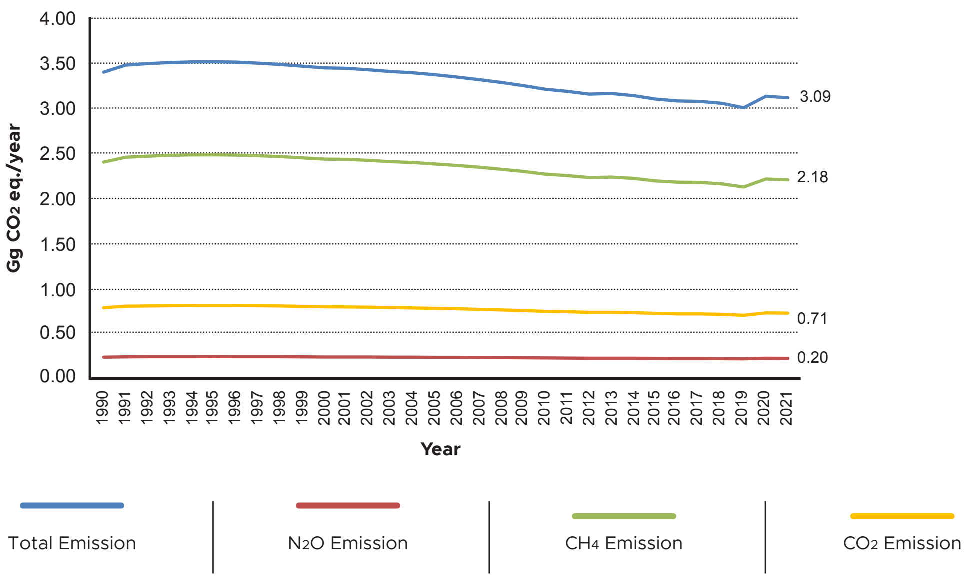


Figure SIC7.8 **Incineration Indirect GHG Emissions from 1990-2021**

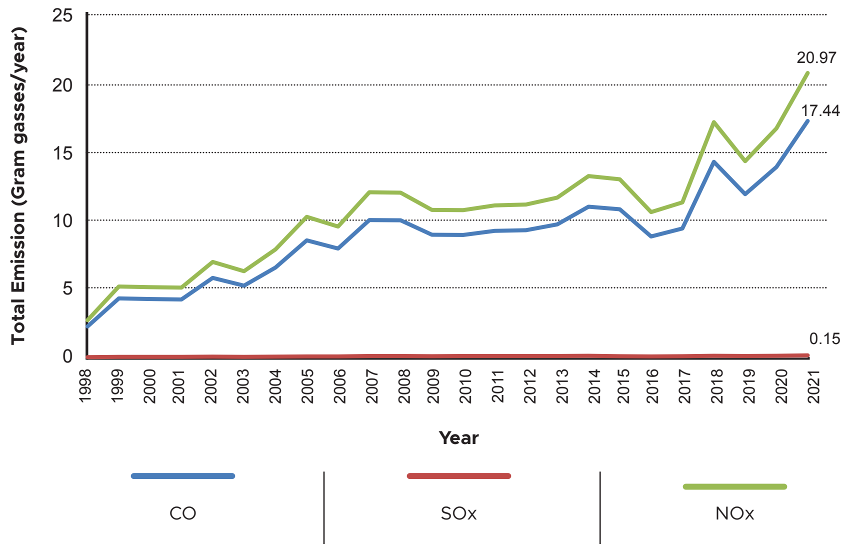
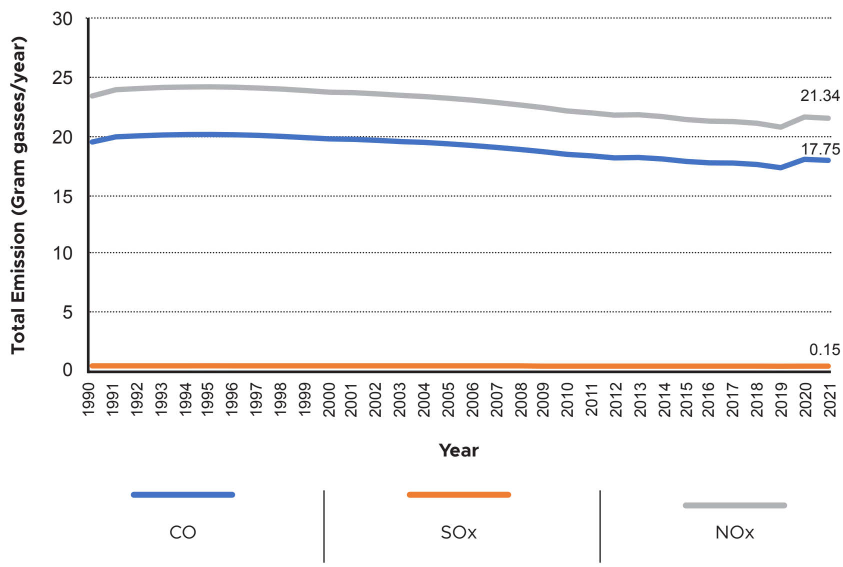


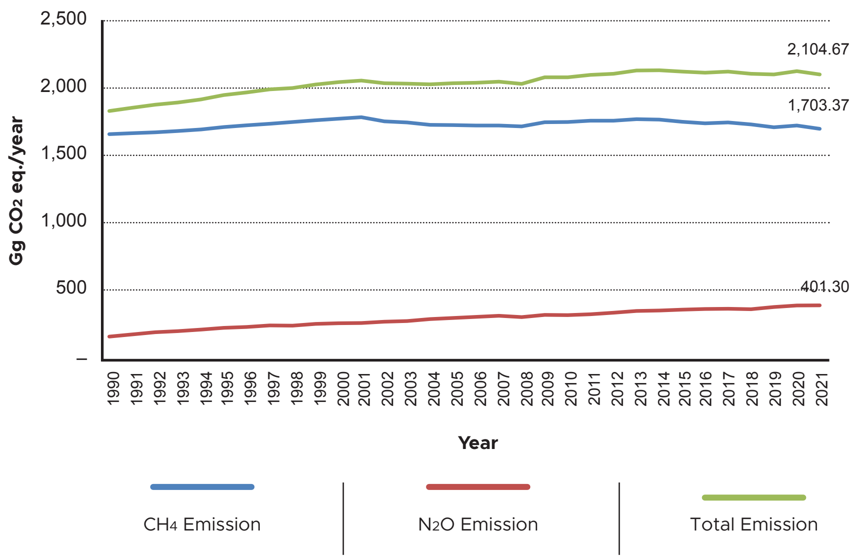
Figure SIC7.9 **Open Burning Indirect GHG Emissions from 1990-2021**



Emission from Domestic Wastewater

The trend for CH_4 (methane) emission from domestic wastewater from 1990 to 2021 showed a fluctuation trend as shown in Figure SIC7.10. The CH_4 emissions showed a fluctuation trend due to enhancement of activity data for Sabah and Sarawak while N_2O (nitrous oxide) emissions show an increasing trend mainly due to the increasing population and protein consumption in the country. In summary, the total emissions are showing an increasing trend due to economy and population growth in the country.

Figure SIC7.10 **Domestic Wastewater GHG Emissions from 1990-2021**



Emission from Industrial Wastewater

The trend from industrial wastewater mainly relies on the market demands of the industrial products because GHG emissions are proportionate to the number of products generated from the industries. The biggest GHG contributor for industrial wastewater is the palm oil industry where it makes up to 99% of the total GHG emissions of this category. Natural rubber industry is the second biggest contributor, followed by pulp and paper, meat and poultry and petroleum refineries.

Figure SIC7.11 shows that there is a significant reduction of the GHG emissions from palm oil mills in 2010. The production of Crude Palm Oil (CPO) in palm oil industry dropped by 3.3% to 16.99 million tonnes in 2010 from 17.56 million tonnes in 2009 although the total oil palm planted area in the country increased by 3.4% in year 2009 to 4.85 million ha in year 2010. The contributing factors were the decline in the average Fresh Fruit Bunch (FFB) yield (6.1%) from 19.20 (2009) to 18.03 (2010) tonnes per hectare and the Oil Extraction Rate (OER) declined from 20.49% (2009) to 20.45% (2010), due to:

Unusual weather patterns of hot and dry conditions from El Nino phenomena in the first half of 2010;

- Excessive rainfalls from La Nina phenomena in the second half of 2010;
- Heavy rainfall and floods especially towards end of 2010 affecting harvesting activity;
- Replanting done under the SITS (*Skim Insentif Tanam Semula*/Replanting Incentive Scheme) incentive program in 2009 and 2010 – with a total of 207,754 ha of old palm trees felled for replanting. This had reduced an estimated 500,000 tonnes of CPO production in year 2010.

Another significant reduction of the GHG emissions from palm oil mills was in year 2016. Between 2015-2016, there were prolonged dry weather conditions in the second half of 2015, and below average rainfall brought about by the El-Nino weather phenomena into the first half of 2016. This had impacted the oil palm industry performance in 2016; where lower FFB yield by 13.9% was recorded, yielding lower CPO production by 13.2% (2016 vs 2015)[32].

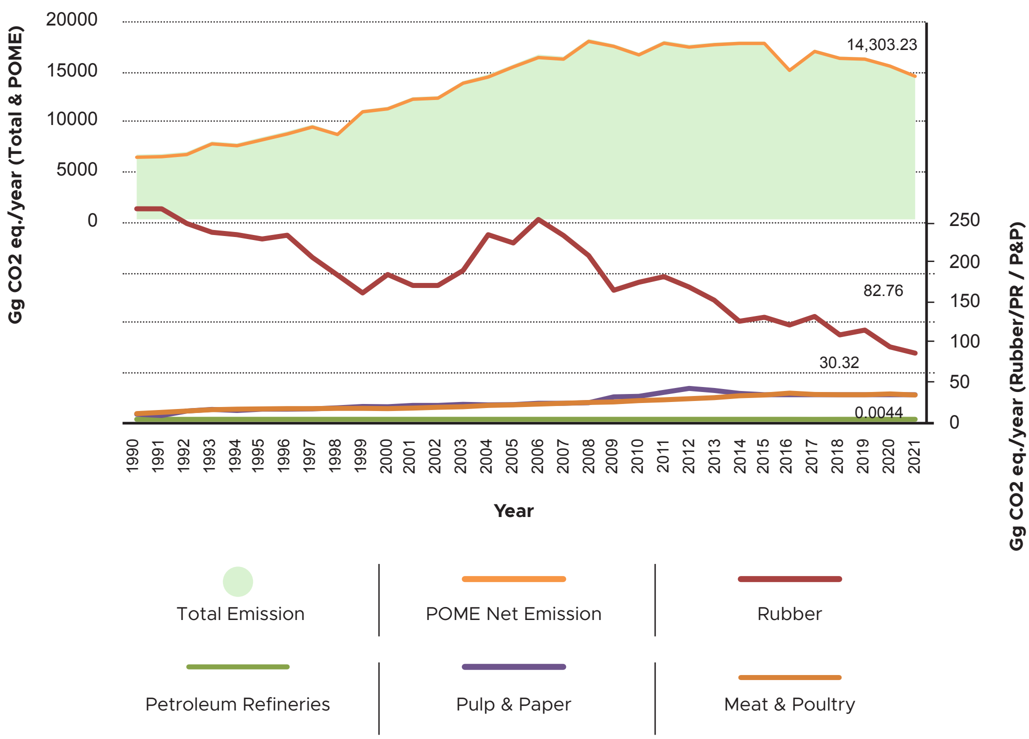
From 2017-2021, although CPO production bounced back to its normal level, the activities on biogas capture had increased; thus, a downward trend in the GHG emissions from palm oil mills.

In particular, methane emission in year 2021 (14,303.23 Gg CO2 eq.) decreased 6.13% compared to that in 2005 (15,236.87 Gg CO2 eq.). In general, GHG emissions from the palm oil wastewater are solely based on trend of CPO (GHG emissions) production from palm oil mills and biogas capturing activities (GHG emission savings). In year 2005, there was no biogas capturing activities, while the CPO production was 14,96 million tonnes. In year 2021, CPO production increased by 21%, number of palm oil mills increased by 14% to reach CPO 18,12 million tonnes, while 135 biogas trapping facilities were built compared to none in year 2005. The first biogas plant was built in

[32] Reference: MPOB (2017)

year 2007. Biogas capturing has contributed to the decreased trend in GHG emissions in year 2021 against 2005 as these activities has led to GHG emissions savings. Since year 2014, biogas capturing activities were subjected to two mandatory requirements: new constructed mills and mills requesting for throughput expansion. Existing mills not fallen under these categories embark on biogas capture on voluntary basis, mostly based on market requirement. Methane recovery trend for 2014-2021 was more obvious compared to those of 2007-2014 prior to the mandatory implementation. In recent years, biogas-capturing and biomass activities are identified as the key area for implementation under the National Energy Transition Roadmap (NETR) and National Agricommodity Policy (DAKN 2030).

Figure SIC7.11 **Industrial Wastewater GHG Emissions from 1990-2021**



7.2 Solid Waste Disposal (CRT Category 5.A.)

7.2.1 Category Description

The legislative framework for solid waste management governance in Malaysia according to the Federal Constitution is enshrined under the Concurrent List of the Ninth Schedule. This provision allows both the Federal and States to enact relevant laws listed in the Concurrent List.

Thus, before year 2007, municipal solid waste was managed respectively by the Local Authorities (LAs), govern by the Local Government Act 1976 (Act 171) in Peninsular of Malaysia including Federal Territories of Labuan; Local Government Ordinance 1961 for Sabah and Local Authorities Ordinance 1996 for State of Sarawak. LAs are responsible for providing solid waste management services mainly related to waste collection and transportation to disposal sites. The State Governments oversee LAs' activities and provide land for disposal facilities. The role of the Federal Government through Ministry of Housing and Local Government (KPKT) is to provide local authorities with technical and financial assistance for better management of their wastes.

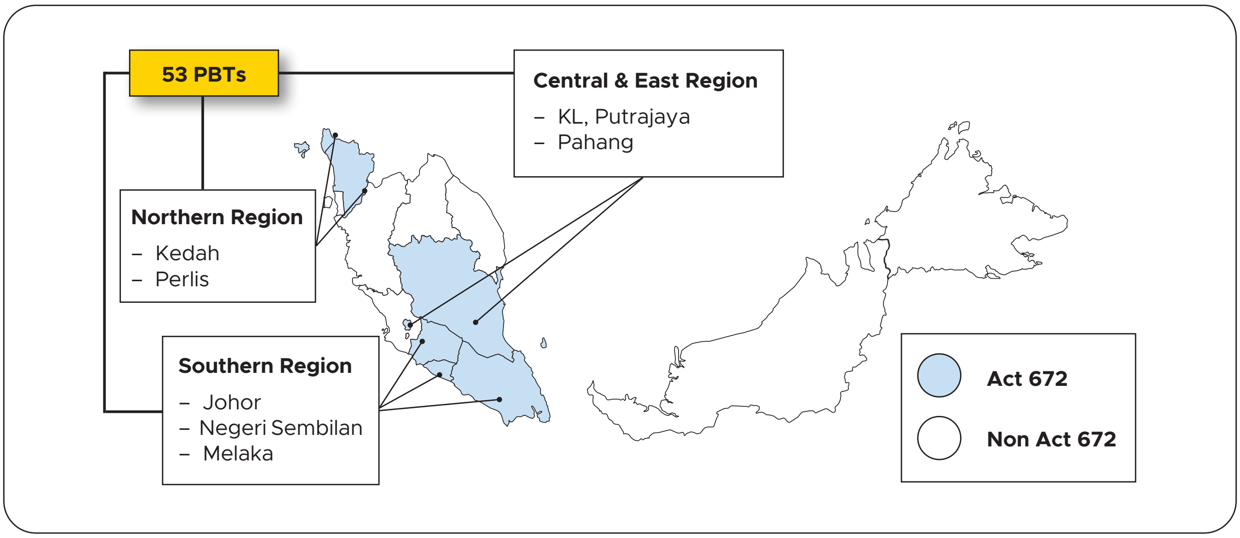
Municipal solid waste in Malaysia includes waste generated from households, institutions, commercial and industrial premises, as well as waste from construction and public cleansing activities. Hazardous waste is not considered municipal solid waste and is not disposed of in general landfills. Hazardous waste is treated according to approved disposal methods by the Department of Environment (DoE).

The federalisation and privatisation processes were initiated in the 1990s to address the increasing challenges in solid waste management. The enhancement of the Federal Government's responsibility intensified the participation of the private sector in privatisation programs and investment to improve the provision of services in a cost-efficient manner.

The Solid Waste Management and Public Cleansing Act (Act 672) was enacted in year 2007 to provide for and regulate the management of controlled solid waste and public cleansing to maintain proper sanitation and related matters. According to the enactment, JPSPN was established to integrate solid waste management at the national level and to empower the Federal Government to implement responsibility regarding solid waste management.

In year 2021, Act 672 was adopted by seven (7) state governments namely Perlis, Kedah, Negeri Sembilan, Melaka, Johor, and Pahang, as well as Federal Territories: Kuala Lumpur and Putrajaya, as shown in Figure SIC7.12. Other states such as Selangor, Perak, Pulau Pinang, Terengganu, Kelantan, Sabah, Sarawak, and the Federal Territories of Labuan are yet to adopt the Act 672. State Governments through LAs is still managing the solid waste management.

Figure SIC7.12 **States and Federal Territories that Adopted Act 672**



The total landfills declined in 2021 to 137 landfills (2020: 138 landfills) with 68 landfills located in Peninsular Malaysia (2020: 69 landfills). Meanwhile, in Sabah and Sarawak remain unchanged at 69 landfills. There were 21 sanitary landfills in Malaysia, and 116 were open dumpsites (non-sanitary) in 2021 as demonstrated in Table SIC7.5.

Table SIC7.5 Numbers of landfills in Malaysia for 2020 and 2021

State	Landfills in operation					Total	
	Sanitary		Location	Non-Sanitary			
	2020	2021		2020	2021	2020	2021
Johor	1	1	Seelong, Kulai	8	7	9	8
Kedah	2	3	Jabi, Pokok Sena Padang Cina, Kulim Belanga Pechah, Langkawi	2	1	4	4
Kelantan	0	0		10	10	10	10
Melaka	1	1	Sg. Udang, Melaka	0	0	1	1
Negeri Sembilan	1	1	Ladang Tanah Merah, Jimah	2	2	3	3
Pahang	2	3	Belenggu, Temerloh	8	7	10	10
Perak	1	1	Padang Sertik, Bentong Jengka 10	15	15	16	16
Perlis	1	1	Lahat, Kinta Rimba Mas, Titi Tinggi	0	0	1	1
Pulau Pinang	1	1	Pulau Burung, Nibong Tebal	0	0	1	1
Sabah	1	1	Kayu Madang, Kota Kinabalu	21	21	22	22
Sarawak	3	3	Mambong, Kuching Sibuti, Miri Kemunyang, Sibu	43	43	46	46
Selangor	3	3	Bukit Tagar, Hulu Selangor Jeram, Kuala Selangor Tanjung Dua Belas, Kuala Langat	2	2	5	5
Terengganu	1	1	Tertak Batu, Marang	8	8	9	9
W.P Kuala Lumpur	0	0		0	0	0	0
W.P. Labuan	1	1	Bukit Kalam	0	0	1	1
TOTAL	**19**	**21**		**119**	**116**	**138**	**137**

An overview of the emissions covered under 5.A. solid waste disposal is as demonstrated in Table SIC7.6.

Table SIC7.6 **Overview of Emissions Covered under 5.A. Solid Waste Disposal**

Emissions Source	Source Included	Methods	Emissions Factors
	5.A. Solid Waste Disposal	T1	D
Gasses Reported	CH_4		
Key Categories (KCA)	Yes		
Coverages	National		
Major Improvements since last submitted	Revised calculation upon improved activity data		

7.2.2 Methodological issues

The methodological issues of 5.A. consisting of its activity data and emission factor is shown in Table SIC7.7.

Table SIC7.7 **Methodological Issues of 5.A. Solid Waste Disposal**

Choice of Method	Tier 1: (Bulk Waste Method as waste is collected and disposed of in bulk mass and not separated at source)			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Solid Waste Disposal	Population Data		Population and Housing Census in 2010
		Waste per Capita	**1990-2000:** Default IPCC Regional values for Southeast Asia for the period from 1970 to 2000	Waste composition varies widely between urban and rural populations within the countries. (Table 3.5, Chapter 3, Vol. 5, 2006GL) Survey on Solid Waste Composition, Characteristics & Existing Practice of Solid Waste Recycling in Malaysia (2012)
			2001-2004: Extrapolated values of MSW composition by percent were obtained from the IPCC default for South-East Asia (2001) and the 2004 data from the study by JICA (2006)	

Activity Data	Sub-Sector	Parameter of Activity Data	Assumption		Data Source
			2005-2012: Extrapolated values obtained from JICA (2006) and JPSPN (2013) **From 2013 onwards:** Actual data from the Survey on Solid Waste Composition, Characteristics & Existing Practice of Solid Waste Recycling in Malaysia (2012)		
		Sludge Disposed vat SWDS	Sludge produced from sewage treatment processes (at an average of 20% dry solid content)		Peninsular Malaysia:
					Sabah: Source data from JPP Sabah. Sludge disposed at Kayu Madang Sanitary Landfill only applicable to Regional Sewage Treatment Plant Kota Kinabalu Southern Catchment (RSTP KKSC).
					Sarawak: Source data from JPP Sarawak website: https://ssd.sarawak.gov.my/web/subpage/webpage_view/ 226
					Data collected from Indah Water Konsortium Sdn. Bhd. (IWK) and Sewerage Services Department Sarawak (JPP Sarawak)
Emission Factor	**Sub-Sector**	**CO_2**	**CH_4**	**N_2O**	**Data Source**
	Solid Waste Disposal		Fraction of degradable organic carbon: – Bulk waste: 0.17 – Sewage Sludge: 0.05 Fraction of organic carbon which decomposes: 0.5 Methane correction factor (MCF): – Uncategorized SWDS: 0.6 – Unmanaged shallow: 0.4 – Managed Anaerobic: 1 – Managed semi aerobic: 0.5		IPCC GLs (2006) Default value

7.2.3 Description of Flexibility Applied

This source category is covered by the general flexibility which is described in Sub-Chapter 1.9 of the NID.

7.2.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

7.2.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures which is described in Sub-Chapter 1.5 of the NID.

7.2.6 Category-Specific Recalculations

Estimates for CH_4 emissions from solid waste disposal site for 5.A. have been revised in this submission. This is primarily due to the improved activity data (e.g. the type of landfill) and due to population data changes (2011-2019) based on Population and Housing Census in 2020 for year 2011-2023 conducted by DOSM. Consequently, CH_4 emissions have significantly reduced between this submission and the previous in BUR4.

7.2.7 Category-specific Planned Improvements

This source category is covered by the sectoral planned improvement which is described in Table SIC7.15.

7.3 Biological Treatment of Solid Waste (CRT Category 5.B.)

7.2.1 Category Description

The biological treatment of solid waste in Malaysia focuses mainly on the composting of solid waste from the palm oil industry, specifically empty fruit bunches (EFB). Composting, characterized as an aerobic process, facilitates the conversion of a significant portion of degradable organic carbon (DOC) in the waste into carbon dioxide (CO_2). Methane (CH_4) generation occurs in the anaerobic sections of the compost; however, this methane is extensively oxidized within the aerobic sections of the compost.

In Malaysia, composting has emerged as one of the most effective approaches to managing EFB and palm oil mill effluent (POME). The first composting facility was established in 1991, peaked by 2019 with 81 plants, and as of 2021, only 55 palm oil mills are equipped with composting facilities. Composting plants may face challenges related to operational inefficiencies, such as inadequate management, poor process control, or equipment malfunctions. These issues can lead to decreased effectiveness and increased costs, prompting the decision to close down the facility. Additionally, the decrease in composting plants is also due to the shift in the use of EFB towards more economically profitable products, such as the production of pellets for fuel. The increased demand for EFB as fuel is driven by government policies such as DAKN 2030, NETR and National Biotechnology Policy (NBP 2.0).

Composting serves as a method for mitigating CH_4 emissions. It prevents the release of CH4 into the atmosphere during the anaerobic decay of stockpiled EFB and the anaerobic digestion of POME in open ponds. Nonetheless, inefficient composting processes may lead to anaerobic conditions, resulting in the production of CH_4 and nitrous oxide (N_2O).

An overview of the emissions covered under 5.A. solid waste disposal is as demonstrated in Table SIC7.8.

Table SIC7.8 Overview of Emissions Covered under 5.B. Biological Treatment of Solid Waste

Emissions Source	Source Included	Methods	Emissions Factors
	5.B. Biological Treatment of Solid Waste	T1	D
Gasses Reported	CH_4, N_2O		
Key Categories (KCA)	No		
Coverages	National		
Major Improvements since last submitted	5.B. Biological Treatment of Solid Waste		

7.2.2 Methodological issues

The methodological issues of 5.B. consisting of its activity data and emission factor is shown in Table SIC7.9.

Table SIC7.7 Methodological Issues of 5.A. Solid Waste Disposal

Choice of Method	Tier 1				
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**		**Data Source**
	Biological Treatment of Solid Waste	Annual amount of EFB treated by biological treatment	The annual amount of EFB for composting: 300 operational days per year		Surveys conducted by MPOB and DoE (2013-2014)
Emission Factor	**Sub-Sector**	**CO_2**	**CH_4**	**N_2O**	**Data Source**
	Biological Treatment of Solid Waste	-	4 g CH_4/kg waste treated	0.24 g N_2O/kg waste treated	IPCC GLs (2006) default value

7.3.3 Description of Flexibility Applied

This source category is covered by the general flexibility which is described in Sub-Chapter 1.9 of the NID.

7.3.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

7.3.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures which is described in Sub-Chapter 1.5 of the NID.

7.3.6 Category-Specific Recalculations

There have been no recalculations to this category.

7.3.7 Category-specific Planned Improvements

This source category is covered by the sectoral planned improvement which is described in Table SIC7.15.

7.4 Incineration and Open Burning of Solid Waste (CRT Category 5.C.)

7.4.1 Category Description

Waste incineration in Malaysia focuses mainly on the hazardous waste, clinical waste and fossil liquid waste (waste oil). The incineration of these wastes was first introduced and started to operate in 1998. Management of these wastes is monitored and enforced by DoE under the Environmental Quality (Scheduled Wastes) Regulations 2005. This Regulation states that any scheduled wastes shall be disposed of at the prescribed premises which are licensed by the DoE.

Malaysia has few incinerators to treat MSW at island and tourism areas (Pulau Langkawi, Pulau Tioman and Pulau Pangkor). However, the capacity of these incinerators is small and is used to treat a small quantity of waste generated in respective areas. Thus, the emission from MSW incineration is insignificant and not considered in this report.

Open burning of solid waste practices is prohibited and controlled by the National Solid Waste Management Department and the local authorities. However, In Malaysia, challenges in waste management include limited collection coverage due to the difficulty of accessing remote areas with garbage trucks.

An overview of the emissions covered under 5.C. incineration and open burning of solid waste is as demonstrated in Table SIC7.10.

Table SIC7.10 **Overview of Emissions Covered under 5.C. Incineration and Open Burning of Solid Waste**

Emissions Source	Source Included	Methods	Emissions Factors
	5.C.1. Incineration	T2a	D
	5.C.2. Open Burning	T1	D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories (KCA)	None identified		
Coverages	National		
Major Improvements since last submitted	No major improvements have been made since the last submission.		

7.4.2 Methodological issues

The methodological issues of 5.C. consisting of its activity data and emission factor is shown in Table SIC7.11.

Table SIC7.11 **Methodological Issues of 5.C. Incineration and Open Burning of Solid Waste**

Choice of Method	5.C.1. Incineration: Tier 2a 5.C.2. Open Burning: Tier 1				
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**		**Data Source**
	Incineration	Annual amount of waste incinerated			Data is acquired from DoE database
	Open Burning	Rural Population			Population and Housing Census in 2010
		Fraction of population burning waste	Only 1% of rural population practices open burning as a mean of waste disposal		Data is acquired from reliable national source through discussion. (Expert judgement)
		Per Capita Waste Generation (MSWp)			Data was taken from JPSPN Waste Characterization Study 2013. (Expert judgement)
		Fraction of the waste amount burned relative to the total amount of waste treated			Default value based on IPCC GLs (2006) (Section 5.7.1, page 5.23)
Emission Factor	**Sub-Sector**	**CO_2**	**CH_4**	**N_2O**	**Data Source**
	Incineration		4 g CH_4/kg waste treated	0.24 g N_2O/kg waste treated	IPCC GLs (2006) default value
	Open Burning	Municipal solid waste: – Fraction dry matter content: 0.43 – Fraction of carbon in dry matter content: 0.46 – Fraction of fossil carbon in total carbon: 0.14 – Oxidation factor: 0.58	Municipal solid waste: 6500 kg CH_4/Gg wet waste	Municipal solid waste: 150 kg N_2O/Gg Dry matter	IPCC GLs (2006) default value

7.4.3 Description of Flexibility Applied

This source category is covered by the general flexibility which is described in Sub-Chapter 1.9 of the NID.

7.4.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

7.4.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures which is described in Sub-Chapter 1.5 of the NID.

7.4.6 Category-Specific Recalculations

5C1 Incineration

There have been no recalculations to this category.

5C2 Open burning

Recalculation was carried out due to Population data changes (2011-2019) based on Population and Housing Census in 2020 for year 2011-2023 conducted by DOSM.

7.4.7 Category-specific Planned Improvements

This source category is covered by the sectoral planned improvement which is described in Table SIC7.15.

7.5 Wastewater Treatment and Discharge (CRT Category 5.D.)

7.5.1 Category Description

5.D.1. Domestic wastewater

Domestic wastewater becomes a source of methane (CH_4) when treated or disposed anaerobically. The protein elements in domestic wastewater are the major source of nitrous oxide (N_2O) emissions. Carbon dioxide (CO_2) emissions from wastewater are not considered in the IPCC Guidelines because these are of biogenic origin and should not be included in national total emissions. For domestic wastewater and sludge, the Biochemical Oxygen Demand (BOD) indicates the amount of carbon that is aerobically biodegradable. Wastewater as well as its sludge components can produce CH4 if it degrades anaerobically. However, for Malaysia, aerobic processes are typically used for domestic wastewater treatment especially in urban areas.

Public sewerage treatment facilities within Peninsular Malaysia and Labuan except for KETENGAH and Indah Bandaran (DARA) areas, are operated by IWK. In year 2021, IWK has expanded its public sewerage services coverage areas in the State of Kelantan, Johor Bahru City Council (MBJB) and Pasir Gudang City Council (MPPG). In Sabah, the public sewage treatment plants were once operated and maintained by the Public Works Department of Sabah until 2020. However, the Sabah Sewerage Services Department (JPP Sabah) was officially formed in January 2020 following the establishment of the Sewerage Services Enactment 2017 to regulate domestic sewage waste in the State of Sabah. In Sarawak, before 2007, the public centralised sewerage system was operated and maintained by the local authorities. Following the establishment of JPP Sarawak under the Sewerage Services and Systems Ordinance, 2005, JPP Sarawak has been responsible for regulating and developing public centralised sewerage systems in the main cities of Sarawak.

There are also private sewage treatment plants located at hotels, service apartments/ condominiums, rest and service areas along the highways and also the government owned buildings (i.e. schools, universities and army camp), which are currently operated by private operators. In addition, there are over a million of individual and communal septic tanks, pour flush scattered all over the country especially in rural areas where connected services are not available.

Septic tanks are required to be desludged periodically to ensure it functions efficiently. In Peninsular Malaysia, the septic tank desludging services are carried out by permit holders registered with SPAN. IWK was appointed by SPAN to monitor the permit holders' movements or activities using Vehicle Monitoring System (VMS). IWK services is confined to the local authority's operational areas only and for outside LA areas, IWK provides responsive services. In Sarawak, the desludging of septic tanks is as per Local Authorities (Compulsory Desludging of Septic Tanks) By-Laws, 2002. In rural areas of Sarawak, the State Health Department is responsible to provide pour flush for longhouses and village houses under its Water Supply and Environment (BAKAS) programme. While in Sabah, desludging works for public septic tanks are carried out by JPP Sabah whereas for desludging on private septic tanks are executed by contractors registered with LA. In the rural areas however the Sabah Health Department has assisted in providing pour flush systems.

Previously, there were no requirements for nutrients removal for the sewage treatment plant in the country. However, in year 2009, the DoE had revised the regulation pertaining to sewage effluent discharge which required the design of the sewage treatment plant to comply with nutrients removal limits. In 2019, there were numbers of sewage treatment plants equipped with ammonia removal facilities. In the next reporting, all treatment plants with nitrification and denitrification processes will be incorporated in the GHG emissions calculation.

An overview of the emissions covered under 5.D. solid waste disposal is as demonstrated in Table SIC7.12.

Table SIC7.12 **Overview of Emissions Covered under 5.D.1. Domestic Wastewater Treatment**

Emissions Source	Source Included	Methods	Emissions Factors
	5.D.1. Domestic Wastewater Treatment	T1	D
Gasses Reported	CH_4, N_2O		
Key Categories (KCA)	No		
Coverages	National		
Major Improvements since last submitted	No major improvements have been made since the last submission.		

5.D.2. Industrial Wastewater

For industrial wastewater treatment and discharge the IPCC GLs (2006) suggested to include only the most significant industrial sources within the country. The palm oil, natural rubber, and pulp and paper and meat and poultry industries are the major contributors for the effluent discharge into the watercourse in Malaysia. The volume and quality of the wastewater depends on water consumption during processing and the nature of the effluent discharge, which is organic-based and high in COD loading. For the petroleum refineries industry, the selection is based on the availability of the production data, and it is the key industry contributing to the economy of Malaysia.

Palm Oil Industry

Palm oil is a major industry in Malaysia, generating substantial revenue and driving economic growth. Aligned with DAKN 2030, which focuses on uplifting socioeconomic conditions and alleviating poverty, the industry remains central to rural development efforts. Each year, the production of palm oil yields considerable volumes of palm oil mill effluent (POME), reflecting the scale of operations and Malaysia's ongoing commitment to sustainable and responsible practices. In year 2021, there were about 5.74 million ha of oil palm plantations throughout Malaysia. The milling sector produced about 60.65 million tonnes of POME from 451 palm oil mills. Since the talk on climate change started in year 1992 at the Earth Summit, the focus of research and development (R&D) of palm oil has been on sustainability. The treatment of POME produces biogas, which contains ~65% methane due to its high BOD content. Thus, the industry players through R&D programs by MPOB had identified wastewater treatment technologies which were economically and environmentally sound. Nowadays, some of the most used systems to treat POME are the ponding system, open tank digester, extended aeration system, closed anaerobic digester, covered lagoon and land application system.

Natural Rubber (NR) Industry

As of 2021, Malaysia is the world's seventh largest producer of natural rubber and the eighth largest consumer of natural rubber (NR), the leader in the production and export of rubber products and the world's largest rubber gloves producer. In year 2021, Malaysia produced a total of 469,669 tonnes of natural rubber, of which only 6.6% was in the form of NR latex and there were 44 raw rubber processing plants in Malaysia[33]. The raw rubber processing factories which process latex concentrate and block rubber (Standard Malaysian Rubber – SMR) discharge about 24 million litres of effluent daily into the watercourses in the year 2021[34]. The rubber processing industry has been identified as one of the leading causes of organic pollution in Malaysia which consumes large amounts of water and emits large amounts of waste and wastewater. Nowadays, the most used wastewater treatment system to treat wastewater from the raw rubber processing industry is the anaerobic/facultative ponding system.

Pulp and Paper Industry

The Pulp and paper industry is known for its high rate of water consumption and hence a high rate of wastewater generation. According to the IPCC GLs (2006), the range of COD loading for pulp and paper industry is one of the highest, between 1-15 kg COD/m^3. This is one of the main reasons the pulp and paper industry has been added into the GHG estimation. In year 2021, Malaysia's total capacity for pulp and paper production was approximately 1.8 million tonnes. Most of the paper mills in Malaysia are small-scale by comparison to the world industry standards with none producing more than 300,000 t/year. Thus, about 50% of the paper consumption within Malaysia still relies on imports. Most of the pulp and paper mills in Malaysia have opted for aerobic treatment types such as activated sludge system to treat their wastewater.

Petroleum Refineries – industrial wastewater

Oil and gas industries have been the major contributors to Malaysia’s economic development. Oil and Gas activities in Malaysia can be classified under three (3) main categories: upstream, midstream, and downstream. The upstream is mainly on exploration and production, midstream is on infrastructure/transportation, while downstream includes refining and distribution.

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[33] 2023 LGM Yearly Statistics Publication
[34] Pretibaa Subhramaniyun (2023) “Transitioning of Wastewater Treatment Systems for Raw Rubber Processing Toward a Circular Economy” LGM Seminar on Industrial Support Services 2023

Petroleum refineries are added into the National GHG inventory due to their high production capacity and availability of historical data. Petroleum refineries are heavily regulated industry in Malaysia due to their complex systems of multiple operations that depend on the type of crude and the desired products. Thus, all petroleum refineries in Malaysia adopted the best available technique to comply with the strict requirements for wastewater effluent standards.

Meat and Poultry Industry

Malaysia's poultry meat per capita consumption is among the highest in the world. The Per Capita consumption (PCC) of poultry meat in 2021 was 47.6 kilograms (kg) a year, followed by chicken/ duck eggs at 20.6 kg a year or 343 pieces.

The meat industry covers both slaughterhouses and cutting plants as well as meat products (fresh, cured, or cooked) manufacturing plants. The slaughterhouses and cutting plants generate large volumes of wastewater with a high organic load. The wastewater generated generally carries with it slurries, meat remnants, blood, hair, pieces of entrails, and surface fat, which together mean that the water has a content of organic matter, material in suspension, oils and fats, nitrogen (ammonia and organic), phosphates, and detergents or disinfectants used during cleaning.

An overview of the emissions covered under 5.D.2. industrial wastewater treatment is as demonstrated in Table SIC7.13.

Industrial sectors that have been identified with large potentials for methane emissions are palm oil, natural rubber, petroleum refineries and pulp and paper. The Tier 2 method is used for estimation of methane emissions from palm oil, as country-specific data for COD and wastewater outflow are available for this industry. For natural rubber processing, petroleum refineries and pulp and paper manufacturing, the estimation is based on production data and default values taken from the IPCC GLs (2006). Hence, Tier 1 method is used for these three (3) industries.

Table SIC7.13 **Overview of Emissions Covered under 5.D.2. Industrial Wastewater Treatment**

Emissions Source	Source Included	Methods	Emissions Factors
	5.D.2 Industrial waste-water Treatment	T2, T1	CS, D
Gasses Reported	CO_2, CH_4, N_2O		
Key Categories (KCA)	Yes		
Coverages	National		
Major Improvements since last submitted	No		

7.5.2 Methodological issues

The methodological issues of 5.D.1 domestic wastewater treatment consisting of its activity data and emission factor is shown in Table SIC7.14.

Table SIC7.14 **Methodological Issues of 5.D.1 Domestic Wastewater Treatment**

Choice of Method	5.D.1. Domestic Wastewater Treatment: CO_2 - Tier 2a			
Activity Data	**Sub-Sector**	**Parameter of Activity Data**	**Assumption**	**Data Source**
	Domestic Wastewater Treatment	Urban and rural population	–	Population and Housing Census in 2010 Data is acquired from Department of Statistics Malaysia (DOSM) based on 2010 population census
		Degradable organic component (BOD)	The BOD or degradable organic component in wastewater, 15.9 kg/person/year wastewater is derived from 56 g/PE/day (MSIG Vol IV) with PE per population ratio of 0.78 as shown in the equation below: $BOD = \frac{56g}{\frac{PE}{day}} \times 0.78PE \times 365 \frac{dy}{year} \times \frac{kg}{1000g}$ $15.9 \frac{kg}{\frac{person}{year}}$	

Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
			The BOD value used for Malaysia (43.56 g/person/day) is within the IPCC BOD range value for Asia, Middle East, Latin America of 33-44 g/person/day. Correction factor is 1.0 is used as industrial wastewater is not collected into the sewer system.	
		Type of treatment or discharge path	Inventory of sewage treatment system (i.e. numbers, capacity and type) was obtained from the following sources: **Peninsular Malaysia** ------------------------------ **1990-1997:** Data extrapolation based on IWK Asset Database ------------------------------ **1998-2014:** IWK Asset Database ------------------------------ **2015 -2016:** SPAN (Malaysia Water Industry Guide (MWIG); published by Malaysian Water Associations (MWA)) ------------------------------ **2017-2021:** SPAN (Water and Sewerage Fact Book)	Peninsular Malaysia: SPAN/IWK Sabah: JPP Sabah Sarawak: JPP Sarawak
			Sabah ------------------------------ **1990-2016:** GHG Data Inventory Improvement Study conducted by Consultant (North Borneo Environmental Services Sdn. Bhd.) **2017-2021:** Data extrapolation based on GHG Data Inventory Improvement Study conducted by consultant.	

Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
			Sarawak ------------------------------ **1990-2007:** Data extrapolation based on JPP Sarawak database ------------------------------ **2007-2021:** JPP Sarawak database Degree of utilisation by treatment type for urban and rural areas were identified based on expert judgment as follows: **Urban** Centralised Aerobic Treatment Plant, Septic System and Sea, River and Lake Discharge ------------------------------ **Rural** Septic System, Latrine 3 (Pour Flush) and Sea, River and Lake Discharge	
		Per capita protein consumption	**1960 to 2009:** Data used for domains [Food Balances (-2013, old methodology and population)] **2010 to 2021:** Data used for domains [Food balances (2010-2021)]	Based on yearly time range for Protein Supply Quantity (g/capita/day), Food and Agriculture Organisation Statistic (FAOSTAT)
		Sludge removed	–	Dokuz Eylul University (DEU) Engineering Faculty. Biological Treatment Processes, 2006. (http://web.deu.edu.tr/atiksu/ana07/4thset.pdf
		Methane Recovered	Methane recovery from domestic wastewater treatment plants is very scarce. Thus, it is assumed that the methane recovery from domestic wastewater treatment plant is negligible.	–
		Nitrogen removed with sludge (N_{SLUDGE})	No study has been conducted in the country to measure the amount of Nitrogen in sludge. Hence, IPCC GLs (2006) default value of zero, 0 kg N/year is being used in this estimation.	–

Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
		Urban and rural population	The BOD or degradable organic component in wastewater, 15.9 kg/person/year wastewater is derived from 56 g/PE/day (MSIG Vol IV) with PE per population ratio of 0.78 as shown in the equation below: $BOD = \frac{\frac{56g}{PE}}{day} x\ 0.78PE\ X\ 365\ \frac{dy}{year} X \frac{kg}{1000g}$ $15.9 \frac{\frac{kg}{person}}{year}$ The BOD value used for Malaysia (43.56 g/person/day) is within the IPCC BOD range value for Asia, Middle East, Latin America of 33-44 g/person/day Correction factor is 1.0 is used as industrial wastewater is not collected into the sewer system.	Malaysian Sewerage Industry Guidelines (MSIG) Vol. IV, published by National Water Services Commission (SPAN)
		Type of treatment or discharge path	Inventory of sewage treatment system (i.e. numbers, capacity and type) was obtained from the following sources: **Peninsular Malaysia** ------------------------------ **1990-1997:** Data extrapolation based on IWK Asset Database ------------------------------ **1998-2014:** IWK Asset Database ------------------------------ **2015 -2016:** SPAN (Malaysia Water Industry Guide (MWIG); published by Malaysian Water Associations (MWA)) ------------------------------ **2017-2021:** SPAN (Water and Sewerage Fact Book)	Peninsular Malaysia: SPAN/IWK Sabah: JPP Sabah Sarawak: JPP Sarawak

Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
			Sabah ------------------------------ **1990-2016:** GHG Data Inventory Improvement Study conducted by Consultant (North Borneo Environmental Services Sdn. Bhd.) ------------------------------ **2017-2021:** Data extrapolation based on GHG Data Inventory Improvement Study conducted by consultant.	
			Sarawak ------------------------------ **1990-2007:** Data extrapolation based on JPP Sarawak database ------------------------------ **2007-2021:** JPP Sarawak database Degree of utilisation by treatment type for urban and rural areas were identified based on expert judgment as follows: **Urban** Centralised Aerobic Treatment Plant, Septic System and Sea, River and Lake Discharge ------------------------------ **Rural** Septic System, Latrine 3 (Pour Flush) and Sea, River and Lake Discharge	
		Per capita protein consumption	**1960 to 2009:** Data used for domains [Food Balances (-2013, old methodology and population)] **2010 to 2021:** Data used for domains [Food balances (2010-2021)]	Based on yearly time range for Protein Supply Quantity (g/capita/day), Food and Agriculture Organization Statistic (FAOSTAT)
		Sludge removed		Dokuz Eylul University (DEU) Engineering Faculty. Biological Treatment Processes., 2006. (http://web.deu.edu.tr/atiksu/ana07/4thset.pdf

Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
	Industrial Wastewater Treatment 5D2: Palm oil	Total Industry Product: Crude Palm Oil (CPO)		MPOB Yearly Statistics
	5D2: Rubber	Total Industry Product: Natural Rubber		Department of Statistic (DOSM) Malaysia and LGM Yearly Statistics[35]
	5D2: Pulp & Paper Petroleum	Total Industry Product: Pulp & Paper Petroleum		Annual production of pulp and paper
	5D2: Refineries	Total Industry Product: Refineries		National Energy Balance 2021
	5D2: Meat & Poultry	Total Industry Product: Meat & Poultry		FAOSTAT 2020
	5D2: Palm oil	Wastewater (POME) Generated: Palm Oil CPO: POME = 3.05		Vijaya et al., 2008, JOPR 20: 484-494; Vijaya et al., 2010, Amer. J. Geosc. 1(1): 1-6.
	5D2: Rubber	Wastewater Generated: Natural Rubber SMR (NR): 19.5 (m^3/ton) LC(NR): 10.5 (m3/ton)		Zaid I., 1993, Publication of Ministry of Science and the Environment, Malaysia, 137-151.
	5D2: Pulp & Paper Petroleum	Wastewater Generated: Pulp & Paper Petroleum		IPCC default value (Table 6.10, Chapter 6, Vol. 5, IPCC GLs (2006))
	5D2: Refineries	Wastewater Generated: Refineries		IPCC default value (Table 6.10, Chapter 6, Vol. 5, IPCC GLs (2006))
	5D2: Meat & Poultry	Wastewater Generated: Meat & Poultry		IPCC default value (Table 6.10, Chapter 6, Vol. 5, IPCC GLs (2006))

[35] 2023 LGM Yearly Statistics Publication

Activity Data	Sub-Sector	Parameter of Activity Data	Assumption	Data Source
	5D2: Palm oil	Chemical Oxygen Demand (COD) wastewater generated: Palm Oil		Survey on actual status of POME in palm oil mills, 2007-2008; Loh et al. 2009. MPOB VIVA No. 455/2009 (05); Ma et al., 1993 (p. 113); Ma, 1999 (p. 115)
	5D2: Rubber	Chemical Oxygen Demand (COD) wastewater generated: Natural Rubber SMR (NR) -1.5 kg/m^3 COD LC(NR)-6.0 kg/m^3 COD		1. Zaid et al, 2006, Proc. IRRDB Conf.; 2. Pretibaa et al, 2007, Proc. IRRDB Conf.; 3. John, 1982, Proc. Workshop; 4. Zaid, 1993; Publication of Ministry of Science and the Environment, Malaysia, 137-151
	5D2: Pulp & Paper Petroleum	Chemical Oxygen Demand (COD) wastewater generated: Pulp & Paper Petroleum		IPCC default value (Table 6.10, Chapter 6, Vol. 5, 2006 IPCC Guidelines
	5D2: Refineries	Chemical Oxygen Demand (COD) wastewater generated: Refineries		IPCC default value (Table 6.10, Chapter 6, Vol. 5, 2006 IPCC Guidelines
	5D2: Meat & Poultry	Chemical Oxygen Demand (COD) wastewater generated: Meat & Poultry		IPCC default value (Table 6.10, Chapter 6, Vol. 5, 2006 IPCC Guidelines

Emission Factor	Sub-Sector	CO_2	CH_4	N_2O	Data Source
	Domestic Wastewater Treatment		Emission factor (Kg CH_4/kg BOD): B_o= 0.6 kg CH4/kg BOD MCFj= an indication of the degree to which the system is anaerobic as below: Centralised Aerobic Treatment Plant: 0 ------------------- Septic Tank: 0.3 ------------------- Latrine 3 (Pour Flush): 0.42 ------------------- Sea, River and Lake Discharge: 0.06	Emission factor for indirect N_2O from wastewater: 0.005 kg N_2O/kg	IPCC GLs (2006) default value
	Industrial Wastewater Treatment		POME 0.225 kg CH_4/kg COD ------------------- B_o = Max methane producing capacity (kg CH_4/kg COD) = 0.25; ------------------- MCF = 0.9 ------------------- Natural Rubber (SMR): 0.2(kg CH_4/kg COD) MCF = 0.8 ------------------- Natural Rubber (Latex): 0.2(kg CH_4/kg COD) MCF = 0.8 ------------------- Paper & Pulp: 0.125 kg CH_4/kg COD; *MCF = 0.05 ------------------- Petroleum Refineries: 0.125 kg CH_4/kg COD; *MCF = 0.05 ------------------- Meat & Poultry: 0.0125 kg CH_4/kg COD; *MCF = 0.05 (*average from the range of default value given in IPCC GLs (2006))		Calculated based on: Loh et al. (2017) – Table 9; IPCC; Loh et al. (2009). MPOB VIVA No. 455/2009 (05) – COD = 53 kg; Ma et al. (1993, p. 127; 1999, p. 255 - sourced from Quah & Gillie (1981); Choo et al. (2011) - 1 tonne POME = 28 m3 biogas; Ma et al. (1993, p. 127), Ma (1999, page 120) - 65% CH4 in biogas. IPCC GLs (2006) default value

7.5.3 Description of Flexibility Applied

This source category is covered by the general flexibility which is described in Sub-Chapter 1.9 of the NID.

7.5.4 Uncertainty Assessment and Time-Series Consistency

This source category is covered by the general uncertainty assessment as the Sub-Chapter 1.6 and Annex II of the NID.

7.5.5 Category-Specific QA/QC and Verification

This source category is covered by the general QA/QC procedures which is described in Sub-Chapter 1.5 of the NID.

7.5.6 Category-Specific Recalculations

5.D.1. Domestic Wastewater

Recalculation was carried out due to changes in activity data for the following:

i. Population data (2011-2019) based on Population and Housing Census in 2020 for year 2011-2023 conducted by DOSM.
ii. Per capita protein consumption data for Malaysia from 2010-2021 based on Food Balances (2010-) from FAOSTAT (2024).

5D2 Industrial Wastewater

There have been no recalculations to this category.

7.5.7 Category-specific Planned Improvements

This source category is covered by the sectoral planned improvement which is described in Table SIC7.15.

7.6 Areas of Improvement

The areas of improvement are provided in Table SIC7.15.

Table SIC7.15 Planned Areas of Improvement for the Waste Sector

Category	Improvement	Description	Progress
5.A. Solid Waste Disposal	Improvement on activity data	A 'Survey on Solid Waste Composition Characteristic and Existing Practice of Solid Waste Recycling in Malaysia' would be conducted from November 2022 until June 2024 (18 months) by SWCorp, the national body responsible for management and enforcement of solid waste disposal and public cleansing regulations. The survey would cover all states throughout Malaysia which would provide an updated activity data information for the waste sector solid waste disposal GHG inventory estimation.	Ongoing (Expected report will be completed by 1st quarter 2025)
	Improvement on activity data	Improvements in methodological tier (to Tier 2) for activity data enhancement.	Planned (4 years – BTR3)
	Improvement on activity data and emission factor	Developing country-specific EFs and improving AD to enable application of the first-order decay model in the waste sector.	Ongoing (Improve data collection)

7.7 Uncertainty Assessment for Waste Sector

The uncertainty in waste sector for 2005 stands at 35.79%. Table SIC7.16 shows the uncertainty analysis table.

Table SIC7.16 **Uncertainty for waste sector for 2005**

CRT category				Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
					(Gg CO_2 equivalent)	%	%	%	
5.	**Waste**								
5.A.	Solid waste disposal			CH_4	6,817.93	51.96%	35.00%	62.65%	0.03
5.B.	Biological treatment of solid waste			CH_4 N_2O	0.01 0.01	154.00% 154.00%	100.00% 150.00%	183.62% 214.98%	0.00 0.00
5.C.	Incineration and open burning of waste	5.C.1.	Waste incineration	CO_2 N_2O	29.61 1.54	10.00% 10.00%	70.00% 100.00%	70.71% 100.50%	0.00 0.00
		5.C.2.	Open burning of waste	CO_2 CH_4 N_2O	2.36 0.77 0.22	54.77% 54.77% 54.77%	65.57% 112.69% 100.00%	85.44% 125.30% 114.02%	0.00 0.00 0.00
5.D.	Wastewater treatment and discharge	5.D.1.	Domestic wastewater	CH_4 N_2O	1,938.68 274.38	60.00% 15.48%	58.31% 50.00%	83.67% 52.34%	0.00 0.00
		5.D.2.	Industrial wastewater	CH_4	15,460.61	28.72%	39.05%	48.48%	0.09
			Total		**24,526.12**				**0.13**
						Percentage uncertainty in total inventory			**35.79%**

The uncertainty in waste sector for 2021 stands at 35.37%, while the trend uncertainty (based on 2005) is 32.22%. Table SIC7.17 shows the uncertainty analysis table.

Table SIC7.17 **Uncertainty for waste sector for 2021**

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
5. Waste													
5.A. Solid waste disposal		CH_4	6,817.93	6,847.50	51.96%	35.00%	62.65%	0.03	0.01	0.28	0.00	0.21	0.04
5.B. Biological treatment of solid waste		CH_4 N_2O	0.01 0.01	0.20 0.11	154.00% 154.00%	100.00% 150.00%	183.62% 214.98%	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
5.C. Incineration and open burning of waste	5.C.1. Waste incineration	CO_2 N_2O	29.61 1.54	61.77 3.12	10.00% 10.00%	70.00% 100.00%	70.71% 100.50%	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
	5.C.2. Open burning of waste	CO_2 CH_4 N_2O	2.36 0.77 0.22	0.71 2.18 0.20	54.77% 54.77% 54.77%	65.57% 112.69% 100.00%	85.44% 125.30% 114.02%	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00
5.D. Wastewater treatment and discharge	5.D.1. Domestic wastewater	CH_4 N_2O	1,938.68 274.38	1,914.39 389.85	60.00% 15.48%	58.31% 50.00%	83.67% 52.34%	0.00 0.00	0.00 0.01	0.08 0.02	0.00 0.00	0.07 0.00	0.00 0.00
	5.D.2. Industrial wastewater	CH_4	15,460.61	14,447.10	28.72%	39.05%	48.48%	0.09	0.02	0.59	0.01	0.24	0.06
Total			**24,526.12**	**23,667.15**				**0.13**					**0.10**
					Percentage uncertainty in total inventory			**35.37%**		**Trend Uncertainty**			**32.22%**

8
CHAPTER

RECALCULATIONS AND IMPROVEMENTS

Recalculations

In general, the AR5 recalculations were performed for each sectoral inventory to transition from the AR4 that was used as the BUR4. The recalculations made for the applicable categories are attributed to the update/change of emissions factor(s), improvement/revision of activity data, change of typical animal mass (TAM) and/or inclusion of new GHGs in the time series. Specific recalculations conducted for sector can be referred in the respective sectoral chapters.

Improvements

Improvement of the GHG inventory system follows a step wise approach. The institutional arrangement and the activity data collection, analysis and archiving system for GHG inventory is continually being reviewed and improved. The 2006 IPCC Guidelines for GHG Inventory would continue to be used for developing the next GHG Inventory. Efforts would be concentrated on improving the disaggregation and completeness of the activity data according to the 2006 IPCC Guidelines and developing country specific emission factors for key categories. As reported in the BUR4, a National GHG Inventory Improvement Plan for emission factors was launched in 2021 under the 12th Malaysia Plan (2021-2025).

For the energy sector, efforts have been carried out to improve the emission factors and collection and disaggregation of activity data to enable higher tier calculations especially for the energy industries and road transport sub-categories. Efforts are also being carried out to improve the completeness of activity data and emission factors for fugitive emissions from the oil and gas sector. For the future improvement, this sector has the highest priority as it contributed the highest amounts of emission and are among the highest ranking in the key categories (refer to the Section I Annex I: Key category analysis).

For the IPPU sector, the improvement includes the engagements with relatively new stakeholders that contribute to the enhancement of the activity data. As mentioned in the BUR4, the activity data for this sector had depended relatively on the willingness of the industries to publish or share information on production and emission factors. Efforts are being undertaken to collect the activity data for those sub-categories not yet reported, in particular for refrigeration and stationary air conditioning, and non-energy products from fuels and solvent use as well as improving the activity data for the electronics industry. Through a technical collaboration with JICA, the GHG inventory for the categories that involve the f-gasses in the IPPU sector is estimated to be enhanced.

For the agriculture sector, efforts have been conducted to develop the country specific emission factor for rice cultivation.

For the LULUCF sector, the improvements intended include improvement of activity data and emission factors from peatland, unmanaged activity data on the unmanaged cropland and the removals from settlement.

For the waste sector, improvement of activity data and emission factors especially for the key categories is intended in order to improve the accuracy of emissions of the sector. A 'Survey on Solid Waste Composition Characteristic and Existing Practice of Solid Waste Recycling in Malaysia' that is conducted by SWCorp, the national body responsible for management and enforcement of solid waste disposal and public cleansing regulations. The survey would cover all states throughout Malaysia which would facilitate the improvement on the activity data and emissions factor for the waste sector solid waste disposal GHG inventory estimation. For the domestic wastewater treatment and discharge category, improvement exercise is undertaken to improve the activity data.

That said, given the capacity and resources limitations, the improvements are intended to be prioritised according to the key categories identified. Table SIC8.1 provides the description of the intended GHG inventory improvement in relation to the key categories. As the table referred, the applicable improvements for the key categories will be updated in the next BTRs.

Besides, Malaysia also seeks to improve its understanding of the latest version of the IPCC software. Malaysia also sees uncertainty assessment as a priority in the improvement plan. The latest reporting year mode is also intended to be improved from X-3 to X-2.

Table SIC8.1 **Description of the GHG inventory Improvement in relation to the Key Categories**[36]

No.	Sector	CRT Category Code	CRT Category Name	Remarks
1.	Energy	1.A.1.a.	Public electricity and heat production – Solid fuels	The improvement that has been conducted pertains to the aggregation of coal a solid fuel into three (3) types of coal as the IPCC 2006 Guidelines, namely bituminous, sub-bituminous and lignite.
2.	Energy	1.A.1.a.	Public electricity and heat production – Gaseous fuels	Lack of capacity and funding.
3.	Energy	1.A.1.a.	Public electricity and heat production – Liquid fuels	Under the National GHG Inventory Improvement Plan, a project to develop the country specific emissions factor for liquid fuel for the usage at the power plants is being conducted. The progress or output of the project is estimated to be reported in the next BTR.
4.	Energy	1.A.1.b.	Petroleum refining – Liquid fuels	Lack of capacity and funding
5.	Energy	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	Lack of capacity and funding
6.	Energy	1.A.2.	Manufacturing industries and construction – Gaseous fuels	Malaysia intends to improve fuel consumption data by sub-sector through enhancement of the quality and detail of activity data related to fuel consumption for each manufacturing sub-sector from 2020 onwards.
7.	Energy	1.A.2.	Manufacturing industries and construction – Liquid fuels	
8.	Energy	1.A.2.	Manufacturing industries and construction – Solid fuels	
9.	Energy	1.A.3.b.	Road transportation – Liquid fuels	Under the National GHG Inventory Improvement Plan, a project to develop country specific emissions factor for the road transportation fuels is being conducted. The progress or output of the project is estimated to be reported in the next BTR. Besides, Malaysia intends to enhance consistency and completeness in road transport emissions reporting through development of a robust methodological approach to estimate emissions based on different vehicle types and fuel usage.

[36] A detailed key category analysis is provided in the Section I Annex I: Key categories. The categories listed in this table are inclusive based on the level assessment without LULUCF, level assessment with LULUCF, trend assessment without LULUCF and trend assessment with LULUCF.

No.	Sector	CRT Category Code	CRT Category Name	Remarks
10.	Energy	1.A.3.d.	Domestic navigation – Liquid fuels	Lack of capacity and funding
11.	Energy	1.A.3.e.	Other transportation	Lack of capacity and funding
12.	Energy	1.A.4.a.	Commercial/Institutional – Liquid fuels	Lack of capacity and funding
13.	Energy	1.A.4.b.	Residential – Liquid fuels	Lack of capacity and funding
14.	Energy	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	Lack of capacity and funding
15.	Energy	1.B.2.a.	Oil	Malaysia intends to develop country-specific emission factors for oil and gas processing activities.
16.	Energy	1.B.2.b.	Natural Gas	
17.	IPPU	2.A.1.	Cement production	The GHG inventory calculation for this category has been performed at Tier2.
18.	IPPU	2.B.1.	Ammonia production	The GHG inventory calculation for this category has been performed at Tier2.
19.	IPPU	2.B.8.	Petrochemical and carbon black production	Lack of capacity and funding
20.	IPPU	2.C.1.	Iron and steel production	Improvement of activity data for this category has been improved through engagement with the stakeholders in this industry. MITI is in the process of planning to develop higher tier EF for this category.
21.	IPPU	2.C.2.	Ferroalloys production	Lack of capacity and funding
22.	IPPU	2.C.3.	Aluminium production	Lack of capacity and funding
23.	Agriculture	3.C.	Rice cultivation	Under the National GHG Inventory Improvement Plan, a project to develop country specific emissions factor and improve the accuracy of activity data is being conducted. The progress or output of the project is estimated to be reported in the next BTR.

No.	Sector	CRT Category Code	CRT Category Name	Remarks
24.	LULUCF	3.C.3[37]	Direct N_2O emissions from drained soils	Lack of capacity and funding
25.	Agriculture	3.D.1.	Direct N_2O emissions from managed soils	Lack of capacity and funding
26.	LULUCF	4.A.	Forest land	For HWP, data pertains to the baseline/parameters is being collected. For harvest, disaggregation of data between PRF and State Land Forest is being conducted. For biomass burning from wildfires, an exercise to estimate fraction of biomass loss is being conducted. For unmanaged cropland converted to forest land, efforts are undertaken in order to improve the assessment of carbon stocks in unmanaged cropland. For forest land converted to wetlands and settlement, improvement on data analysis especially for data prior to 2015 in some regions is being conducted.
27.	LULUCF	4.B.	Cropland	For soil carbon, an exercise is being conducted to explore the use of the Bayesian approach to estimate the soil carbon stocks. For emissions from drained peatlands, data collection from peatlands drained more than 50 years is intended.
28.	LULUCF	4.E.	Settlement	For settlement remaining settlement, an exercise to refine the methodological approach in order to estimate emissions and removals from settlement is intended. For forest and crop land converted to settlement, Malaysia intends to explore the use of Bayesian approach in order to estimate the soil carbon stocks.
29.	Waste	5.A.	Solid waste disposal	Efforts are being conducted to improve the activity data and emission factor.
30.	WASTE	5.D.1.	Domestic wastewater treatment and discharge	For domestic wastewater, the activity data has been estimated / utilised based on Tier 2 method. Efforts are being conducted to improve the activity data.
31.	Waste	5.D.2.	Industrial wastewater treatment and discharge	For industrial wastewater particularly the palm oil mill effluent, the emission factor has been estimated/utilised based on Tier 2 method.

[37] Based on 2006 IPCC Guidelines category code

SECTION I
ANNEX I: KEY CATEGORIES

The key categories analysis conducted according to the level assessment and trend assessment methods are each as the following.

i. Approach 1 Level Assessment for GHG Inventory Year 2005 – Excluding LULUCF

ii. Approach 1 Level Assessment for GHG Inventory Year 2005 – Including LULUCF

iii. Approach 1 Level Assessment for GHG Inventory Year 2021 – Excluding LULUCF

iv. Approach 1 Level Assessment for GHG Inventory Year 2021 – Including LULUCF

v. Approach 1 Trend Assessment for GHG Inventory Year 2021 – Excluding LULUCF

vi. Approach 1 Trend Assessment for GHG Inventory Year 2021 – Including LULUCF

Each type of key categories analysis above are tabulated respectively as the Table SIAI.1-SIAI.6 The key categories that accumulate up to the 95% of total GHG emissions are written in bold.

Table SIAI.1

Approach 1 Level Assessment for GHG Inventory Year 2005 – Excluding LULUCF

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CO_2	33,600.15	33,600.15	0.13	13.17%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CO_2	30,969.27	30,969.27	0.12	25.31%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CO_2	26,744.27	26,744.27	0.10	35.79%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CO_2	22,279.39	22,279.39	0.09	44.52%
ENERGY	1.B.2.a.	Oil	CH_4	19,053.67	19,053.67	0.07	51.99%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CO_2	17,297.09	17,297.09	0.07	58.76%
WASTE	5.D.2.	Industrial wastewater treatment and discharge	CH_4	15,493.58	15,493.58	0.06	64.84%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CO_2	12,480.19	12,480.19	0.05	69.73%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CO_2	9,936.67	9,936.67	0.04	73.62%
IPPU	2.A.1.	Cement production	CO_2	7,615.98	7,615.98	0.03	76.61%
ENERGY	1.B.2.b.	Natural Gas	CH_4	7,353.28	7,353.28	0.03	79.49%
WASTE	5.A.	Solid waste disposal	CH_4	6,827.64	6,827.64	0.03	82.16%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CO_2	5,420.07	5,420.07	0.02	84.29%
ENERGY	1.B.2.a.	Oil	CO_2	5,387.14	5,387.14	0.02	86.40%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CO_2	3,947.29	3,947.29	0.02	87.95%
AGRICULTURE	3.D.1.	Direct N_2O emissions from managed soils	N_2O	3,425.87	3,425.87	0.01	89.29%
IPPU	2.B.8.	Petrochemical and carbon black production	CO_2	2,633.90	2,633.90	0.01	90.32%
AGRICULTURE	3.C.	Rice cultivation	CH_4	2,372.38	2,372.38	0.01	91.25%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CO_2	2,156.27	2,156.27	0.01	92.10%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CO_2	2,085.98	2,085.98	0.01	92.91%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	CH_4	1,938.75	1,938.75	0.01	93.67%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CO_2	1,820.67	1,820.67	0.01	94.39%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
AGRICULTURE	3.A.	Enteric fermentation	CH_4	1,626.37	1,626.37	0.01	95.02%
ENERGY	1.A.3.e.	Other transportation	CO_2	1,409.64	1,409.64	0.01	95.58%
IPPU	2.C.1.	Iron and steel production	CO_2	1,367.98	1,367.98	0.01	96.11%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CO_2	1,202.61	1,202.61	0.00	96.58%
AGRICULTURE	3.D.2.	Indirect N_2O emissions from managed soils	N_2O	1,054.48	1,054.48	0.00	97.00%
IPPU	2.B.1.	Ammonia production	CO_2	988.52	988.52	0.00	97.38%
AGRICULTURE	3.H.	Urea application	CO_2	575.07	575.07	0.00	97.61%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-14	573.92	573.92	0.00	97.83%
AGRICULTURE	3.B.	Manure management	CH_4	567.61	567.61	0.00	98.06%
IPPU	2.F.1.e.	Refrigeration and air conditioning – Mobile air conditioning	HFC-134a	435.76	435.76	0.00	98.23%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	N_2O	430.85	430.85	0.00	98.40%
AGRICULTURE	3.B.5.	Indirect N_2O emissions from manure management	N_2O	406.01	406.01	0.00	98.56%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	SF6	313.54	313.54	0.00	98.68%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CO2	313.42	313.42	0.00	98.80%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CH_4	311.43	311.43	0.00	98.92%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	N_2O	271.73	271.73	0.00	99.03%
ENERGY	1.A.5.	Other	CO_2	240.69	240.69	0.00	99.12%
IPPU	2.A.2.	Lime production	CO_2	239.24	239.24	0.00	99.22%
IPPU	2.B.8.	Petrochemical and carbon black production	CH_4	227.20	227.20	0.00	99.31%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels Nitric acid production	CO_2	222.99	222.99	0.00	99.39%
IPPU	2.B.2.	Other process uses of carbonates –	N_2O	193.05	193.05	0.00	99.47%
IPPU	2.A.4.	Limestone and dolomite	CO_2	178.68	178.68	0.00	99.54%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CO_2	158.12	158.12	0.00	99.60%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	N_2O	92.15	92.15	0.00	99.64%
AGRICULTURE	3.B.	Manure management	N_2O	86.07	86.07	0.00	99.67%
ENERGY	1.B.2.b.	Natural Gas	CO_2	58.49	58.49	0.00	99.70%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CO_2	53.99	53.99	0.00	99.72%
IPPU	2.B.5.	Carbide production	CO_2	49.49	49.49	0.00	99.74%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	NF_3	42.96	42.96	0.00	99.75%
IPPU	2.C.1.	Iron and steel production	CH_4	37.77	37.77	0.00	99.77%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	N_2O	35.62	35.62	0.00	99.78%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	HFC-23	33.09	33.09	0.00	99.79%
WASTE	5.C.1.	Waste incineration	CO_2	29.61	29.61	0.00	99.81%
IPPU	2.A.3.	Glass production	CO_2	28.34	28.34	0.00	99.82%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	N_2O	28.23	28.23	0.00	99.83%
ENERGY	1.B.1.	Solid fuels	CH_4	27.70	27.70	0.00	99.84%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	N_2O	24.64	24.64	0.00	99.85%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	N_2O	22.42	22.42	0.00	99.86%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	N_2O	21.55	21.55	0.00	99.87%
IPPU	2.G.3.a.	Other product manufacture and use – N_2O in medical applications	N_2O	19.87	19.87	0.00	99.87%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	CH_4	19.52	19.52	0.00	99.88%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CH_4	18.95	18.95	0.00	99.89%
ENERGY	1.A.3.e.	Other transportation	CH_4	18.80	18.80	0.00	99.90%
AGRICULTURE	3.F.	Field burning of agricultural residues	CH_4	17.85	17.85	0.00	99.90%
ENERGY	1.A.3.e.	Other transportation	N_2O	17.25	17.25	0.00	99.91%
ENERGY	1.B.2.a.	Oil	N_2O	16.40	16.40	0.00	99.92%
ENERGY	1.A.3.c.	Railways – Liquid fuels	N_2O	16.17	16.17	0.00	99.92%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.2.	Manufacturing industries and construction Solid fuels	CH_4	15.79	15.79	0.00	99.93%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CH_4	15.46	15.46	0.00	99.93%
IPPU	2.G.1.	Other product manufacture and use – Electrical equipment	SF_6	15.28	15.28	0.00	99.94%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	N_2O	14.63	14.63	0.00	99.95%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	N_2O	13.35	13.35	0.00	99.95%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CH_4	13.35	13.35	0.00	99.96%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CO_2	11.74	11.74	0.00	99.96%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CH_4	11.39	11.39	0.00	99.97%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CH_4	10.44	10.44	0.00	99.97%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CH_4	10.24	10.24	0.00	99.97%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	N_2O	8.91	8.91	0.00	99.98%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CH_4	6.49	6.49	0.00	99.98%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CH_4	6.23	6.23	0.00	99.98%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CH_4	6.00	6.00	0.00	99.98%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	N_2O	5.90	5.90	0.00	99.99%
AGRICULTURE	3.F.	Field burning of agricultural residues	N_2O	5.29	5.29	0.00	99.99%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CH_4	4.89	4.89	0.00	99.99%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	N_2O	3.83	3.83	0.00	99.99%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	N_2O	3.16	3.16	0.00	99.99%
WASTE	5.C.2.	Open burning of waste	N_2O	2.36	2.36	0.00	99.99%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	N_2O	2.32	2.32	0.00	100.00%
ENERGY	1.A.5.	Other	N_2O	2.08	2.08	0.00	100.00%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CH_4	2.02	2.02	0.00	100.00%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
WASTE	5.C.1.	Waste incineration	N_2O	1.54	1.54	0.00	100.00%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CH_4	1.19	1.19	0.00	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	N_2O	1.15	1.15	0.00	100.00%
WASTE	5.C.2.	Open burning of waste	CH_4	0.77	0.77	0.00	100.00%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	N_2O	0.67	0.67	0.00	100.00%
ENERGY	1.A.5.	Other	CH_4	0.31	0.31	0.00	100.00%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CH_4	0.25	0.25	0.00	100.00%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CH_4	0.24	0.24	0.00	100.00%
WASTE	5.C.2.	Open burning of waste	N_2O	0.22	0.22	0.00	100.00%
ENERGY	1.B.2.b.	Natural Gas	N_2O	0.15	0.15	0.00	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CH_4	0.13	0.13	0.00	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CH_4	0.03	0.03	0.00	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	N_2O	0.03	0.03	0.00	100.00%
WASTE	5.B.	Biological treatment of solid waste	CH_4	0.01	0.01	0.00	100.00%
WASTE	5.B.	Biological treatment of solid waste	N_2O	0.01	0.01	0.00	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	N_2O	0.01	0.01	0.00	100.00%
IPPU	2.C.2.	Ferroalloys production	CO_2				100.00%
IPPU	2.C.2.	Ferroalloys production	CH_4				100.00%
IPPU	2.C.3.	Aluminium production	PFC-14				100.00%
IPPU	2.C.3.	Aluminium production	CO2				100.00%
IPPU	2.C.3.	Aluminium production	PFC-116				100.00%
IPPU	2.D.1.	Lubricant use	CO_2				100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	N_2O				100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	CH_4				100.00%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-116				100.00%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-218				100.00%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-14				100.00%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-116				100.00%
AGRICULTURE	3.G.	Liming	CO_2				100.00%

Table SIAI.2 Approach 1 Level Assessment for GHG Inventory Year 2005 - Including LULUCF

Sector	CRT Category Code	CRT CC Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
LULUCF	4.A.	Forest land	CO_2	(214,453.80)	214,453.80	44.62%	44.62%
LULUCF	4.E.	Settlement	CO_2	34,335.00	34,335.00	7.14%	51.77%
ENERGY	1.A.3.b.	Road transportation - Liquid fuels	CO_2	33,600.15	33,600.15	6.99%	58.76%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CO_2	30,969.27	30,969.27	6.44%	65.20%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CO_2	26,744.27	26,744.27	5.56%	70.77%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CO_2	22,279.39	22,279.39	4.64%	75.40%
ENERGY	1.B.2.a.	Oil	CH_4	19,053.67	19,053.67	3.96%	79.37%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CO_2	17,297.09	17,297.09	3.60%	82.96%
WASTE	5.D.2.	Industrial wastewater treatment and discharge	CH_4	15,493.58	15,493.58	3.22%	86.19%
AGRICULTURE	3.D.1.	Direct N_2O emissions from managed soils	N_2O	15,460.61	15,460.61	3.22%	89.40%
LULUCF	4.B.	Cropland	CO_2	(12,561.10)	12,561.10	2.61%	92.02%
WASTE	5.A.	Solid waste disposal	CH_4	6,817.93	6,817.93	1.42%	93.44%
IPPU	2.B.8.	Petrochemical and carbon black production	CO_2	2,633.90	2,633.90	0.55%	93.99%
AGRICULTURE	3.C.	Rice cultivation	CH_4	2,372.38	2,372.38	0.49%	94.48%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CO_2	2,156.27	2,156.27	0.45%	94.93%
ENERGY	1.A.4.b.	Residential - Liquid fuels	CO_2	2,085.98	2,085.98	0.43%	95.36%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	CH_4	1,938.75	1,938.75	0.40%	95.76%
ENERGY	1.B.2.a.	Oil	CO_2	1,938.68	1,938.68	0.40%	96.17%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CO_2	1,820.67	1,820.67	0.38%	96.55%
LULUCF	4.(III)	Total for all land-use categories (Direct and indirect nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	N_2O	1,809.16	1,809.16	0.38%	96.92%

Sector	CRT Category Code	CRT CC Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
AGRICULTURE	4.(II)	Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)	CH_4	1,626.37	1,626.37	0.34%	97.26%
ENERGY	1.A.3.e.	Other transportation	CO_2	1,409.64	1,409.64	0.29%	97.56%
IPPU	2.C.1.	Iron and steel production	CO_2	1,367.98	1,367.98	0.28%	97.84%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CO_2	1,202.61	1,202.61	0.25%	98.09%
AGRICULTURE	3.D.2.	Indirect N_2O emissions from managed soils	N_2O	1,054.48	1,054.48	0.22%	98.31%
IPPU	2.B.1.	Ammonia production	CO_2	988.52	988.52	0.21%	98.52%
AGRICULTURE	3.H.	Urea application	CO_2	575.07	575.07	0.12%	98.63%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-14	573.92	573.92	0.12%	98.75%
AGRICULTURE	3.B.	Manure management	CH_4	567.61	567.61	0.12%	98.87%
IPPU	2.F.1.e.	Refrigeration and air conditioning – Mobile air conditioning	HFC-134a	435.76	435.76	0.09%	98.96%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	N_2O	430.85	430.85	0.09%	99.05%
AGRICULTURE	3.B.5.	Indirect N_2O emissions from manure management	N_2O	406.01	406.01	0.08%	99.14%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	SF_6	313.54	313.54	0.07%	99.20%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CO_2	313.42	313.42	0.07%	99.27%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CH_4	311.43	311.43	0.06%	99.33%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CO_2	274.38	274.38	0.06%	99.39%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	N_2O	271.73	271.73	0.06%	99.45%
ENERGY	1.A.5.	Other	CO_2	240.69	240.69	0.05%	99.50%
IPPU	2.A.2.	Lime production	CO_2	239.24	239.24	0.05%	99.55%
IPPU	2.B.8.	Petrochemical and carbon black production	CH_4	227.20	227.20	0.05%	99.59%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CO_2	222.99	222.99	0.05%	99.64%
IPPU	2.B.2.	Nitric acid production	N_2O	193.05	193.05	0.04%	99.68%
IPPU	2.A.4.	Other process uses of carbonates – Limestone and dolomite	CO_2	178.68	178.68	0.04%	99.72%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CO_2	158.12	158.12	0.03%	99.75%

Sector	CRT Category Code	CRT CC Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
LULUCF	4.C.	Grassland	CO_2	105.08	105.08	0.02%	99.77%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	N_2O	92.15	92.15	0.02%	99.79%
AGRICULTURE	3.B.	Manure management	N_2O	86.07	86.07	0.02%	99.81%
ENERGY	1.B.2.b.	Natural Gas	CO_2	58.49	58.49	0.01%	99.82%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CO_2	53.99	53.99	0.01%	99.83%
IPPU	2.B.5.	Carbide production	CO_2	49.49	49.49	0.01%	99.84%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	NF_3	42.96	42.96	0.01%	99.85%
IPPU	2.C.1.	Iron and steel production	CH_4	37.77	37.77	0.01%	99.86%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	N_2O	35.62	35.62	0.01%	99.87%
LULUCF	4.(II)	Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)	CH_4	33.65	33.65	0.01%	99.87%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	HFC-23	33.09	33.09	0.01%	99.88%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CO_2	29.61	29.61	0.01%	99.89%
WASTE	5.C.1.	Waste incineration	CO_2	29.61	29.61	0.01%	99.89%
IPPU	2.A.3.	Glass production	CO_2	28.34	28.34	0.01%	99.90%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	N2O	28.23	28.23	0.01%	99.90%
ENERGY	1.B.1.	Solid fuels	CH_4	27.70	27.70	0.01%	99.91%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	N_2O	24.64	24.64	0.01%	99.92%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	N_2O	22.42	22.42	0.00%	99.92%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	N_2O	21.55	21.55	0.00%	99.92%
IPPU	2.G.3.a.	Other product manufacture and use – N_2O in medical applications	N_2O	19.87	19.87	0.00%	99.93%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	CH_4	19.52	19.52	0.00%	99.93%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CH_4	18.95	18.95	0.00%	99.94%

Sector	CRT Category Code	CRT CC Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.3.e.	Other transportation	CH_4	18.80	18.80	0.00%	99.94%
AGRICULTURE	3.F.	Field burning of agricultural residues	CH_4	17.85	17.85	0.00%	99.94%
ENERGY	1.A.3.e.	Other transportation	N_2O	17.25	17.25	0.00%	99.95%
ENERGY	1.B.2.a.	Oil	N_2O	16.40	16.40	0.00%	99.95%
ENERGY	1.A.3.c.	Railways – Liquid fuels	N_2O	16.17	16.17	0.00%	99.95%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CH_4	15.79	15.79	0.00%	99.96%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CH_4	15.46	15.46	0.00%	99.96%
IPPU	2.G.1.	Other product manufacture and use – Electrical equipment	SF_6	15.28	15.28	0.00%	99.96%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	N_2O	14.63	14.63	0.00%	99.97%
LULUCF	4(IV)	Total for all land-use categories (Biomass Burning)	CH_4	13.83	13.83	0.00%	99.97%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	N_2O	13.35	13.35	0.00%	99.97%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CH_4	13.35	13.35	0.00%	99.98%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CO_2	11.74	11.74	0.00%	99.98%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CH_4	11.39	11.39	0.00%	99.98%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CH_4	10.44	10.44	0.00%	99.98%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CH_4	10.24	10.24	0.00%	99.99%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	N_2O	8.91	8.91	0.00%	99.99%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CH_4	6.49	6.49	0.00%	99.99%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CH_4	6.23	6.23	0.00%	99.99%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CH_4	6.00	6.00	0.00%	99.99%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	N_2O	5.90	5.90	0.00%	99.99%
AGRICULTURE	3.F.	Field burning of agricultural residues	N_2O	5.29	5.29	0.00%	99.99%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CH_4	4.89	4.89	0.00%	99.99%

Sector	CRT Category Code	CRT CC Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.3.e.	Other transportation	CH_4	18.80	18.80	0.00%	99.94%
AGRICULTURE	3.F.	Field burning of agricultural residues	CH_4	17.85	17.85	0.00%	99.94%
ENERGY	1.A.3.e.	Other transportation	N_2O	17.25	17.25	0.00%	99.95%
ENERGY	1.B.2.a.	Oil	N_2O	16.40	16.40	0.00%	99.95%
ENERGY	1.A.3.c.	Railways – Liquid fuels	N_2O	16.17	16.17	0.00%	99.95%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CH_4	15.79	15.79	0.00%	99.96%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CH_4	15.46	15.46	0.00%	99.96%
IPPU	2.G.1.	Other product manufacture and use – Electrical equipment	SF_6	15.28	15.28	0.00%	99.96%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	N_2O	14.63	14.63	0.00%	99.97%
LULUCF	4(IV)	Total for all land-use categories (Biomass Burning)	CH_4	13.83	13.83	0.00%	99.97%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	N_2O	13.35	13.35	0.00%	99.97%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CH_4	13.35	13.35	0.00%	99.98%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CO_2	11.74	11.74	0.00%	99.98%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CH_4	11.39	11.39	0.00%	99.98%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CH_4	10.44	10.44	0.00%	99.98%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CH_4	10.24	10.24	0.00%	99.99%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	N_2O	8.91	8.91	0.00%	99.99%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CH_4	6.49	6.49	0.00%	99.99%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CH_4	6.23	6.23	0.00%	99.99%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CH_4	6.00	6.00	0.00%	99.99%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	N_2O	5.90	5.90	0.00%	99.99%
AGRICULTURE	3.F.	Field burning of agricultural residues	N_2O	5.29	5.29	0.00%	99.99%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CH_4	4.89	4.89	0.00%	99.99%

Sector	CRT Category Code	CRT CC Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	N_2O	3.83	3.83	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation - Gaseous fuels	N_2O	3.16	3.16	0.00%	100.00%
ENERGY	1.B.2.b.	Natural Gas	CH_4	2.36	2.36	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CO_2	2.36	2.36	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional - Liquid fuels	N_2O	2.32	2.32	0.00%	100.00%
ENERGY	1.A.5.	Other	N_2O	2.08	2.08	0.00%	100.00%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CH_4	2.02	2.02	0.00%	100.00%
IPPU	2.A.1.	Cement production	CO_2	1.54	1.54	0.00%	100.00%
WASTE	5.C.1.	Waste incineration	N_2O	1.54	1.54	0.00%	100.00%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CH_4	1.19	1.19	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	N_2O	1.15	1.15	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CH_4	0.77	0.77	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	CH_4	0.77	0.77	0.00%	100.00%
ENERGY	1.A.4.c.	Agriculture/ Fishery/Forestry – Liquid fuels	N_2O	0.67	0.67	0.00%	100.00%
LULUCF	4.D.	Wetland	CO_2	0.45	0.45	0.00%	100.00%
ENERGY	1.A.5.	Other	CH_4	0.31	0.31	0.00%	100.00%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CH_4	0.25	0.25	0.00%	100.00%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CH_4	0.24	0.24	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	N_2O	0.22	0.22	0.00%	100.00%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CO_2	0.22	0.22	0.00%	100.00%
ENERGY	1.B.2.b.	Natural Gas	N_2O	0.15	0.15	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CH_4	0.13	0.13	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CH_4	0.03	0.03	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional - Gaseous fuels	N_2O	0.03	0.03	0.00%	100.00%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CO_2	0.01	0.01	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	N_2O	0.01	0.01	0.00%	100.00%

Sector	CRT Category Code	CRT CC Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.4.b.	Residential – Gaseous fuels	N_2O	0.01	0.01	0.00%	100.00%
LULUCF	4(I)	Direct and indirect N_2O emissions from N inputs to managed soils	N_2O			0.00%	100.00%
AGRICULTURE	3.G.	Liming	CO2			0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	N2O			0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	CH4			0.00%	100.00%
IPPU	2.C.2.	Ferroalloys production	CO2			0.00%	100.00%
IPPU	2.C.2.	Ferroalloys production	CH4			0.00%	100.00%
IPPU	2.C.3.	Aluminium production	PFC-14			0.00%	100.00%
IPPU	2.C.3.	Aluminium production	CO2			0.00%	100.00%
IPPU	2.C.3.	Aluminium production	PFC-116			0.00%	100.00%
IPPU	2.D.1.	Lubricant use	CO2			0.00%	100.00%
IPPU	2.E.1.	Electronic industry - Integrated circuit or semiconductor	PFC-116			0.00%	100.00%
IPPU	2.E.1.	Electronic industry - Integrated circuit or semiconductor	PFC-218			0.00%	100.00%
IPPU	2.E.3.	Electronic industry - Photovoltaics	PFC-14			0.00%	100.00%
IPPU	2.E.3.	Electronic industry - Photovoltaics	PFC-116			0.00%	100.00%

Table SIAI.3

Approach 1 Level Assessment for GHG Inventory Year 2021 - Excluding LULUCF

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CO_2	86,604.62	86,604.62	26.43%	26.43%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CO_2	43,091.87	43,091.87	13.15%	39.58%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CO_2	27,173.81	27,173.81	8.29%	47.87%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CO_2	26,105.47	26,105.47	7.97%	55.84%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CO_2	20,334.00	20,334.00	6.21%	62.05%
IPPU	2.C.1.	Iron and steel production	CO_2	14,945.92	14,945.92	4.56%	66.61%
WASTE	5.D.2	Industrial wastewater treatment and discharge	CH_4	14,447.10	14,447.10	4.41%	71.02%
ENERGY	1.B.2.b.	Natural Gas	CH_4	8,678.63	8,678.63	2.65%	73.67%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CO_2	8,087.34	8,087.34	2.47%	76.13%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CO_2	7,688.59	7,688.59	2.35%	78.48%
ENERGY	1.B.2.a.	Oil	CH_4	7,177.56	7,177.56	2.19%	80.67%
WASTE	5.A.	Solid waste disposal	CH_4	6,847.50	6,847.50	2.09%	82.76%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CO_2	5,596.99	5,596.99	1.71%	84.47%
IPPU	2.A.1.	Cement production	CO_2	5,479.64	5,479.64	1.67%	86.14%
IPPU	2.B.8.	Petrochemical and carbon black production	CO_2	4,029.45	4,029.45	1.23%	87.37%
ENERGY	1.B.2.a.	Oil	CO_2	3,503.46	3,503.46	1.07%	88.44%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CO_2	3,045.49	3,045.49	0.93%	89.37%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CO_2	2,793.50	2,793.50	0.85%	90.22%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CO_2	2,622.73	2,622.73	0.80%	91.02%
AGRICULTURE	3.C.	Rice cultivation	CH4	2,499.50	2,499.50	0.76%	91.78%
IPPU	2.C.3.	Aluminium production	PFC-14	2,330.21	2,330.21	0.71%	92.50%
AGRICULTURE	3.D.1.	Direct N_2O emissions from managed soils	N_2O	2,201.35	2,201.35	0.67%	93.17%
ENERGY	1.A.3.e.	Other transportation	CO_2	2,152.32	2,152.32	0.66%	93.82%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
WASTE	5.D.1.	Domestic wastewater treatment and discharge	CH_4	1,914.39	1,914.39	0.58%	94.41%
IPPU	2.B.1.	Ammonia production	CO_2	1,499.21	1,499.21	0.46%	94.87%
IPPU	2.C.2.	Ferroalloys production	CO_2	1,436.27	1,436.27	0.44%	95.30%
IPPU	2.C.3.	Aluminium production	CO_2	1,405.86	1,405.86	0.43%	95.73%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CO_2	1,305.41	1,305.41	0.40%	96.13%
AGRICULTURE	3.A.	Enteric fermentation	CH_4	1,247.65	1,247.65	0.38%	96.51%
IPPU	2.F.1.e.	Refrigeration and air conditioning – Mobile air conditioning	HFC-134a	928.04	928.04	0.28%	96.80%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CO_2	871.87	871.87	0.27%	97.06%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-116	820.39	820.39	0.25%	97.31%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-14	785.15	785.15	0.24%	97.55%
IPPU	2.A.4.	Other process uses of carbonates – Limestone and dolomite	CO_2	648.44	648.44	0.20%	97.75%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	N_2O	553.25	553.25	0.17%	97.92%
AGRICULTURE	3.D.2.	Indirect N_2O emissions from managed soils	N_2O	542.71	542.71	0.17%	98.08%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-14	441.02	441.02	0.13%	98.22%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CH_4	394.66	394.66	0.12%	98.34%
AGRICULTURE	3.H.	Urea application	CO_2	394.47	394.47	0.12%	98.46%
IPPU	2.C.3.	Aluminium production	PFC-116	390.13	390.13	0.12%	98.58%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	N_2O	389.85	389.85	0.12%	98.70%
ENERGY	1.A.3.a.	Domestic Aviation – Liquid fuels	CO_2	379.85	379.85	0.12%	98.81%
IPPU	2.B.8.	Petrochemical and carbon black production	CH_4	365.29	365.29	0.11%	98.93%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	N_2O	357.99	357.99	0.11%	99.03%
IPPU	2.E.1.	Electronic industry - Integrated circuit or semiconductor	SF_6	347.37	347.37	0.11%	99.14%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.B.2.b.	Natural Gas	CO_2	343.36	343.36	0.10%	99.25%
IPPU	2.A.3.	Glass production	CO_2	320.77	320.77	0.10%	99.34%
IPPU	2.A.2.	Lime production	CO_2	309.05	309.05	0.09%	99.44%
ENERGY	1.A.5.	Other	CO_2	285.98	285.98	0.09%	99.52%
AGRICULTURE	3.B.	Manure management	CH_4	260.7035	260.7035	0.08%	99.60%
IPPU	2.B.5.	Carbide production	CO_2	187.00	187.00	0.06%	99.66%
IPPU	2.G.1.	Other product manufacture and use – Electrical equipment	SF_6	127.35	127.35	0.04%	99.70%
AGRICULTURE	3.B.5.	Indirect N_2O emissions	N_2O	108.7090	108.7090	0.03%	99.73%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CO_2	82.15	82.15	0.03%	99.76%
WASTE	5.C.1.	Waste incineration	CO_2	61.77	61.77	0.02%	99.78%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-116	52.58	52.58	0.02%	99.79%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	NF_3	47.60	47.60	0.01%	99.81%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	HFC-23	36.66	36.66	0.01%	99.82%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-218	32.89	32.89	0.01%	99.83%
ENERGY	1.B.1.	Solid fuels	CH_4	32.21	32.21	0.01%	99.84%
ENERGY	1.A.3.e.	Other transportation	CH_4	28.70	28.70	0.01%	99.85%
IPPU	2.G.3.b.	Other product manufacture and use – N_2O in medical applications	N2O	27.70	27.70	0.01%	99.86%
AGRICULTURE	3.B.	Manure management	N_2O	27.1358	27.1358	0.01%	99.86%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CO_2	26.94	26.94	0.01%	99.87%
ENERGY	1.A.3.e.	Other transportation	N_2O	26.34	26.34	0.01%	99.88%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CO_2	25.82	25.82	0.01%	99.89%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CH_4	25.22	25.22	0.01%	99.90%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	N_2O	23.15	23.15	0.01%	99.90%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	N_2O	19.98	19.98	0.01%	99.91%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	N_2O	17.54	17.54	0.01%	99.91%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
IPPU	2.C.1.	Iron and steel production	CH_4	17.29	17.29	0.01%	99.92%
AGRICULTURE	3.G.	Liming	CO_2	17.1801	17.1801	0.01%	99.93%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CH_4	16.31	16.31	0.00%	99.93%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	N_2O	15.75	15.75	0.00%	99.94%
IPPU	2.C.2.	Ferroalloys production	CH_4	15.01	15.01	0.00%	99.94%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CH_4	13.56	13.56	0.00%	99.94%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CH_4	13.03	13.03	0.00%	99.95%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	N_2O	12.84	12.84	0.00%	99.95%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	N_2O	12.33	12.33	0.00%	99.96%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CH_4	11.55	11.55	0.00%	99.96%
ENERGY	1.B.2.a.	Oil	N_2O	10.67	10.67	0.00%	99.96%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CH_4	10.15	10.15	0.00%	99.97%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	N_2O	9.61	9.61	0.00%	99.97%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CH_4	9.27	9.27	0.00%	99.97%
AGRICULTURE	3.F.	Field burning of agricultural residues	CH_4	8.5434	8.5434	0.00%	99.97%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CH_4	8.41	8.41	0.00%	99.98%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CH_4	7.39	7.39	0.00%	99.98%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	N_2O	6.75	6.75	0.00%	99.98%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	N_2O	6.56	6.56	0.00%	99.98%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CH_4	5.83	5.83	0.00%	99.98%
ENERGY	1.A.3.b.	Road transportation – Biomass	N_2O	5.50	5.50	0.00%	99.99%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	CH_4	5.38	5.38	0.00%	99.99%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CH_4	3.77	3.77	0.00%	99.99%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CH_4	3.77	3.77	0.00%	99.99%
WASTE	5.C.1.	Waste incineration	N_2O	3.12	3.12	0.00%	99.99%
ENERGY	1.A.3.b.	Road transportation – Biomass	CH_4	2.91	2.91	0.00%	99.99%
ENERGY	1.A.3.a.	Domestic Aviation – Liquid fuels	N_2O	2.82	2.82	0.00%	99.99%
ENERGY	1.A.3.c.	Railways – Liquid fuels	N_2O	2.76	2.76	0.00%	99.99%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CO_2	2.35	2.35	0.00%	99.99%
ENERGY	1.A.5.	Other	N_2O	2.35	2.35	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CH_4	2.18	2.18	0.00%	100.00%
AGRICULTURE	3.F.	Field burning of agricultural residues	N_2O	2.10	2.10	0.00%	100.00%
IPPU	2.D.1.	Lubricant use	CO_2	2.08	2.08	0.00%	100.00%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	N_2O	1.87	1.87	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	N_2O	1.52	1.52	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	N_2O	1.16	1.16	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	N_2O	1.12	1.12	0.00%	100.00%
ENERGY	1.B.2.b.	Natural Gas	N_2O	1.01	1.01	0.00%	100.00%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CH_4	0.99	0.99	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CO_2	0.71	0.71	0.00%	100.00%
ENERGY	1.A.5.	Other	CH_4	0.55	0.55	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	CH_4	0.20	0.20	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	N_2O	0.20	0.20	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	N_2O	0.11	0.11	0.00%	100.00%
ENERGY	1.A.3.a.	Domestic Aviation – Liquid fuels	CH_4	0.07	0.07	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CH_4	0.06	0.06	0.00%	100.00%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CH_4	0.04	0.04	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	N_2O	0.01	0.01	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CH_4	0.01	0.01	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	N_2O	0.00	0.00	0.00%	100.00%
IPPU	2.B.2.	Nitric acid production	N_2O			0.00%	100.00%

Table SIAI.4

Approach 1 Level Assessment for GHG Inventory Year 2021 – Including LULUCF

Sector	CRT Category Code	CRT Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
LULUCF	4.A.	Forest land	CO_2	(248,823.48)	248,823.48	40.55%	40.55%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CO_2	86,604.62	86,604.62	14.11%	54.67%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CO_2	43,091.87	43,091.87	7.02%	61.69%
LULUCF	4.E.	Settlement	CO_2	34,795.51	34,795.51	5.67%	67.36%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CO_2	27,173.81	27,173.81	4.43%	71.79%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CO_2	26,105.47	26,105.47	4.25%	76.04%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CO_2	20,334.00	20,334.00	3.31%	79.36%
IPPU	2.C.1.	Iron and steel production	CO_2	14,945.92	14,945.92	2.44%	81.79%
WASTE	5.D.2	Industrial wastewater treatment and discharge	CH_4	14,447.10	14,447.10	2.35%	84.15%
ENERGY	1.B.2.b.	Natural Gas	CH_4	8,678.63	8,678.63	1.41%	85.56%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CO_2	8,087.34	8,087.34	1.32%	86.88%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CO_2	7,688.59	7,688.59	1.25%	88.13%
ENERGY	1.B.2.a.	Oil	CH_4	7,177.56	7,177.56	1.17%	89.30%
WASTE	5.A.	Solid waste disposal	CH_4	6,847.50	6,847.50	1.12%	90.42%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CO_2	5,596.99	5,596.99	0.91%	91.33%
IPPU	2.A.1.	Cement production	CO_2	5,479.64	5,479.64	0.89%	92.22%
IPPU	2.B.8.	Petrochemical and carbon black production	CO_2	4,029.45	4,029.45	0.66%	92.88%
ENERGY	1.B.2.a.	Oil	CO_2	3,503.46	3,503.46	0.57%	93.45%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CO_2	3,045.49	3,045.49	0.50%	93.95%
ENERGY	1.A.3.d.	Domestic navigation - Liquid fuels	CO_2	2,793.50	2,793.50	0.46%	94.40%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CO_2	2,622.73	2,622.73	0.43%	94.83%
AGRICULTURE	3.C.	Rice cultivation	CH_4	2,499.50	2,499.50	0.41%	95.24%
IPPU	2.C.3.	Aluminium production	PFC-14	2,330.21	2,330.21	0.38%	95.62%

Sector	CRT Category Code	CRT Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
AGRICULTURE	3.D.1.	Direct N_2O emissions from managed soils	N_2O	2,201.35	2,201.35	0.36%	95.98%
ENERGY	1.A.3.e.	Other transportation	CO_2	2,152.32	2,152.32	0.35%	96.33%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	CH_4	1,914.39	1,914.39	0.31%	96.64%
LULUCF	4.(III)	Total for all land-use categories (Direct and indirect nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	N_2O	1,552.64	1,552.64	0.25%	96.89%
IPPU	2.B.1.	Ammonia production	CO_2	1,499.21	1,499.21	0.24%	97.14%
IPPU	2.C.2.	Ferroalloys production	CO_2	1,436.27	1,436.27	0.23%	97.37%
IPPU	2.C.3.	Aluminium production	CO_2	1,405.86	1,405.86	0.23%	97.60%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CO_2	1,305.41	1,305.41	0.21%	97.81%
AGRICULTURE	3.A.	Enteric fermentation	CH_4	1,247.65	1,247.65	0.20%	98.02%
IPPU	2.F.1.e.	Refrigeration and air conditioning – Mobile air conditioning	HFC-134a	928.04	928.04	0.15%	98.17%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CO_2	871.87	871.87	0.14%	98.31%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-116	820.39	820.39	0.13%	98.44%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-14	785.15	785.15	0.13%	98.57%
IPPU	2.A.4.	Other process uses of carbonates – Limestone and dolomite	CO_2	648.44	648.44	0.11%	98.68%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	N_2O	553.25	553.25	0.09%	98.77%
Agriculture	3.D.2.	Indirect N_2O emissions from managed soils	N_2O	542.71	542.71	0.09%	98.86%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-14	441.02	441.02	0.07%	98.93%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CH_4	394.66	394.66	0.06%	98.99%
Agriculture	3.H.	Urea application	CO_2	394.47	394.47	0.06%	99.06%
IPPU	2.C.3.	Aluminium production	PFC-116	390.13	390.13	0.06%	99.12%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	N_2O	389.85	389.85	0.06%	99.18%
ENERGY	1.A.3.a.	Domestic Aviation – Liquid fuels	CO_2	379.85	379.85	0.06%	99.24%

Sector	CRT Category Code	CRT Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
IPPU	2.B.8.	Petrochemical and carbon black production	CH_4	365.29	365.29	0.06%	99.30%
LULUCF	4.(II)	Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)	CH_4	359.89	359.89	0.06%	99.36%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	N_2O	357.99	357.99	0.06%	99.42%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	SF_6	347.37	347.37	0.06%	99.48%
ENERGY	1.B.2.b.	Natural Gas	CO_2	343.36	343.36	0.06%	99.53%
IPPU	2.A.3.	Glass production	CO_2	320.77	320.77	0.05%	99.59%
IPPU	2.A.2.	Lime production	CO_2	309.05	309.05	0.05%	99.64%
ENERGY	1.A.5.	Other	CO_2	285.98	285.98	0.05%	99.68%
LULUCF	4.B.	Cropland	CO_2	(278.04)	278.04	0.05%	99.73%
AGRICULTURE	3.B.	Manure management	CH_4	260.70	260.70	0.04%	99.77%
IPPU	t2.B.5.	Carbide production	CO_2	187.00	187.00	0.03%	99.80%
IPPU	2.G.1.	Other product manufacture and use – Electrical equipment	SF_6	127.35	127.35	0.02%	99.82%
AGRICULTURE	3.B.5.	Indirect N2O emissions	N_2O	108.71	108.71	0.02%	99.84%
LULUCF	4.C.	Grassland	CO_2	105.08	105.08	0.02%	99.86%
ENERGY	1.A.3.b.	Road transportation - Gaseous fuels	CO_2	82.15	82.15	0.01%	99.87%
WASTE	5.C.1.	Waste incineration	CO_2	61.77	61.77	0.01%	99.88%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-116	52.58	52.58	0.01%	99.89%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	NF_3	47.60	47.60	0.01%	99.90%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	HFC-23	36.66	36.66	0.01%	99.90%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-218	32.89	32.89	0.01%	99.91%
ENERGY	1.B.1.	Solid fuels	CH_4	32.21	32.21	0.01%	99.91%
ENERGY	1.A.3.e.	Other transportation	CH_4	28.70	28.70	0.00%	99.92%
IPPU	2.G.3.b.	Other product manufacture and use – N_2O in medical applications	CO_2	27.70	27.70	0.00%	99.92%

Sector	CRT Category Code	CRT Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
AGRICULTURE	3.B.	Manure management	N_2O	27.14	27.14	0.00%	99.93%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CO_2	26.94	26.94	0.00%	99.93%
ENERGY	1.A.3.e.	Other transportation	N_2O	26.34	26.34	0.00%	99.94%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CO_2	25.82	25.82	0.00%	99.94%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CH_4	25.22	25.22	0.00%	99.94%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	N_2O	23.15	23.15	0.00%	99.95%
ENERGY	1.A.3.d.	Domestic navigation - Liquid fuels	N_2O	19.98	19.98	0.00%	99.95%
ENERGY	1.A.1.b.	Petroleum refining - Liquid fuels	N_2O	17.54	17.54	0.00%	99.95%
IPPU	2.C.1.	Iron and steel production	CH_4	17.29	17.29	0.00%	99.96%
AGRICULTURE	3.G.	Liming	CO_2	17.18	17.18	0.00%	99.96%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CH_4	16.31	16.31	0.00%	99.96%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	N_2O	15.75	15.75	0.00%	99.96%
IPPU	2.C.2.	Ferroalloys production	CH_4	15.01	15.01	0.00%	99.97%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CH_4	13.56	13.56	0.00%	99.97%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CH_4	13.03	13.03	0.00%	99.97%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	N_2O	12.84	12.84	0.00%	99.97%
ENERGY	1.A.1.a.	Public electricity and heat production Gaseous fuels	N_2O	12.33	12.33	0.00%	99.98%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	CH_4	11.55	11.55	0.00%	99.98%
ENERGY	1.B.2.a.	Oil	N_2O	10.67	10.67	0.00%	99.98%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CH_4	10.15	10.15	0.00%	99.98%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	N2O	9.61	9.61	0.00%	99.98%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CH_4	9.27	9.27	0.00%	99.98%
AGRICULTURE	3.F.	Field burning of agricultural residues	CH_4	8.54	8.54	0.00%	99.99%

Sector	CRT Category Code	CRT Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CH_4	8.41	8.41	0.00%	99.99%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CH_4	7.39	7.39	0.00%	99.99%
ENERGY	1.A.1.a	Public electricity and heat production – Biomass	N_2O	6.75	6.75	0.00%	99.99%
ENERGY	1.A.4.c.	Agriculture/Fishery/Forestry – Liquid fuels	N_2O	6.56	6.56	0.00%	99.99%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CH_4	5.83	5.83	0.00%	99.99%
ENERGY	1.A.3.b.	Road transportation – Biomass	N_2O	5.50	5.50	0.00%	99.99%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	CH_4	5.38	5.38	0.00%	99.99%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CH_4	3.77	3.77	0.00%	99.99%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CH_4	3.77	3.77	0.00%	99.99%
LULUCF	4(IV)	Total for all land-use categories (Biomass Burning)	CH_4	3.42	3.42	0.00%	99.99%
WASTE	5.C.1.	Waste incineration	N_2O	3.12	3.12	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	CH_4	2.91	2.91	0.00%	100.00%
ENERGY	1.A.3.a.	Domestic Aviation – Liquid fuels	N_2O	2.82	2.82	0.00%	100.00%
ENERGY	1.A.3.c.	Railways - Liquid fuels	N_2O	2.76	2.76	0.00%	100.00%
ENERGY	1.A.4.b.	Residential - Gaseous fuels	CO_2	2.35	2.35	0.00%	100.00%
ENERGY	1.A.5.	Other	N_2O	2.35	2.35	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CH_4	2.18	2.18	0.00%	100.00%
AGRICULTURE	3.F.	Field burning of agricultural residues	N_2O	2.10	2.10	0.00%	100.00%
IPPU	2.D.1.	Lubricant use	N_2O	2.08	2.08	0.00%	100.00%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	N_2O	1.87	1.87	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	N_2O	1.52	1.52	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	N_2O	1.16	1.16	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	N_2O	1.12	1.12	0.00%	100.00%
ENERGY	1.B.2.b.	Natural Gas	N_2O	1.01	1.01	0.00%	100.00%
ENERGY	1.A.1.a. .	Public electricity and heat production – Liquid fuels	CH_4	0.99	0.99	0.00%	100.00%

Sector	CRT Category Code	CRT Category Name	Greenhouse Gas	2005 Base Year Estimate (Gg CO_2 eq.)	|D|	Level Assessment (%)	Cumulative (%)
WASTE	5.C.2.	Open burning of waste	CO_2	0.71	0.71	0.00%	100.00%
LULUCF	4.D.	Wetland	CO_2	0.65	0.65	0.00%	100.00%
ENERGY	1.A.5.	Other	CH_4	0.55	0.55	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	CH_4	0.20	0.20	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	N_2O	0.20	0.20	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	N_2O	0.11	0.11	0.00%	100.00%
ENERGY	1.A.3.a.	Domestic Aviation – Liquid fuels	CH_4	0.07	0.07	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CH_4	0.06	0.06	0.00%	100.00%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CH_4	0.04	0.04	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	N_2O	0.01	0.01	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CH_4	0.01	0.01	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	N_2O	0.00	0.00	0.00%	100.00%
LULUCF	4(I)	Direct and indirect N_2O emissions from N inputs to managed soils	N_2O	–	–	0.00%	100.00%
IPPU	2.B.2.	Nitric acid production	N_2O	–	–	0.00%	100.00%

Table SIAI.5

Approach 1 Trend Assessment for GHG Inventory Year 2021 – Excluding LULUCF

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CO_2	22,279.39	86,604.62	22,279.39	86,604.62	0.23	34.11%	34.11%
ENERGY	1.B.2.a.	Oil	CH_4	19,053.67	7,177.56	19,053.67	7,177.56	0.07	10.17%	44.29%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CO_2	17,297.09	7,688.59	17,297.09	7,688.59	0.06	8.55%	52.83%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CO_2	30,969.27	26,105.47	30,969.27	26,105.47	0.05	8.04%	60.87%
IPPU	2.C.1.	Iron and steel production	CO_2	1,367.98	14,945.92	1,367.98	14,945.92	0.05	7.76%	68.63%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CO_2	26,744.27	27,173.81	26,744.27	27,173.81	0.03	4.22%	72.85%
WASTE	5.D.2.	Industrial wastewater treatment and discharge	CH_4	15,460.61	14,447.10	15,460.61	14,447.10	0.02	3.18%	76.04%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CO_2	9,936.67	8,087.34	9,936.67	8,087.34	0.02	2.75%	78.79%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CO_2	12,480.19	20,334.00	12,480.19	20,334.00	0.02	2.53%	81.32%
IPPU	2.A.1.	Cement production	CO_2	7,615.98	5,479.64	7,615.98	5,479.64	0.02	2.53%	83.85%
ENERGY	1.B.2.a.	Oil	CO_2	5,387.14	3,503.46	5,387.14	3,503.46	0.01	2.01%	85.86%
ENERGY	1.A.4.c.	Agriculture/Fishery/ Forestry – Liquid fuels	CO_2	313.42	3,045.49	313.42	3,045.49	0.01	1.55%	87.41%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CO_2	3,947.29	2,793.50	3,947.29	2,793.50	0.01	1.34%	88.75%
AGRICULTURE	3.D.1.	Direct N_2O emissions from managed soils	N_2O	3,425.87	2,201.35	3,425.87	2,201.35	0.01	1.29%	90.05%
WASTE	5.A.	Solid waste disposal	CH_4	6,817.93	6,847.50	6,817.93	6,847.50	0.01	1.12%	91.17%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CO_2	1,820.67	871.87	1,820.67	871.87	0.01	0.86%	92.03%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CO_2	2,156.27	1,305.41	2,156.27	1,305.41	0.01	0.86%	92.89%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CO_2	5,420.07	5,596.99	5,420.07	5,596.99	0.01	0.80%	93.70%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CO_2	1,202.61	379.85	1,202.61	379.85	0.00	0.69%	94.38%
AGRICULTURE	3.A.	Enteric fermentation	CH_4	1,626.37	1,247.65	1,626.37	1,247.65	0.00	0.49%	94.88%
AGRICULTURE	3.D.2.	Indirect N_2O emissions from managed soils	N_2O	1,054.48	542.71	1,054.48	542.71	0.00	0.48%	95.35%
ENERGY	1.B.2.b.	Natural Gas	CH_4	7,353.28	8,678.63	7,353.28	8,678.63	0.00	0.45%	95.80%
IPPU	2.B.8.	Petrochemical and carbon black production	CO_2	2,633.90	4,029.45	2,633.90	4,029.45	0.00	0.38%	96.18%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	CH_4	1,938.68	1,914.39	1,938.68	1,914.39	0.00	0.34%	96.52%
AGRICULTURE	3.C.	Rice cultivation	CH_4	2,372.38	2,499.50	2,372.38	2,499.50	0.00	0.32%	96.84%
AGRICULTURE	3.B.	Manure management	CH_4	567.61	260.70	567.61	260.70	0.00	0.28%	97.12%
IPPU	2.A.4.	Other process uses of carbonates – Limestone and dolomite	CO_2	178.68	648.44	178.68	648.44	0.00	0.25%	97.37%
AGRICULTURE	3.B.5.	Indirect N_2O emissions from manure management	N_2O	406.01	108.71	406.01	108.71	0.00	0.24%	97.61%
IPPU	2.F.1.e.	Refrigeration and air conditioning – Mobile air conditioning	HFC-134a	435.76	928.04	435.76	928.04	0.00	0.22%	97.83%
AGRICULTURE	3.H.	Urea application	CO_2	575.07	394.47	575.07	394.47	0.00	0.20%	98.03%
ENERGY	1.A.3.e.	Other transportation	CO_2	1,409.64	2,152.32	1,409.64	2,152.32	0.00	0.20%	98.23%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-14	573.92	441.02	573.92	441.02	0.00	0.17%	98.40%
IPPU	2.A.3.	Glass production	CO_2	28.34	320.77	28.34	320.77	0.00	0.17%	98.57%
ENERGY	1.B.2.b.	Natural Gas	CO_2	58.49	343.36	58.49	343.36	0.00	0.16%	98.73%
IPPU	2.B.2.	Nitric acid production	N_2O	193.05	–	193.05	–	0.00	0.15%	98.87%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	N_2O	92.15	357.99	92.15	357.99	0.00	0.14%	99.02%
IPPU	2.B.1.	Ammonia production	CO_2	988.52	1,499.21	988.52	1,499.21	0.00	0.14%	99.15%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CO_2	222.99	82.15	222.99	82.15	0.00	0.12%	99.27%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CO_2	158.12	26.94	158.12	26.94	0.00	0.10%	99.37%
IPPU	2.B.5.	Carbide production	CO_2	49.49	187.00	49.49	187.00	0.00	0.07%	99.45%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
IPPU	2.G.1.	Other product manufacture and use – Electrical equipment	SF_6	15.28	127.35	15.28	127.35	0.00	0.06%	99.51%
AGRICULTURE	3.B.	Manure management	N_2O	86.07	27.14	86.07	27.14	0.00	0.05%	99.56%
IPPU	2.B.8.	Petrochemical and carbon black production	CH_4	227.20	365.29	227.20	365.29	0.00	0.04%	99.60%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CO_2	33,600.15	43,091.87	33,600.15	43,091.87	0.00	0.04%	99.64%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CO_2	2,085.98	2,622.73	2,085.98	2,622.73	0.00	0.03%	99.67%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	SF_6	313.54	347.37	313.54	347.37	0.00	0.03%	99.71%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CO_2	53.99	25.82	53.99	25.82	0.00	0.03%	99.73%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	N_2O	274.38	389.85	274.38	389.85	0.00	0.02%	99.75%
IPPU	2.C.1.	Iron and steel production	CH_4	37.77	17.29	37.77	17.29	0.00	0.02%	99.77%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	N_2O	35.62	15.75	35.62	15.75	0.00	0.02%	99.79%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	N_2O	24.64	6.75	24.64	6.75	0.00	0.01%	99.80%
WASTE	5.C.1.	Waste incineration	CO_2	29.61	61.77	29.61	61.77	0.00	0.01%	99.82%
ENERGY	1.A.5.	Other	CO_2	240.69	285.98	240.69	285.98	0.00	0.01%	99.83%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	CH_4	19.52	5.38	19.52	5.38	0.00	0.01%	99.84%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	NF_3	42.96	36.66	42.96	36.66	0.00	0.01%	99.85%
ENERGY	1.A.3.c.	Railways – Liquid fuels	N_2O	16.17	2.76	16.17	2.76	0.00	0.01%	99.86%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CH_4	6.49	25.22	6.49	25.22	0.00	0.01%	99.87%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	N_2O	28.23	19.98	28.23	19.98	0.00	0.01%	99.88%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CH_4	18.95	8.41	18.95	8.41	0.00	0.01%	99.89%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
AGRICULTURE	3.F.	Field burning of agricultural residues	CH_4	17.85	8.54	17.85	8.54	0.00	0.01%	99.90%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CO_2	11.74	2.35	11.74	2.35	0.00	0.01%	99.91%
ENERGY	1.B.2.a.	Oil	N_2O	16.40	10.67	16.40	10.67	0.00	0.01%	99.92%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	N_2O	21.55	17.54	21.55	17.54	0.00	0.01%	99.92%
ENERGY	1.A.4.c.	Agriculture/Fishery/ Forestry – Liquid fuels	CH_4	1.19	11.55	1.19	11.55	0.00	0.01%	99.93%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	HFC-23	33.09	32.89	33.09	32.89	0.00	0.01%	99.93%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CH_4	10.24	3.77	10.24	3.77	0.00	0.01%	99.94%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	N_2O	8.91	2.82	8.91	2.82	0.00	0.01%	99.94%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CH_4	15.46	13.03	15.46	13.03	0.00	0.00%	99.95%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	N_2O	14.63	12.32	14.63	12.32	0.00	0.00%	99.95%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CH_4	10.44	7.39	10.44	7.39	0.00	0.00%	99.95%
ENERGY	1.A.4.c.	Agriculture/Fishery/ Forestry – Liquid fuels	N_2O	0.67	6.56	0.67	6.56	0.00	0.00%	99.96%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	N_2O	22.42	23.15	22.42	23.15	0.00	0.00%	99.96%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CH_4	11.39	9.27	11.39	9.27	0.00	0.00%	99.96%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CH_4	311.43	394.66	311.43	394.66	0.00	0.00%	99.97%
AGRICULTURE	3.F.	Field burning of agricultural residues	N_2O	5.29	2.10	5.29	2.10	0.00	0.00%	99.97%
ENERGY	1.A.3.e.	Other transportation	CH_4	18.80	28.70	18.80	28.70	0.00	0.00%	99.97%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	N_2O	13.35	12.84	13.35	12.84	0.00	0.00%	99.98%
ENERGY	1.A.3.e.	Other transportation	N_2O	17.25	26.34	17.25	26.34	0.00	0.00%	99.98%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CH_4	15.79	16.31	15.79	16.31	0.00	0.00%	99.98%
ENERGY	1.A.4.a.	Commercial/ Institutional – Liquid fuels	CH_4	6.00	3.77	6.00	3.77	0.00	0.00%	99.98%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CH_4	13.35	13.56	13.35	13.56	0.00	0.00%	99.98%
ENERGY	1.B.1.	Solid fuels	CH_4	27.70	32.21	27.70	32.21	0.00	0.00%	99.99%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	N_2O	3.83	1.87	3.83	1.87	0.00	0.00%	99.99%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	N_2O	3.16	1.16	3.16	1.16	0.00	0.00%	99.99%
IPPU	2.G.3.a.	Other product manufacture and use – N_2O in medical applications	N_2O	19.87	27.70	19.87	27.70	0.00	0.00%	99.99%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CH_4	6.23	10.15	6.23	10.15	0.00	0.00%	99.99%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	N_2O	5.90	9.61	5.90	9.61	0.00	0.00%	99.99%
IPPU	2.A.2.	Lime production	CO_2	239.24	309.05	239.24	309.05	0.00	0.00%	99.99%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CH_4	2.02	0.99	2.02	0.99	0.00	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/ Institutional – Liquid fuels	N_2O	2.32	1.52	2.32	1.52	0.00	0.00%	100.00%
WASTE	5.C.1.	Waste incineration	N_2O	1.54	3.12	1.54	3.12	0.00	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CO_2	2.36	2.18	2.36	2.18	0.00	0.00%	100.00%
ENERGY	1.B.2.b.	Natural Gas	N_2O	0.15	1.01	0.15	1.01	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CH_4	4.89	5.83	4.89	5.83	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	N_2O	1.15	1.12	1.15	1.12	0.00	0.00%	100.00%
ENERGY	1.A.5.	Other	N_2O	2.08	2.35	2.08	2.35	0.00	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CH_4	0.77	0.71	0.77	0.71	0.00	0.00%	100.00%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CH_4	0.25	0.04	0.25	0.04	0.00	0.00%	100.00%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CH_4	0.24	0.07	0.24	0.07	0.00	0.00%	100.00%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
WASTE	5.B.	Biological treatment of solid waste	CH_4	0.01	0.20	0.01	0.20	0.00	0.00%	100.00%
ENERGY	1.A.5.	Other	CH_4	0.31	0.55	0.31	0.55	0.00	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	N_2O	430.85	553.25	430.85	553.25	0.00	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CH_4	0.13	0.06	0.13	0.06	0.00	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	N_2O	0.01	0.11	0.01	0.11	0.00	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	N_2O	0.22	0.20	0.22	0.20	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CH_4	0.03	0.01	0.03	0.01	0.00	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	N_2O	0.03	0.01	0.03	0.01	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	N_2O	0.01	0.00	0.01	0.00	0.00	0.00%	100.00%
IPPU	2.C.2.	Ferroalloys production	CO_2	–	1,436.27	–	1,436.27	–	0.00%	100.00%
IPPU	2.C.2.	Ferroalloys production	CH_4	–	15.01	–	15.01	–	0.00%	100.00%
IPPU	2.C.3.	Aluminium production	PFC-14	–	2,330.21	–	2,330.21	–	0.00%	100.00%
IPPU	2.C.3.	Aluminium production	CO_2	–	1,405.86	–	1,405.86	–	0.00%	100.00%
IPPU	2.C.3.	Aluminium production	PFC-116	–	390.13	–	390.13	–	0.00%	100.00%
IPPU	2.D.1.	Lubricant use	CO_2	–	2.08	–	2.08	–	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	N_2O	–	5.50	–	5.50	–	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	CH_4	–	2.91	–	2.91	–	0.00%	100.00%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-116	–	820.39	–	820.39	–	0.00%	100.00%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-218	–	47.60	–	47.60	–	0.00%	100.00%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-14	–	785.15	–	785.15	–	0.00%	100.00%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-116	–	52.58	–	52.58	–	0.00%	100.00%
AGRICULTURE	3.G.	Liming	CO_2	–	17.18	–	17.18	–	0.00%	100.00%

Table SIAI.6

Approach 1 Trend Assessment for GHG Inventory Year 2021 – Including LULUCF

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
LULUCF	4.A.	Forest land	CO_2	(214,453.80)	(248,823.48)	214,453.80	248,823.48	0.39	40.12%	40.12%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CO_2	22,279.39	86,604.62	22,279.39	86,604.62	0.09	9.18%	49.30%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CO_2	30,969.27	26,105.47	30,969.27	26,105.47	0.06	5.77%	55.07%
ENERGY	1.B.2.a.	Oil	CH_4	19,053.67	7,177.56	19,053.67	7,177.56	0.05	5.30%	60.37%
LULUCF	4.E.	Settlement	CO_2	34,335.00	34,795.51	34,335.00	34,795.51	0.05	5.25%	65.62%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CO_2	17,297.09	7,688.59	17,297.09	7,688.59	0.04	4.58%	70.20%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CO_2	26,744.27	27,173.81	26,744.27	27,173.81	0.04	4.08%	74.28%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CO_2	12,480.19	20,334.00	12,480.19	20,334.00	0.04	4.00%	78.28%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CO_2	33,600.15	43,091.87	33,600.15	43,091.87	0.03	3.36%	81.64%
WASTE	5.D.2.	Industrial wastewater treatment and discharge	CH_4	15,460.61	14,447.10	15,460.61	14,447.10	0.03	2.60%	84.24%
IPPU	2.C.1.	Iron and steel production	CO_2	1,367.98	14,945.92	1,367.98	14,945.92	0.02	2.46%	86.70%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CO_2	9,936.67	8,087.34	9,936.67	8,087.34	0.02	1.91%	88.61%
ENERGY	1.B.2.a.	Oil	CO_2	5,387.14	3,503.46	5,387.14	3,503.46	0.01	1.21%	89.82%
WASTE	5.A.	Solid waste disposal	CH_4	6,817.93	6,847.50	6,817.93	6,847.50	0.01	1.05%	90.87%
ENERGY	1.B.2.b.	Natural Gas	CH_4	7,353.28	8,678.63	7,353.28	8,678.63	0.01	0.88%	91.75%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CO_2	3,947.29	2,793.50	3,947.29	2,793.50	0.01	0.84%	92.60%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CO_2	5,420.07	5,596.99	5,420.07	5,596.99	0.01	0.81%	93.40%
AGRICULTURE	3.D.1.	Direct N_2O emissions from managed soils	N_2O	3,425.87	2,201.35	3,425.87	2,201.35	0.01	0.77%	94.18%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CO_2	2,156.27	1,305.41	2,156.27	1,305.41	0.00	0.50%	94.68%
AGRICULTURE	3.C.	Rice cultivation Agriculture/Fishery/	CH_4	2,372.38	2,499.50	2,372.38	2,499.50	0.00	0.49%	95.17%
ENERGY	1.A.4.c.	Forestry – Liquid fuels	CO_2	313.42	3,045.49	313.42	3,045.49	0.00	0.49%	95.66%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CO_2	1,820.67	871.87	1,820.67	871.87	0.00	0.47%	96.13%
LULUCF	4.B.	Cropland	CO_2	(12,561.10)	(278.04)	12,561.10	278.04	0.00	0.46%	96.59%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CO_2	1,202.61	379.85	1,202.61	379.85	0.00	0.35%	96.94%
LULUCF	4.(III)	Total for all land-use categories (Direct and indirect nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/ immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	N_2O	1,809.16	1,552.64	1,809.16	1,552.64	0.00	0.33%	97.27%
AGRICULTURE	3.A.	Enteric fermentation	CH_4	1,626.37	1,247.65	1,626.37	1,247.65	0.00	0.33%	97.60%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	CH_4	1,938.68	1,914.39	1,938.68	1,914.39	0.00	0.31%	97.90%
IPPU	2.B.1.	Ammonia production	CO_2	988.52	1,499.21	988.52	1,499.21	0.00	0.29%	98.20%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CO_2	2,085.98	2,622.73	2,085.98	2,622.73	0.00	0.22%	98.42%
IPPU	2.B.8.	Petrochemical and carbon black production	CO_2	2,633.90	4,029.45	2,633.90	4,029.45	0.00	0.14%	98.55%
AGRICULTURE	3.H.	Urea application	CO_2	575.07	394.47	575.07	394.47	0.00	0.12%	98.68%
AGRICULTURE	3.B.5.	Indirect N_2O emissions from manure management	N_2O	406.01	108.71	406.01	108.71	0.00	0.12%	98.80%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-14	573.92	441.02	573.92	441.02	0.00	0.12%	98.92%
AGRICULTURE	3.D.2.	Indirect N2O emissions from managed soils	N_2O	1,054.48	542.71	1,054.48	542.71	0.00	0.11%	99.02%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	CH_4	311.43	394.66	311.43	394.66	0.00	0.08%	99.10%
ENERGY	1.A.3.e.	Other transportation	CO_2	1,409.64	2,152.32	1,409.64	2,152.32	0.00	0.07%	99.17%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
IPPU	2.A.4.	Other process uses of carbonates – Limestone and dolomite	CO_2	178.68	648.44	178.68	648.44	0.00	0.06%	99.24%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CO_2	222.99	82.15	222.99	82.15	0.00	0.06%	99.30%
LULUCF	4.(II)	Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)	CH_4	33.65	359.89	33.65	359.89	0.00	0.06%	99.36%
IPPU	2.A.3.	Glass production	CO_2	28.34	320.77	28.34	320.77	0.00	0.05%	99.41%
AGRICULTURE	3.B.	Manure management	CH_4	567.61	260.70	567.61	260.70	0.00	0.05%	99.46%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CO_2	158.12	26.94	158.12	26.94	0.00	0.05%	99.51%
ENERGY	1.B.2.b.	Natural Gas	CO_2	58.49	343.36	58.49	343.36	0.00	0.05%	99.56%
ENERGY	1.A.3.b.	Road transportation – Liquid fuels	N_2O	430.85	553.25	430.85	553.25	0.00	0.04%	99.60%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	SF_6	313.54	347.37	313.54	347.37	0.00	0.04%	99.65%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	N2O	92.15	357.99	92.15	357.99	0.00	0.04%	99.68%
IPPU	2.F.1.e.	Refrigeration and air conditioning – Mobile air conditioning	HFC-134a	435.76	928.04	435.76	928.04	0.00	0.03%	99.71%
ENERGY	1.A.5.	Other	CO_2	240.69	285.98	240.69	285.98	0.00	0.03%	99.74%
AGRICULTURE	3.B.	Manure management	N_2O	86.07	27.14	86.07	27.14	0.00	0.02%	99.77%
IPPU	2.A.2.	Lime production	CO_2	239.24	309.05	239.24	309.05	0.00	0.02%	99.79%
WASTE	5.D.1.	Domestic wastewater treatment and discharge	N_2O	274.38	389.85	274.38	389.85	0.00	0.02%	99.81%
IPPU	2.G.1.	Other product manufacture and use – Electrical equipment	SF_6	15.28	127.35	15.28	127.35	0.00	0.02%	99.83%
IPPU	2.B.5.	Carbide production	CO_2	49.49	187.00	49.49	187.00	0.00	0.02%	99.85%
LULUCF	4.C.	Grassland	CO_2	105.08	105.08	105.08	105.08	0.00	0.02%	99.86%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CO_2	53.99	25.82	53.99	25.82	0.00	0.01%	99.88%
IPPU	2.C.1.	Iron and steel production	CH4	37.77	17.29	37.77	17.29	0.00	0.01%	99.89%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	N_2O	35.62	15.75	35.62	15.75	0.00	0.01%	99.90%
IPPU	2.B.8.	Petrochemical and carbon black production	CH_4	227.20	365.29	227.20	365.29	0.00	0.01%	99.91%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	NF_3	42.96	36.66	42.96	36.66	0.00	0.01%	99.91%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	N_2O	24.64	6.75	24.64	6.75	0.00	0.01%	99.92%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	N_2O	28.23	19.98	28.23	19.98	0.00	0.01%	99.93%
ENERGY	1.A.1.a.	Public electricity and heat production – Biomass	CH_4	19.52	5.38	19.52	5.38	0.00	0.01%	99.93%
ENERGY	1.A.3.c.	Railways – Liquid fuels	N_2O	16.17	2.76	16.17	2.76	0.00	0.01%	99.94%
ENERGY	1.A.2.	Manufacturing industries and construction – Liquid fuels	CH_4	18.95	8.41	18.95	8.41	0.00	0.01%	99.94%
AGRICULTURE	3.F.	Field burning of agricultural residues	CH_4	17.85	8.54	17.85	8.54	0.00	0.00%	99.95%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	N_2O	21.55	17.54	21.55	17.54	0.00	0.00%	99.95%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CO_2	11.74	2.35	11.74	2.35	0.00	0.00%	99.96%
ENERGY	1.B.1.	Solid fuels	CH_4	27.70	32.21	27.70	32.21	0.00	0.00%	99.96%
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	N_2O	22.42	23.15	22.42	23.15	0.00	0.00%	99.96%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	CH_4	15.46	13.03	15.46	13.03	0.00	0.00%	99.97%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	CH_4	10.24	3.77	10.24	3.77	0.00	0.00%	99.97%
ENERGY	1.A.1.a.	Public electricity and heat production – Gaseous fuels	N_2O	14.63	12.32	14.63	12.32	0.00	0.00%	99.97%
ENERGY	1.A.1.a.	Public electricity and heat production – Solid fuels	CH_4	6.49	25.22	6.49	25.22	0.00	0.00%	99.97%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	N_2O	8.91	2.82	8.91	2.82	0.00	0.00%	99.98%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
ENERGY	1.A.2.	Manufacturing industries and construction – Solid fuels	CH_4	15.79	16.31	15.79	16.31	0.00	0.00%	99.98%
ENERGY	1.A.3.d.	Domestic navigation – Liquid fuels	CH_4	10.44	7.39	10.44	7.39	0.00	0.00%	99.98%
ENERGY	1.A.1.b.	Petroleum refining – Liquid fuels	CH_4	11.39	9.27	11.39	9.27	0.00	0.00%	99.98%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	N_2O	13.35	12.84	13.35	12.84	0.00	0.00%	99.98%
ENERGY	1.A.1.c.	Manufacture of solid fuels and other energy industries – Gaseous fuels	CH_4	13.35	13.56	13.35	13.56	0.00	0.00%	99.99%
ENERGY	1.A.4.c.	Agriculture/Fishery/ Forestry – Liquid fuels	CH_4	1.19	11.55	1.19	11.55	0.00	0.00%	99.99%
WASTE	5.C.1.	Waste incineration	CO_2	29.61	61.77	29.61	61.77	0.00	0.00%	99.99%
IPPU	2.G.3.a.	Other product manufacture and use – N_2O in medical applications	N_2O	19.87	27.70	19.87	27.70	0.00	0.00%	99.99%
ENERGY	1.A.4.c.	Agriculture/Fishery/ Forestry – Liquid fuels	N_2O	0.67	6.56	0.67	6.56	0.00	0.00%	99.99%
ENERGY	1.A.3.e.	Other transportation	CH_4	18.80	28.70	18.80	28.70	0.00	0.00%	99.99%
ENERGY	1.A.3.b.	Road transportation – Gaseous fuels	N_2O	3.16	1.16	3.16	1.16	0.00	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	CH_4	6.00	3.77	6.00	3.77	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	CH_4	4.89	5.83	4.89	5.83	0.00	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Liquid fuels	N_2O	2.32	1.52	2.32	1.52	0.00	0.00%	100.00%
ENERGY	1.A.5.	Other	N_2O	2.08	2.35	2.08	2.35	0.00	0.00%	100.00%
AGRICULTURE	3.F.	Field burning of agricultural residues	N_2O	5.29	2.10	5.29	2.10	0.00	0.00%	100.00%
IPPU	2.D.1.	Lubricant use	CO_2	0.00	2.08	0.00	2.08	0.00	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CO_2	2.36	2.18	2.36	2.18	0.00	0.00%	100.00%
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	CH_4	6.23	10.15	6.23	10.15	0.00	0.00%	100.00%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
ENERGY	1.A.2.	Manufacturing industries and construction – Gaseous fuels	N_2O	5.90	9.61	5.90	9.61	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Liquid fuels	N_2O	1.15	1.12	1.15	1.12	0.00	0.00%	100.00%
ENERGY	1.B.2.b.	Natural Gas	N_2O	0.15	1.01	0.15	1.01	0.00	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	CH_4	0.77	0.71	0.77	0.71	0.00	0.00%	100.00%
ENERGY	1.A.3.c.	Railways – Liquid fuels	CH_4	0.25	0.04	0.25	0.04	0.00	0.00%	100.00%
WASTE	5.C.1.	Waste incineration	N_2O	1.54	3.12	1.54	3.12	0.00	0.00%	100.00%
WASTE	5.C.2.	Open burning of waste	N_2O	0.22	0.20	0.22	0.20	0.00	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	CH_4	0.01	0.20	0.01	0.20	0.00	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	CH_4	0.13	0.06	0.13	0.06	0.00	0.00%	100.00%
LULUCF	4.D.	Wetland	CO_2	0.45	0.65	0.45	0.65	0.00	0.00%	100.00%
WASTE	5.B.	Biological treatment of solid waste	N_2O	0.01	0.11	0.01	0.11	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	CH_4	0.03	0.01	0.03	0.01	0.00	0.00%	100.00%
ENERGY	1.A.4.a.	Commercial/Institutional – Gaseous fuels	N_2O	0.03	0.01	0.03	0.01	0.00	0.00%	100.00%
ENERGY	1.A.5.	Other	CH_4	0.31	0.55	0.31	0.55	0.00	0.00%	100.00%
ENERGY	1.A.4.b.	Residential – Gaseous fuels	N_2O	0.01	0.00	0.01	0.00	0.00	0.00%	100.00%
AGRICULTURE	3.G.	Liming	CO_2	0.00	17.18	0.00	17.18	0.00	0.00%	100.00%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	N_2O	3.83	1.87	3.83	1.87	0.00	0.00%	100.00%
ENERGY	1.A.1.a.	Public electricity and heat production – Liquid fuels	CH_4	2.02	0.99	2.02	0.99	0.00	0.00%	100.00%
ENERGY	1.A.3.a.	Domestic aviation – Liquid fuels	CH_4	0.24	0.07	0.24	0.07	0.00	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	N_2O	0.00	5.50	0.00	5.50	0.00	0.00%	100.00%
ENERGY	1.A.3.b.	Road transportation – Biomass	CH_4	0.00	2.91	0.00	2.91	0.00	0.00%	100.00%
ENERGY	1.A.3.e.	Other transportation	N_2O	17.25	26.34	17.25	26.34	0.00	0.00%	100.00%
ENERGY	1.B.2.a.	Oil	N_2O	16.40	10.67	16.40	10.67	0.00	0.00%	100.00%

Sector	CRT Category Code	CRT Category Name	GHG	2005 Base Year Estimate (Gg CO_2 eq.)	2021 Year (Gg CO_2 eq.)	|P|	|Q|	Trend Assessment (Txt)	Contribution to Trend (%)	Cumulative (%)
IPPU	2.A.1.	Cement production	CO_2	7,615.98	5,479.64	7,615.98	5,479.64	0.00	0.00%	100.00%
IPPU	2.B.2.	Nitric acid production	N_2O	193.05	0.00	193.05	0.00	0.00	0.00%	100.00%
IPPU	2.C.2.	Ferroalloys production	CO_2	0.00	1,436.27	0.00	1,436.27	0.00	0.00%	100.00%
IPPU	2.C.2.	Ferroalloys production	CH_4	0.00	15.01	0.00	15.01	0.00	0.00%	100.00%
IPPU	2.C.3.	Aluminium production	PFC-14	0.00	2,330.21	0.00	2,330.21	0.00	0.00%	100.00%
IPPU	2.C.3.	Aluminium production	CO_2	0.00	1,405.86	0.00	1,405.86	0.00	0.00%	100.00%
IPPU	2.C.3.	Aluminium production	PFC-116	0.00	390.13	0.00	390.13	0.00	0.00%	100.00%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	HFC-23	33.09	32.89	33.09	32.89	0.00	0.00%	100.00%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-116	0.00	820.39	0.00	820.39	0.00	0.00%	100.00%
IPPU	2.E.1.	Electronic industry – Integrated circuit or semiconductor	PFC-218	0.00	47.60	0.00	47.60	0.00	0.00%	100.00%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-14	0.00	785.15	0.00	785.15	0.00	0.00%	100.00%
IPPU	2.E.3.	Electronic industry – Photovoltaics	PFC-116	0.00	52.58	0.00	52.58	0.00	0.00%	100.00%
LULUCF	4(IV)	Total for all land-use categories (Biomass Burning)	CH_4	13.83	3.42	13.83	3.42	0.00	0.00%	100.00%
LULUCF	4(I)	Direct and indirect N_2O emissions from N inputs to managed soils	N_2O	0.00	0.00	0.00	0.00	0.00	0.00%	100.00%

SECTION I ANNEX II: UNCERTAINTY ASSESSMENT

The uncertainty table analysis is provided as Table SIAII.1 - Table SIAII.2 which follows.

Table SIAII.1 **Uncertainty assessment without LULUCF for 2005**

CRT category			Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
				(Gg CO_2 equivalent)	%	%	%	
1.A.	**Fuel combustion activities (sectoral approach)**							
1.A.1.	**Energy industries**							
1.A.1.a.	Public electricity and heat production	Liquids	CO_2 CH_4 N_2O	1,820.67 2.02 3.83	0.97% 0.97% 0.97%	0.92% 226.15% 226.86%	1.33% 226.15% 226.86%	0.00 0.00 0.00
		Solids	CO_2 CH_4 N_2O	22,279.39 6.49 92.15	0.69% 0.69% 0.69%	13.86% 138.46% 161.79%	13.88% 138.47% 161.80%	0.00 0.00 0.00
		Gas	CO_2 CH_4 N_2O	30,969.27 15.46 14.63	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
		Biomass & Biogas	CH_4 N_2O	19.52 24.64	1.00% 1.00%	200.00% 275.00%	200.00% 275.00%	0.00 0.00
1.A.1.b.	Petroleum refining	Liquids	CO_2 CH_4 N_2O	9,936.67 11.39 21.55	1.00% 1.00% 1.00%	3.00% 233.33% 233.33%	3.16% 233.34% 233.34%	0.00 0.00 0.00
1.A.1.c.	Manufacture of solid fuels and other energy industries	Gas	CO_2 CH_4 N_2O	26,744.27 13.35 12.63	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
1.A.2.	Manufacturing industries and construction	Liquids	CO_2 CH_4 N_2O	17,297.09 18.95 35.62	2.38% 3.00% 0.00%	0.82% 4.06% 0.00%	2.52% 5.05% 0.00%	0.00 0.00 0.00
		Solids	CO_2 CH_4 N_2O	5,420.07 15.79 22.42	2.45% 3.00% 0.00%	190.47% 200.00% 0.00%	190.48% 200.02% 0.00%	0.00 0.00 0.00
		Gas	CO_2 CH_4 N_2O	12,480.19 6.23 5.90	2.47% 3.00% 0.00%	192.01% 233.33% 0.00%	192.03% 233.35% 0.00%	0.01 0.00 –
1.A.3.a.	Domestic Aviation	Liquids	CO_2 CH_4 N_2O	1,202.61 0.24 8.91	5.00% 5.00% 5.00%	4.06% 233.33% 233.33%	6.44% 233.38% 233.38%	0.00 0.00 0.00

CRT category			Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
				(Gg CO_2 equivalent)	%	%	%	
1.A.3.b.	Road transportation	Liquids	CO_2	33,600.15	0.76%	3.69%	3.77%	0.00
			CH_4	311.43	0.95%	221.59%	221.59%	0.00
			N_2O	430.85	575.91%	172.54%	601.20%	0.00
		Gas	CO_2	222.99	1.00%	3.92%	4.05%	0.00
			CH_4	10.24	1.00%	200.00%	200.00%	0.00
			N_2O	3.16	1.00%	200.00%	200.00%	0.00
		Biomass (Biodiesel)	CH_4	0.00	0.95%	221.59%	221.59%	0.00
			N_2O	0.00	575.91%	172.54%	601.20%	0.00
1.A.3.c.	Railways	Liquids	CO_2	158.12	5.00%	0.94%	5.09%	0.00
			CH_4	0.25	5.00%	233.33%	233.39%	0.00
			N_2O	16.17	5.00%	233.33%	233.39%	0.00
1.A.3.d.	Domestic navigation	Liquids	CO_2	3,947.29	5.00%	0.94%	5.09%	0.00
			CH_4	10.44	5.00%	233.33%	233.39%	0.00
			N_2O	28.23	5.00%	233.33%	233.39%	0.00
1.A.3.e.	Other transportation	Liquids	CO_2	1,409.64	5.00%	5.34%	7.31%	0.00
			CH_4	18.80	5.00%	233.33%	233.39%	0.00
			N_2O	17.25	5.00%	233.33%	233.39%	0.00
1.A.4.a.	Commercial/ Institutional	Liquids	CO_2	2,156.27	3.49%	1.21%	3.70%	0.00
			CH_4	6.00	3.75%	173.55%	173.59%	0.00
			N_2O	2.32	4.13%	13.05%	13.69%	0.00
		Gas	CO_2	53.99	5.00%	3.92%	6.35%	0.00
			CH_4	0.13	5.00%	200.00%	200.06%	0.00
			N_2O	0.03	5.00%	3.92%	6.35%	0.00
1.A.4.b.	Residential	Liquids	CO_2	2,085.98	4.93%	3.90%	6.29%	0.00
			CH_4	4.89	4.87%	195.02%	195.08%	0.00
			N_2O	1.15	4.65%	186.29%	186.35%	0.00
		Gas	CO_2	11.74	5.00%	3.92%	6.35%	0.00
			CH_4	0.03	5.00%	200.00%	200.06%	0.00
			N_2O	0.01	5.00%	200.00%	200.06%	0.00
1.A.4.c.	Agriculture/ forestry/fishing	Liquids	CO_2	313.42	4.07%	1.92%	4.50%	0.00
			CH_4	1.19	4.03%	161.16%	161.21%	0.00
			N_2O	0.67	4.03%	188.02%	188.06%	0.00
1.A.5.	Other	Liquids	CO_2	240.69	3.64%	2.77%	4.58%	0.00
			CH_4	0.31	3.24%	129.47%	129.51%	0.00
			N_2O	2.08	3.45%	160.94%	160.98%	0.00
1.B.	**Fugitive emissions from fuels**							
1.B.1.	Solid fuels	Solids	CH_4	27.70	5.00%	200.00%	200.06%	0.00
1.B.2.	Oil and natural gas and other emissions from energy production	Liquids	CO_2	5,387.14	5.00%	3.00%	5.83%	0.00
			CH_4	19,053.67	5.00%	233.33%	233.39%	0.03
			N_2O	16.40	5.00%	233.33%	233.39%	0.00
		Gas	CO_2	58.49	5.00%	3.92%	6.35%	0.00
			CH_4	7,353.28	5.00%	200.00%	200.06%	0.00
			N_2O	0.15	0.00%	200.00%	200.00%	0.00

CRT category			Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
				(Gg CO_2 equivalent)	%	%	%	
2. Industrial processes and product Use								
2.A. Mineral industry	2.A.1.	Cement production	CO_2	7,615.98	2.00%	8.00%	8.25%	0.00
	2.A.2.	Lime production	CO_2	239.24	8.00%	2.00%	8.25%	0.00
	2.A.3.	Glass production	CO_2	28.34	5.00%	10.00%	11.18%	0.00
	2.A.4.d.	Limestone and dolomite	CO_2	178.68	3.00%	5.00%	5.83%	0.00
2.B. Chemical industry	2.B.1.	Ammonia production	CO_2	988.52	5.00%	6.00%	7.81%	0.00
	2.B.2.	Nitric acid production	N_2O	193.05	2.00%	40.00%	40.05%	0.00
	2.B.5.	Carbide production	CO_2	49.49	5.00%	10.00%	11.18%	0.00
	2.B.8.	Petrochemicals and carbon black production	CO_2 CH_4	2,633.90 227.20	5.00% 5.00%	30.00% 60.00%	30.41% 60.21%	0.00 0.00
2.C. Metal industry	2.C.1.	Iron and steel production	CO_2 CH4	1,367.98 37.77	10.00% 10.00%	25.00% 25.00%	26.93% 26.93%	0.00 0.00
	2.C.2.	Ferroalloys production	CO_2 CH_4	0.00 0.00	5.00% 5.00%	25.00% 25.00%	25.50% 25.50%	0.00 0.00
	2.C.3.	Aluminium production	CO_2 PFC	0.00 0.00	1.00% 1.00%	10.00% 10.00%	10.05% 10.05%	0.00 0.00
2.D. Non-energy products from fuels and solvent use	2.D.1.	Lubricant use	CO_2	0.00	3.00%	5.00%	5.83%	0.00
2.E. Electronics industry	2.E.1.	Integrated circuit or semiconductor	PFC, HFC, SF_6, NH_3	8.90	10.00%	10.00%	14.14%	0.00
	2.E.3.	Photovoltaics	PFC	0.00	10.00%	10.00%	14.14%	0.00
2.F. Product uses as substitutes for ODS	2.F.1.e.	Mobile air-conditioning	HFC134a	435.76	10.00%	10.00%	14.14%	0.00
2.G. Other product manufacture and use	2.G.1.	Electrical Equipment	SF_6	15.28	10.00%	10.00%	14.14%	0.00
	2.G.3.a.	N_2O in Medical Applications	N_2O	19.87	10.00%	1.00%	10.05%	0.00
3. AFOLU - Agriculture								
3.A. Enteric fermentation			CH_4	1,626.37	13.23%	97.47%	98.36%	0.00
3.B. Manure management			CH_4 N_2O	567.61 86.07	15.00% 15.00%	93.81% 141.42%	95.00% 142.21%	0.00 0.00
3.B.5 Indirect N_2O emissions			N_2O	406.01	16.58%	20.00%	25.98%	0.00
3.C. Rice cultivations			CH_4	2,372.38	10.00%	62.50%	63.29%	0.00

2. Industrial processes and product Use

CRT category		Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
			(Gg CO_2 equivalent)	%	%	%	
3.D. Agricultural soils	3.D.1 Direct N_2O Emissions from managed soils	N_2O	3,425.87	113.58%	112.85%	160.11%	0.00
	3.D.2. Indirect N_2O Emissions from managed soils	N_2O	1,054.48	90.88%	21.08%	93.29%	0.00
3.F. Field burning of agricultural residues		CH_4 N_2O	17.85 5.29	10.00% 10.00%	0.00% 0.00%	10.00% 10.00%	0.00 0.00
3. G. Liming		CO_2	0.00	50.00%	50.00%	70.71%	0.00
3.H. Urea application		CO_2	575.07	50.00%	50.00%	70.71%	0.00
5. WASTE							
5.A. Solid waste disposal		CH_4	6,817.93	51.96%	35.00%	62.65%	0.00
5.B. Biological treatment of solid waste		CH_4 N_2O	0.01 0.01	154.00% 154.00%	100.00% 150.00%	183.62% 214.98%	0.00 0.00
5.C. Incineration and open burning of waste	5.C.1. Waste incineration	CO_2 N_2O	29.61 1.54	10.00% 10.00%	70.00% 100.00%	70.71% 100.50%	0.00 0.00
	5.C.2. Open burning of waste	CO_2 CH_4 N_2O	2.36 0.77 0.22	54.77% 54.77% 54.77%	65.57% 112.69% 100.00%	85.44% 125.30% 114.02%	0.00 0.00 0.00
5.D. Wastewater treatment and discharge	5.D.1. Domestic wastewater	CH_4 N_2O	1,938.68 274.38	60.00% 15.48%	58.31% 50.00%	83.67% 52.34%	0.00 0.00
	5.D.2. Industrial wastewater	CH_4	15,460.61	8.72%	39.05%	48.48%	0.00
	Total		**254,167.73**				**0.05**
				Percentage uncertainty in total inventory			**21.59%**

Table SIAII.2 Uncertainty assessment with LULUCF for 2005

CRT category		Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
			(Gg CO_2 equivalent)	%	%	%	
1.A. Fuel combustion activities (sectoral approach)							
1.A.1. Energy industries							
1.A.1.a. Public electricity and heat production	Liquids	CO_2 CH_4 N_2O	1,820.67 2.02 3.83	0.97% 0.97% 0.97%	0.92% 226.15% 226.86%	1.33% 226.15% 226.86%	0.00 0.00 0.00
	Solids	CO_2 CH_4 N_2O	22,279.39 6.49 92.15	0.69% 0.69% 0.69%	13.86% 138.46% 161.79%	13.88% 138.47% 161.80%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	30,969.27 15.46 14.63	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
	Biomass & Biogas	CH_4 N_2O	19.52 24.64	1.00% 1.00%	200.00% 275.00%	200.00% 275.00%	0.00 0.00
1.A.1.b. Petroleum Refining	Liquids	CO_2 CH_4 N_2O	9,936.67 11.39 21.55	1.00% 1.00% 1.00%	3.00% 233.33% 233.33%	3.16% 233.34% 233.34%	0.00 0.00 0.00
1.A.1.c. Manufacture of solid fuels and other energy industries	Gas	CO_2 CH_4 N_2O	26,744.27 13.35 12.63	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
1.A.2. Manufacturing industries and construction	Liquids	CO_2 CH_4 N_2O	17,297.09 18.95 35.62	2.38% 3.00% 0.00%	0.82% 4.06% 0.00%	2.52% 5.05% 0.00%	0.00 0.00 0.00
	Solids	CO_2 CH_4 N_2O	5,420.07 15.79 22.42	2.45% 3.00% 0.00%	190.47% 200.00% 0.00%	190.48% 200.02% 0.00%	0.03 0.00 0.00
	Gas	CO_2 CH_4 N_2O	12,480.19 6.23 5.90	2.47% 3.00% 0.00%	192.01% 233.33% 0.00%	192.03% 233.35% 0.00%	0.14 0.00 0.00
1.A.3.a. Domestic Aviation	Liquids	CO_2 CH_4 N_2O	1,202.61 0.24 8.91	5.00% 5.00% 5.00%	4.06% 233.33% 233.33%	6.44% 233.38% 233.38%	0.00 0.00 0.00
1.A.3.b. Road transportation	Liquids	CO_2 CH_4 N_2O	33,600.15 311.43 430.85	0.76% 0.95% 575.91%	3.69% 221.59% 172.54%	3.77% 221.59% 601.20%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	222.99 10.24 3.16	1.00% 1.00% 1.00%	3.92% 200.00% 200.00%	4.05% 200.00% 200.00%	0.00 0.00 0.00
	Biomass (Biodiesel)	CH_4 N_2O	0.00 0.00	0.95% 575.91%	221.59% 172.54%	221.59% 601.20%	0.00 0.00
1.A.3.c. Railways	Liquids	CO_2 CH_4 N_2O	158.12 0.25 16.17	5.00% 5.00% 5.00%	0.94% 233.33% 233.33%	5.09% 233.39% 233.39%	0.00 0.00 0.00

CRT category		Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
			(Gg CO_2 equivalent)	%	%	%	
1.A.3.d. Domestic navigation	Liquids	CO_2 CH_4 N_2O	3,947.29 10.44 28.23	5.00% 5.00% 5.00%	0.94% 233.33% 233.33%	5.09% 233.39% 233.39%	0.00 0.00 0.00
1.A.3.e. Other transportation	Liquids	CO_2 CH_4 N_2O	1,409.64 18.80 17.25	5.00% 5.00% 5.00%	5.34% 233.33% 233.33%	7.31% 233.39% 233.39%	0.00 0.00 0.00
1.A.4.a. Commercial / Institutional	Liquids	CO_2 CH_4 N_2O	2,156.27 6.00 2.32	3.49% 3.75% 4.13%	1.21% 173.55% 13.05%	3.70% 173.59% 13.69%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	53.99 0.13 0.03	5.00% 5.00% 5.00%	3.92% 200.00% 3.92%	6.35% 200.06% 6.35%	0.00 0.00 0.00
1.A.4.b. Residential	Liquids	CO_2 CH_4 N_2O	2,085.98 4.89 1.15	4.93% 4.87% 4.65%	3.90% 195.02% 186.29%	6.29% 195.08% 186.35%	0.00 0.00 0.00
	Gas	CO_2 CH_4 N_2O	11.74 0.03 0.01	5.00% 5.00% 5.00%	3.92% 200.00% 200.00%	6.35% 200.06% 200.06%	0.00 0.00 0.00
1.A.4.c. Agriculture/ forestry/fishing	Liquids	CO_2 CH_4 N_2O	313.42 1.19 0.67	4.07% 4.03% 4.03%	1.92% 161.16% 188.02%	4.50% 161.21% 188.06%	0.00 0.00 0.00
1.A.5. Other	Liquids	CO_2 CH_4 N_2O	240.69 0.31 2.08	3.64% 3.24% 3.45%	2.77% 129.47% 160.94%	4.58% 129.51% 160.98%	0.00 0.00 0.00
1.B. Fugitive emissions from fuels							
1.B.1. Solid fuels	Solids	CH_4	27.70	5.00%	200.00%	200.06%	0.00
1.B.2. Oil and natural gas and other emissions from energy production	Liquids	CO_2 CH_4 N_2O	5,387.14 19,053.67 16.40	5.00% 5.00% 5.00%	3.00% 233.33% 233.33%	5.83% 233.39% 233.39%	0.00 8.27 0.00
	Gas	CO_2 CH_4 N_2O	58.49 7,353.28 0.15	5.00% 5.00% 0.00%	3.92% 200.00% 200.00%	6.35% 200.06% 200.00%	0.00 0.91 0.00
2. Industrial processes and product Use							
2.A. Mineral industry	2.A.1. Cement production	CO_2	7,615.98	2.00%	8.00%	8.25%	0.00
	2.A.2. Lime production	CO_2	239.24	8.00%	2.00%	8.25%	0.00
	2.A.3. Glass production	CO_2	28.34	5.00%	10.00%	11.18%	0.00
	2.A.4.d. Limestone and dolomite	CO_2	178.68	3.00%	5.00%	5.83%	0.00

CRT category				Gas	Base year (2005) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year *t*
					(Gg CO_2 equivalent)	%	%	%	
2.B.	Chemical industry	2.B.1.	Ammonia production	CO_2	988.52	5.00%	6.00%	7.81%	0.00
		2.B.2.	Nitric acid production	N_2O	193.05	2.00%	40.00%	40.05%	0.00
		2.B.5.	Carbide production	CO_2	49.49	5.00%	10.00%	11.18%	0.00
		2.B.8.	Petrochemicals and carbon black production	CO_2 CH_4	2,633.90 227.20	5.00% 5.00%	30.00% 60.00%	30.41% 60.21%	0.00 0.00
2.C.	Metal industry	2.C.1.	Iron and steel production	CO_2 CH_4	1,367.98 37.77	10.00% 10.00%	25.00% 25.00%	26.93% 26.93%	0.00
		2.C.2.	Ferroalloys production	CO_2 CH_4	0.00 0.00	5.00% 5.00%	25.00% 25.00%	25.50% 25.50%	0.00 0.00
		2.C.3.	Aluminium production	CO_2 PFC	0.00 0.00	1.00% 1.00%	10.00% 10.00%	10.05% 10.05%	0.00 0.00
2.D.	Non-energy products from fuels and solvent use	2.D.1.	Lubricant use	CO_2	0.00	3.00%	5.00%	5.83%	0.00
2.E.	Electronics industry	2.E.1.	Integrated circuit or semiconductor	PFC, HFC, SF_6, NH_3	8.90	10.00%	10.00%	14.14%	0.00
		2.E.3.	Photovoltaics	PFC	0.00	10.00%	10.00%	14.14%	0.00
2.F.	Product uses as substitutes for ODS	2.F.1.e.	Mobile air-conditioning	HFC134a	435.76	10.00%	10.00%	14.14%	0.00
2.G.	Other product manufacture and use	2.G.1.	Electrical Equipment	SF_6	15.28	10.00%	10.00%	14.14%	0.00 0.00
		2.G.3.a.	N_2O in Medical Applications	N_2O	19.87	10.00%	1.00%	10.05%	0.00
3.	**Agriculture**								
3.A.	Enteric Fermentation			CH_4	1,626.37	13.23%	97.47%	98.36%	0.00
3.B.	Manure Management			CH_4 N_2O	567.61 86.07	15.00% 15.00%	93.81% 141.42%	95.00% 142.21%	0.00 0.00
3.B.5	Indirect N_2O emissions			N_2O	406.01	16.58%	20.00%	25.98%	0.00
3.C.	Rice cultivations			CH_4	2,372.38	10.00%	62.50%	63.29%	0.00
3.D.	Agricultural soils	3.D.1	Direct N_2O Emissions from managed soils	N_2O	3,425.87	113.58%	112.85%	160.11%	0.01
		3.D.2.	Indirect N_2O Emissions from managed soils	N_2O	1,054.48	90.88%	21.08%	93.29%	0.00

CRT category				Gas	Base year (2005) emissions or removals (Gg CO_2 equivalent)	Activity data uncertainty %	Emission factor uncertainty/ estimation parameter uncertainty %	Combined uncertainty %	Contribution to variance by source/ sink category in year *t*
3.F.	Field burning of agricultural residues			CH_4 N_2O	17.85 5.29	10.00% 10.00%	0.00% 0.00%	10.00% 10.00%	0.00 0.00
3.G.	Liming			CO_2	0.00	50.00%	50.00%	70.71%	0.00
3.H.	Urea application			CO_2	575.07	50.00%	50.00%	70.71%	0.00
4.	**LULUCF**								
4.A.	Forest land			CO_2	(214,453.80)	32.00%	10.00%	33.53%	1.28
4.B.	Cropland			CO_2	(12,561.10)	20.00%	20.00%	28.28%	0.00
4.C.	Grassland			CO_2	105.08	25.00%	71.00%	75.27%	0.00
4.D.	Wetland			CO_2	0.45	71.00%	71.00%	100.41%	0.00
4.E.	Settlement			CO_2	34,335.00	22.50%	26.00%	34.38%	0.03
4.(II)	Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)			CH_4	33.65	32.00%	10.00%	33.53%	0.00
4.(I)	Direct and indirect N_2O emissions from N inputs to managed soils			N_2O	0.00	32.00%	10.00%	33.53%	0.00
4.(III)	Total for all land-use categories (Direct and indirect nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)			N_2O	1,809.16	32.00%	10.00%	33.53%	0.00
4(IV).	Total for all land-use categories (Biomass Burning)			CH_4	13.83	32.00%	10.00%	33.53%	0.00
5.	**Waste**								
5.A.	Solid waste disposal			CH_4	6,817.93	51.96%	35.00%	62.65%	0.00
5.B.	Biological treatment of solid waste			CH_4 N_2O	0.01 0.01	154.00% 154.00%	100.00% 150.00%	183.62% 214.98%	0.00 0.00
5.C.	Incineration and open burning of waste	5.C.1.	Waste incineration	CO_2 N_2O	29.61 1.54	10.00% 10.00%	70.00% 100.00%	70.71% 100.50%	0.00 0.00
		5.C.2.	Open burning of waste	CO_2 CH_4 N_2O	2.36 0.77 0.22	54.77% 54.77% 54.77%	65.57% 112.69% 100.00%	85.44% 125.30% 114.02%	0.00 0.00 0.00
5.D.	Wastewater treatment and discharge	5.D.1.	Domestic wastewater	CH_4 N_2O	1,938.68 274.38	60.00% 15.48%	58.31% 50.00%	83.67% 52.34%	0.00 0.00
		5.D.2.	Industrial wastewater	CH_4	15,460.61	28.72%	39.05%	48.48%	0.01
			Total		**63,449.99**				**10.70**
						Percentage uncertainty in total inventory			**327.16%**

Table SIAII.3 Uncertainty assessment without LULUCF for 2021

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.A. Fuel combustion activities (sectoral approach)													
1.A.1. Energy industries													
1.A.1.a. Public electricity and heat production	Liquids	CO_2	1,820.67	871.87	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00
		CH_4	2.02	0.99	0.01	2.26	2.26	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	3.83	1.87	0.01	2.27	2.27	0.00	0.00	0.00	0.00	0.00	0.00
	Solids	CO_2	22,279.39	86,604.62	0.01	0.14	0.14	0.00	0.23	0.34	0.03	0.00	0.00
		CH_4	6.49	25.22	0.01	1.38	1.38	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	92.15	357.99	0.01	1.62	1.62	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	30,969.27	26,105.47	0.01	0.04	0.04	0.00	0.05	0.10	0.00	0.00	0.00
		CH_4	15.46	13.03	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	14.63	12.33	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	Biomass & Biogas	CH_4	19.52	5.38	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	24.64	6.75	0.01	2.75	2.75	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b. Petroleum refining	Liquids	CO_2	9,936.67	8,087.34	0.01	0.03	0.03	0.00	0.02	0.03	0.00	0.00	0.00
		CH_4	11.39	9.27	0.01	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	21.55	17.54	0.01	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c. Manufacture of solid fuels and other energy industries	Gas	CO_2	26,744.27	27,173.81	0.01	0.04	0.04	0.00	0.03	0.11	0.00	0.00	0.00
		CH_4	13.35	13.56	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	12.63	12.84	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2. Manufacturing industries and construction	Liquids	CO_2	17,297.09	7,688.59	0.02	0.01	0.03	0.00	0.06	0.03	0.00	0.00	0.00
		CH_4	18.95	8.41	0.03	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	35.62	15.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Solids	CO_2	5,420.07	5,596.99	0.02	1.90	1.90	0.00	0.01	0.02	0.01	0.00	0.00
		CH_4	15.79	16.31	0.03	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	22.42	23.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	12,480.19	20,334.00	0.02	1.92	1.92	0.01	0.02	0.08	0.03	0.00	0.00
		CH_4	6.23	10.15	0.03	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	5.90	9.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.A.3.a. Domestic aviation	Liquids	CO_2	1,202.61	379.85	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.24	0.07	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	8.91	2.82	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b. Road transportation	Liquids	CO_2	33,600.15	43,091.87	0.01	0.04	0.04	0.00	0.00	0.17	0.00	0.00	0.00
		CH_4	311.43	394.66	0.01	2.22	2.22	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	430.85	553.25	5.76	1.73	6.01	0.00	0.00	0.00	0.00	0.02	0.00
	Gas	CO_2	222.99	82.15	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	10.24	3.77	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	3.16	1.16	0.01	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	Biomass (Biodiesel)	CH_4	0.00	2.91	0.01	2.22	2.22	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.00	5.50	5.76	1.73	6.01	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.c. Railways	Liquids	CO_2	158.12	26.94	0.05	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.25	0.04	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	16.17	2.76	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d. Domestic navigation	Liquids	CO_2	3,947.29	2,793.50	0.05	0.01	0.05	0.00	0.01	0.01	0.00	0.00	0.00
		CH_4	10.44	7.39	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	28.23	19.98	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e. Other Transportation	Liquids	CO_2	1,409.64	2,152.32	0.05	0.05	0.07	0.00	0.00	0.01	0.00	0.00	0.00
		CH_4	18.80	28.70	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	17.25	26.34	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.a. Commercial/ Institutional	Liquids	CO_2	2,156.27	1,305.41	0.03	0.01	0.04	0.00	0.01	0.01	0.00	0.00	0.00
		CH_4	6.00	3.77	0.04	1.74	1.74	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	2.32	1.52	0.04	0.13	0.14	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	53.99	25.82	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.13	0.06	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.03	0.01	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.b. Residential	Liquids	CO_2	2,085.98	2,622.73	0.05	0.04	0.06	0.00	0.00	0.01	0.00	0.00	0.00
		CH_4	4.89	5.83	0.05	1.95	1.95	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	1.15	1.12	0.05	1.86	1.86	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	11.74	2.35	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.03	0.01	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.01	0.00	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.c. Agriculture/ forestry/fishing	Liquids	CO_2	313.42	3,045.49	0.04	0.02	0.04	0.00	0.01	0.01	0.00	0.00	0.00
		CH_4	1.19	11.55	0.04	1.61	1.61	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.67	6.56	0.04	1.88	1.88	0.00	0.00	0.00	0.00	0.00	0.00
1.A.5. Other	Liquids	CO_2	240.69	285.98	0.04	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.31	0.55	0.03	1.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	2.08	2.35	0.03	1.61	1.61	0.00	0.00	0.00	0.00	0.00	0.00

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.B.	**Fugitive emissions from fuels**												
1.B.1. Solid fuels	Solids	CH_4	27.70	32.21	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2. Oil and natural gas and other emissions from energy production	Liquids	CO_2	5,387.14	3,503.46	0.05	0.03	0.06	0.00	0.01	0.01	0.00	0.00	0.00
		CH_4	19,053.67	7,177.56	0.05	2.33	2.33	0.00	0.07	0.03	0.16	0.00	0.03
		N_2O	16.40	10.67	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	58.49	343.36	0.05	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	7,353.28	8,678.63	0.05	2.00	2.00	0.00	0.00	0.03	0.01	0.00	0.00
		N_2O	0.15	1.01	0.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
2.	**Industrial processes and product Use**												
2.A. Mineral industry	2.A.1. Cement production	CO_2	7,615.98	5,479.64	0.02	0.08	0.08	0.00	0.02	0.02	0.00	0.00	0.00
	2.A.2. Lime production	CO_2	239.24	309.05	0.08	0.02	0.08	0.00	0.00	0.00	0.00	0.00	0.00
	2.A.3. Glass production	CO_2	28.34	320.77	0.05	0.10	0.11	0.00	0.00	0.00	0.00	0.00	0.00
	2.A.4.d. Limestone and dolomite	CO_2	178.68	648.44	0.03	0.05	0.06	0.00	0.00	0.00	0.00	0.00	0.00
2.B. Chemical industry	2.B.1. Ammonia production	CO_2	988.52	1,499.21	0.05	0.06	0.08	0.00	0.00	0.01	0.00	0.00	0.00
	2.B.2. Nitric acid production	N_2O	193.05	0.00	0.02	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.00
	2.B.5. Carbide production	CO_2	49.49	187.00	0.05	0.10	0.11	0.00	0.00	0.00	0.00	0.00	0.00
	2.B.8. Petrochemicals and carbon black production	CO_2	2,633.90	4,029.45	0.05	0.30	0.30	0.00	0.00	0.02	0.00	0.00	0.00
		CH_4	227.20	365.29	0.05	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.00

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
2.C. Metal industry	2.C.1. Iron and steel production	CO_2 CH_4	1,367.98 37.77	14,945.92 17.29	0.10 0.10	0.25 0.25	0.27 0.27	0.00 0.00	0.05 0.00	0.06 0.00	0.01 0.00	0.01 0.00	0.00 0.00
	2.C.2. Ferroalloys production	CO_2 CH_4	0.00 0.00	1,436.27 15.01	0.05 0.05	0.25 0.25	0.25 0.25	0.00 0.00	0.01 0.00	0.01 0.00	0.00 0.00	0.00 0.00	0.00 0.00
	2.C.3. Aluminium production	CO_2 PFC	0.00 0.00	1,405.86 2,720.33	0.01 0.01	0.10 0.10	0.10 0.10	0.00 0.00	0.01 0.01	0.01 0.01	0.00 0.00	0.00 0.00	0.00 0.00
2.D. Non-energy products from fuels and solvent use	2.D.1. Lubricant use	CO_2	0.00	2.08	0.01	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00
2.E. Electronics industry	2.E.1. Integrated circuit or semiconductor	PFC, HFC, SF_6, NH_3	8.90	1,725.92	0.10	0.10	0.14	0.00	0.01	0.01	0.00	0.00	0.00
	2.E.3. Photovoltaics	PFC	0.00	837.73	0.10	0.10	0.14	0.00	0.00	0.00	0.00	0.00	0.00
2.F. Product uses as substitutes for ODS	2.F.1.e. Mobile air-conditioning	HFC134a	435.76	928.04	0.10	0.10	0.14	0.00	0.00	0.00	0.00	0.00	0.00
2.G. Other product manufacture and use	2.G.1. Electrical Equipment	SF_6	15.28	127.35	0.10	0.10	0.14	0.00	0.00	0.00	0.00	0.00	0.00
	2.G.3.a. N_2O in Medical Applications	N_2O	19.87	27.70	0.10	0.01	0.10	0.00	0.00	0.00	0.00	0.00	0.00
3. AFOLU - Agriculture													
3.A. Enteric fermentation		CH_4	1,626.37	1,247.65	0.13	0.97	0.98	0.00	0.00	0.00	0.00	0.00	0.00
3.B. Manure management		CH_4 N_2O	567.61 86.07	260.70 27.14	0.15 0.15	0.94 1.41	0.95 1.42	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
3.B.5 Indirect N_2O emissions		N_2O	406.01	108.71	0.17	0.20	0.26	0.00	0.00	0.00	0.00	0.00	0.00
3.C. Rice cultivations		CH_4	2,372.38	2,499.50	0.10	0.63	0.63	0.00	0.00	0.01	0.00	0.00	0.00
3.D. Agricultural soils	3.D.1 Direct N_2O Emissions from managed soils	N_2O	3,425.87	2,201.35	1.14	1.13	1.60	0.00	0.01	0.01	0.01	0.01	0.00
	3.D.2. Indirect N_2O Emissions from managed soils	N_2O	1,054.48	542.71	0.91	0.21	0.93	0.00	0.00	0.00	0.00	0.00	0.00
3.F. Field burning of agricultural residues		CH_4 N_2O	17.85 5.29	8.54 2.10	0.10 0.10	0.00 0.00	0.10 0.10	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
3.G. Liming		CO_2	0.00	17.18	0.50	0.50	0.71	0.00	0.00	0.00	0.00	0.00	0.00
3.H. Urea application		CO_2	575.07	394.47	0.50	0.50	0.71	0.00	0.00	0.00	0.00	0.00	0.00
5. Waste													
5.A. Solid waste disposal		CH_4	6,817.93	6,847.50	0.52	0.35	0.63	0.00	0.01	0.03	0.00	0.02	0.00
5.B. Biological treatment of solid waste		CH_4 N_2O	0.01 0.01	0.20 0.11	1.54 1.54	1.00 1.50	1.84 2.15	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
5.C. Incineration and open burning of waste	5.C.1. Waste incineration	CO_2 N_2O	29.61 1.54	61.77 3.12	0.10 0.10	0.70 1.00	0.71 1.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
	5.C.2. Open burning of waste	CO_2 CH_4 N_2O	2.36 0.77 0.22	0.71 2.18 0.20	0.55 0.55 0.55	0.66 1.13 1.00	0.85 1.25 1.14	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00
5.D. Wastewater treatment and discharge	5.D.1. Domestic wastewater	CH_4 N_2O	1,938.68 274.38	1,914.39 389.85	0.60 0.15	0.58 0.50	0.84 0.52	0.00 0.00	0.00 0.00	0.01 0.00	0.00 0.00	0.01 0.00	0.00 0.00
	5.D.2. Industrial wastewater	CH_4	15,460.61	14,447.10	0.29	0.39	0.48	0.00	0.02	0.06	0.01	0.02	0.00
			254,167.73	**327,672.37**				**0.02**					**0.03**
				Percentage uncertainty in total inventory				**15.22%**		**Trend Uncertainty**			**17.20%**

Table SIAII.4 Uncertainty assessment with LULUCF for 2021

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.A. Fuel combustion activities (sectoral approach)													
1.A.1. Energy industries													
1.A.1.a. Public electricity and heat production	Liquids	CO_2	1,820.67	871.87	0.01	0.01	0.01	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	2.02	0.99	0.01	2.26	2.26	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	3.83	1.87	0.01	2.27	2.27	0.00	0.07	0.02	0.00	0.00	0.00
	Solids	CO_2	22,279.39	86,604.62	0.01	0.14	0.14	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	6.49	25.22	0.01	1.38	1.38	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	92.15	357.99	0.01	1.62	1.62	0.00	0.07	0.02	0.00	0.00	0.00
	Gas	CO_2	30,969.27	26,105.47	0.01	0.04	0.04	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	15.46	13.03	0.01	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	14.63	12.33	0.01	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
	Biomass & Biogas	CH_4	19.52	5.38	0.01	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	24.64	6.75	0.01	2.75	2.75	0.00	0.07	0.02	0.00	0.00	0.00
1.A.1.b. Petroleum refining	Liquids	CO_2	9,936.67	8,087.34	0.01	0.03	0.03	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	11.39	9.27	0.01	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	21.55	17.54	0.01	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
1.A.1.c. Manufacture of solid fuels and other energy industries	Gas	CO_2	26,744.27	27,173.81	0.01	0.04	0.04	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	13.35	13.56	0.01	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	12.63	12.84	0.01	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
1.A.2. Manufacturing industries and construction	Liquids	CO_2	17,297.09	7,688.59	0.02	0.01	0.03	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	18.95	8.41	0.03	0.04	0.05	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	35.62	15.75	0.00	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.00
	Solids	CO_2	5,420.07	5,596.99	0.02	1.90	1.90	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	15.79	16.31	0.03	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	22.42	23.15	0.00	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.00
	Gas	CO_2	12,480.19	20,334.00	0.02	1.92	1.92	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	6.23	10.15	0.03	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	5.90	9.61	0.00	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.00

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.A.3.a. Domestic aviation	Liquids	CO_2	1,202.61	379.85	0.05	0.04	0.06	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	0.24	0.07	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	8.91	2.82	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
1.A.3.b. Road transportation	Liquids	CO_2	33,600.15	43,091.87	0.01	0.04	0.04	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	311.43	394.66	0.01	2.22	2.22	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	430.85	553.25	5.76	1.73	6.01	0.00	0.07	0.02	0.00	0.02	0.00
	Gas	CO_2	222.99	82.15	0.01	0.04	0.04	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	10.24	3.77	0.01	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	3.16	1.16	0.01	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
	Biomass (Biodiesel)	CH_4	0.00	2.91	0.01	2.22	2.22	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	0.00	5.50	5.76	1.73	6.01	0.00	0.07	0.02	0.00	0.00	0.00
1.A.3.c. Railways	Liquids	CO_2	158.12	26.94	0.05	0.01	0.05	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	0.25	0.04	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	16.17	2.76	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
1.A.3.d. Domestic navigation	Liquids	CO_2	3,947.29	2,793.50	0.05	0.01	0.05	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	10.44	7.39	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	28.23	19.98	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
1.A.3.e. Other Transportation	Liquids	CO_2	1,409.64	2,152.32	0.05	0.05	0.07	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	18.80	28.70	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	17.25	26.34	0.05	2.33	2.33	0.00	0.07	0.02	0.00	0.00	0.00
1.A.4.a. Commercial/ Institutional	Liquids	CO_2	2,156.27	1,305.41	0.03	0.01	0.04	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	6.00	3.77	0.04	1.74	1.74	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	2.32	1.52	0.04	0.13	0.14	0.00	0.07	0.02	0.00	0.00	0.00
	Gas	CO_2	53.99	25.82	0.05	0.04	0.06	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	0.13	0.06	0.05	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	0.03	0.01	0.05	0.04	0.06	0.00	0.07	0.02	0.00	0.00	0.00
1.A.4.b. Residential	Liquids	CO_2	2,085.98	2,622.73	0.05	0.04	0.06	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	4.89	5.83	0.05	1.95	1.95	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	1.15	1.12	0.05	1.86	1.86	0.00	0.07	0.02	0.00	0.00	0.00
	Gas	CO_2	11.74	2.35	0.05	0.04	0.06	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	0.03	0.01	0.05	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	0.01	0.00	0.05	2.00	2.00	0.00	0.07	0.02	0.00	0.00	0.00
1.A.4.c. Agriculture/ forestry/fishing	Liquids	CO_2	313.42	3,045.49	0.04	0.02	0.04	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	1.19	11.55	0.04	1.61	1.61	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	0.67	6.56	0.04	1.88	1.88	0.00	0.07	0.02	0.00	0.00	0.00
1.A.5. Other	Liquids	CO_2	240.69	285.98	0.04	0.03	0.05	0.00	0.07	0.02	0.00	0.00	0.00
		CH_4	0.31	0.55	0.03	1.29	1.30	0.00	0.07	0.02	0.00	0.00	0.00
		N_2O	2.08	2.35	0.03	1.61	1.61	0.00	0.07	0.02	0.00	0.00	0.00

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
1.B. Fugitive emissions from fuels													
1.B.1. Solid fuels	Solids	CH_4	27.70	32.21	0.05	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2. Oil and natural gas and other emissions from energy production	Liquids	CO_2	5,387.14	3,503.46	0.05	0.03	0.06	0.00	0.10	0.06	0.00	0.00	0.00
		CH_4	19,053.67	7,177.56	0.05	2.33	2.33	0.02	0.43	0.11	1.01	0.01	1.01
		N_2O	16.40	10.67	0.05	2.33	2.33	0.00	0.00	0.00	0.00	0.00	0.00
	Gas	CO_2	58.49	343.36	0.05	0.04	0.06	0.00	0.00	0.01	0.00	0.00	0.00
		CH_4	7,353.28	8,678.63	0.05	2.00	2.00	0.02	0.07	0.14	0.15	0.01	0.02
		N_2O	0.15	1.01	0.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Industrial processes and product Use													
2.A. Mineral industry	2.A.1. Cement production	CO_2	7,615.98	5,479.64	0.02	0.08	0.08	0.00	0.13	0.09	0.01	0.00	0.00
	2.A.2. Lime production	CO_2	239.24	309.05	0.08	0.02	0.08	0.00	0.00	0.00	0.00	0.00	0.00
	2.A.3. Glass production	CO_2	28.34	320.77	0.05	0.10	0.11	0.00	0.00	0.01	0.00	0.00	0.00
	2.A.4.d. Limestone and dolomite	CO_2	178.68	648.44	0.03	0.05	0.06	0.00	0.01	0.01	0.00	0.00	0.00
2.B. Chemical industry	2.B.1. Ammonia production	CO_2	988.52	1,499.21	0.05	0.06	0.08	0.00	0.00	0.02	0.00	0.00	0.00
	2.B.2. Nitric acid production	N_2O	193.05	0.00	0.02	0.40	0.40	0.00	0.01	0.00	0.00	0.00	0.00
	2.B.5. Carbide production	CO_2	49.49	187.00	0.05	0.10	0.11	0.00	0.00	0.00	0.00	0.00	0.00
	2.B.8. Petrochemicals and carbon black production	CO_2	2,633.90	4,029.45	0.05	0.30	0.30	0.00	0.01	0.06	0.00	0.00	0.00
		CH_4	227.20	365.29	0.05	0.60	0.60	0.00	0.00	0.01	0.00	0.00	0.00

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
2.C. Metal industry	2.C.1. Iron and steel production	CO_2 CH_4	1,367.98 37.77	14,945.92 17.29	0.10 0.10	0.25 0.25	0.27 0.27	0.00 0.00	0.20 0.00	0.24 0.00	0.05 0.00	0.03 0.00	0.00 0.00
	2.C.2. Ferroalloys production	CO_2 CH_4	0.00 0.00	1,436.27 15.01	0.05 0.05	0.25 0.25	0.25 0.25	0.00 0.00	0.02 0.00	0.02 0.00	0.01 0.00	0.00 0.00	0.00 0.00
	2.C.3. Aluminium production	CO_2 PFC	0.00 0.00	1,405.86 2,720.33	0.01 0.01	0.10 0.10	0.10 0.10	0.00 0.00	0.02 0.04	0.02 0.04	0.00 0.00	0.00 0.00	0.00 0.00
2.D. Non-energy products from fuels and solvent use	2.D.1. Lubricant use	CO_2	0.00	2.08	0.01	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00
2.E. Electronics industry	2.E.1. Integrated circuit or semiconductor	PFC, HFC, SF_6, NH_3	8.90	1,725.92	0.10	0.10	0.14	0.00	0.03	0.03	0.00	0.00	0.00
	2.E.3. Photovoltaics	PFC	0.00	837.73	0.10	0.10	0.14	0.00	0.01	0.01	0.00	0.00	0.00
2.F. Product uses as substitutes for ODS	2.F.1.e. Mobile air-conditioning	HFC134a	435.76	928.04	0.10	0.10	0.14	0.00	0.00	0.01	0.00	0.00	0.00
2.G. Other product manufacture and use	2.G.1. Electrical Equipment	SF_6	15.28	127.35	0.10	0.10	0.14	0.00	0.00	0.00	0.00	0.00	0.00
	2.G.3.a. N_2O in Medical Applications	N_2O	19.87	27.70	0.10	0.01	0.10	0.00	0.00	0.00	0.00	0.00	0.00
3. AFOLU - Agriculture													
3.A. Enteric fermentation		CH_4	1,626.37	1,247.65	0.13	0.97	0.98	0.00	0.03	0.02	0.03	0.00	0.00
3.B. Manure management		CH_4 N_2O	567.61 86.07	260.70 27.14	0.15 0.15	0.94 1.41	0.95 1.42	0.00 0.00	0.01 0.00	0.00 0.00	0.01 0.00	0.00 0.00	0.00 0.00

CRT category		Gas	Base year (2005) emissions or removals	Year *t* (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
3.B.5 Indirect N_2O emissions		N_2O	406.01	108.71	0.17	0.20	0.26	0.00	0.01	0.00	0.00	0.00	0.00
3.C. Rice cultivations		CH_4	2,372.38	2,499.50	0.10	0.63	0.63	0.00	0.03	0.04	0.02	0.01	0.00
3.D. Agricultural soils	3.D.1 Direct N_2O Emissions from managed soils	N_2O	3,425.87	2,201.35	1.14	1.13	1.60	0.00	0.06	0.03	0.07	0.06	0.01
	3.D.2. Indirect N_2O Emissions from managed soils	N_2O	1,054.48	542.71	0.91	0.21	0.93	0.00	0.02	0.01	0.00	0.01	0.00
3.F. Field burning of agricultural residues		CH_4 N_2O	17.85 5.29	8.54 2.10	0.10 0.10	0.00 0.00	0.10 0.10	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
3.G. Liming		CO_2	0.00	17.18	0.50	0.50	0.71	0.00	0.00	0.00	0.00	0.00	0.00
3.H. Urea application		CO_2	575.07	394.47	0.50	0.50	0.71	0.00	0.01	0.01	0.01	0.00	0.00
4. LULUCF													
4.A. Forest land		CO_2	(214,453.80)	(248,823.48)	0.32	0.10	0.34	0.52	2.30	3.92	0.23	1.77	3.20
4.B. Cropland		CO_2	(12,561.10)	(278.04)	0.20	0.20	0.28	0.00	0.36	0.00	0.07	0.00	0.01
4.C. Grassland		CO_2	105.08	105.08	0.25	0.71	0.75	0.00	0.00	0.00	0.00	0.00	0.00
4.D. Wetland		CO_2	0.45	0.65	0.71	0.71	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E. Settlement		CO_2	34,335.00	34,795.51	0.23	0.26	0.34	0.01	0.43	0.55	0.11	0.17	0.04
4.(II) Total for all land use categories (Emissions and removals from drainage and rewetting and other management of organic and mineral soils)		CH_4	33.65	359.89	0.32	0.10	0.34	0.00	0.00	0.01	0.00	0.00	0.00
4.(I) Direct and indirect N_2O emissions from N inputs to managed soils		N_2O	0.00	0.00	0.32	0.10	0.34	0.00	0.00	0.00	0.00	0.00	v0.00

CRT category		Gas	Base year (2005) emissions or removals	Year t (2021) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
4.(III) Total for all land-use categories (Direct and indirect nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)		CH_4	1,809.16	1,552.64	0.32	0.10	0.34	0.00	0.03	0.02	0.00	0.01	0.00
4(IV). Total for all land-use categories (Biomass Burning)		N_2O	13.83	3.42	0.32	0.10	0.34	0.00	0.00	0.00	0.00	0.00	0.00
5. Waste													
5.A. Solid waste disposal		CH_4	6,817.93	6,847.50	0.52	0.35	0.63	0.00	0.09	0.11	0.03	0.08	0.01
5.B. Biological treatment of solid waste		CH_4	0.01	0.20	1.54	1.00	1.84	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.01	0.11	1.54	1.50	2.15	0.00	0.00	0.00	0.00	0.00	0.00
5.C. Incineration and open burning of waste	5.C.1. Waste incineration	CO_2	29.61	61.77	0.10	0.70	0.71	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	1.54	3.12	0.10	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	5.C.2. Open burning of waste	CO_2	2.36	0.71	0.55	0.66	0.85	0.00	0.00	0.00	0.00	0.00	0.00
		CH_4	0.77	2.18	0.55	1.13	1.25	0.00	0.00	0.00	0.00	0.00	0.00
		N_2O	0.22	0.20	0.55	1.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00
5.D. Wastewater treatment and discharge	5.D.1. Domestic wastewater	CH_4	1,938.68	1,914.39	0.60	0.58	0.84	0.00	0.03	0.03	0.01	0.03	0.00
		N_2O	274.38	389.85	0.15	0.50	0.52	0.00	0.00	0.01	0.00	0.00	0.00
	5.D.2. Industrial wastewater	CH_4	15,460.61	14,447.10	0.29	0.39	0.48	0.00	0.21	0.23	0.08	0.09	0.02
			63,449.99	**115,388.03**				**0.59**					**4.32**
			Percentage uncertainty in total inventory					**76.49%**	**Trend Uncertainty**				**207.96%**

SECTION I ANNEX III: DETAILED DESCRIPTION OF THE REFERENCE APPROACH

A detailed and comparison between Sectoral Approach (SA) and Reference Approach (RA) is provided in the sub-chapter 3.2.1 of the NID (Section I, Chapter 3: Energy, sub-chapter 3.2.1).

SECTION I ANNEX IV: QA/QC PLAN

Description of the QA/QC plan is elaborated in the sub-chapter 1.5 of the Chapter 1 of the NID

SECTION I ANNEX V: SUMMARY OF EMISSION FACTORS USED

The summary of the emission factors used is contained within the Common Reporting Table (CRT) of Malaysia's GHG inventory for 1990-2021 which is provided in the ETF Tools according to the requirement by UNFCCC.

SECTION I ANNEX VI: SUMMARY OF ASSUMPTIONS AND ACTIVITY DATA SOURCES

The summary of assumptions and activity data sources used is contained within the Common Reporting Table (CRT) of Malaysia's GHG inventory for 1990-2021 which is provided in the ETF Tools according to the requirement by UNFCCC.

The key categories that accumulate up to the 95% of total GHG emissions are written in bold.

II

SECTION

INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

1
CHAPTER

NATIONAL CIRCUMSTANCES AND INSTITUTIONAL ARRANGEMENTS

1.1 Introduction

In this section, we present the national circumstances for Chapter II and the coordinated effort being made to fulfil the commitments undertaken in the updated Nationally Determined Contribution of Malaysia. NRES, as the country's focal point to the UNFCCC, coordinates this effort together with each of the cross-cutting and sectoral stakeholders.

1.2 Geographical Profile

Malaysia is situated in Southeast Asia, between 0° 51' N and 7° 33' N, and 98° 01' E and 119° 30' E. It consists of 13 states and three Federal Territories, with a coastline stretching over 8,840 km and encompassing more than 879 islands. Covering an area of over 330,650 km², the country boasts a rich biodiversity and abundant natural resources. Its diverse topography, featuring coastal plains and inland mountains, is a testament to its natural wealth. The land is adorned with expansive rivers, mangrove swamps, and tropical rainforests. Eleven states and two Federal Territories (Kuala Lumpur and Putrajaya) are in Peninsular Malaysia, while the South China Sea separates the states of Sabah, Sarawak and the Federal Territory of Labuan in Borneo Island from Peninsular Malaysia Figure SIIC1.1.

Peninsular Malaysia, with its diverse landforms, is roughly 3,771.5 km long along the shore and covers a land area of roughly 132,078 km². Its maximum east-west breadth is around 315 km, and its north-south extension is approximately 746 km. The Titiwangsa Range, a central mountain-range that stretches 617 km from north to south with a maximum elevation of 2,183 m above sea level, plays a significant role in dividing the region into the east and west coasts. It also serves as the headwater of the Pahang River, the third-longest river in Malaysia and the longest in Peninsular Malaysia at 482 km.

Figure SIIC1.1 Map of Malaysia

The land area of Sabah, located on the north-eastern tip of Borneo Island, is roughly 73,621 km. Its coastline stretches for about 3,753 km. Sabah's geography is mountainous, particularly on its western flank, with varying lowland basins on its eastern side. The Crocker Range separates Sabah's heartland from its western coastal plains. The highest peak in Malaysia is Low's Peak, located on the Kinabalu plateau of the Crocker Range, at 4,095 meters above sea level. At 568 km, the Kinabatangan River is the second longest in Malaysia and the longest in Sabah.

Sarawak is located in the western and north-central regions of Borneo Island, with a land area of about 124,450 km^2. It has approximately 1,234 km of coastline. Its terrain consists of coastal lowlands, a narrow band of hills, and a steep rise into a mountainous area as it approaches the Indonesian border of Kalimantan. Mount Murud, at 2,422 meters, is the highest peak in Sarawak. The most extensive natural limestone cave system in the world is found in the Mulu Caves, located on Mount Mulu's second-highest peak at 2,377 meters. The Rajang River, spanning 780 km, is the longest river in Sarawak and Malaysia.

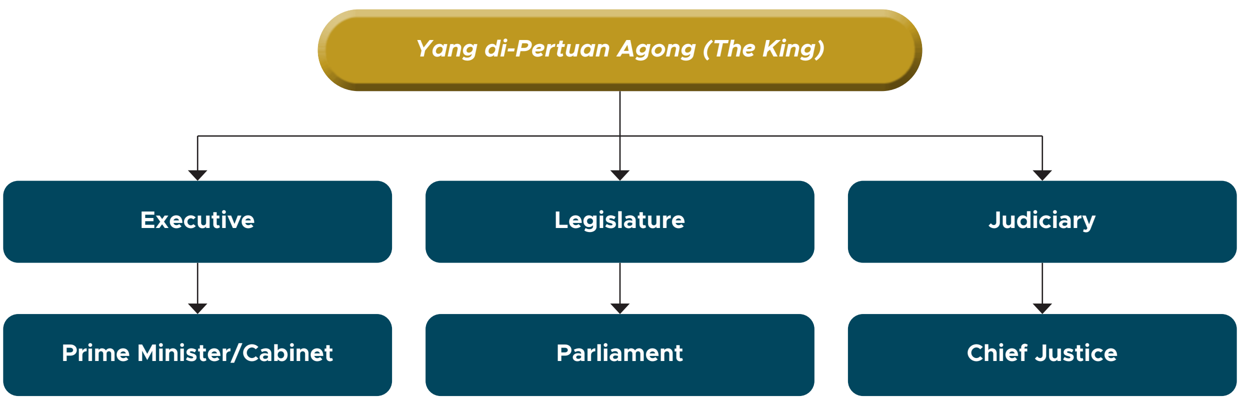
1.3 Constitutional Structure

Malaysia is a federation that practices Parliamentary Democracy with Constitutional Monarchy and His Majesty the King *(Yang di-Pertuan Agong)* as the Paramount Ruler. One of the characteristics of Parliament Democracy is the separation of powers into three parts: the Legislative, the Judiciary and the Executive. Parliament is the highest legislative body in Malaysia. It consists of His Majesty the King as the Head of State, the Senate and the House of Representatives. The Judiciary body is headed by the Chief Justice, and the Executive body is led by the Prime Minister. Malaysia constitutional arrangement is shown in Figure SIIC1.2.

1.3.1 Constitutional Monarchy

The *Yang di-Pertuan Agong* is also act as the chief of the hereditary rulers of the nine states and chair the Council of Malay Rulers. His Majesty the King act as the safeguard of the Malay customs and traditions and the Islamic religion in the Federation, and also the Head of the Islamic affairs for the states of Pulau Pinang, Melaka, Sabah, Sarawak and the Federal Territories.

Figure SIIC1.2 **Constitutional Arrangement of Malaysia**



1.3.2 Legislative Body

Malaysia's Parliament is consisting of the lower house, *Dewan Rakyat* (House of Representatives) and the upper house, *Dewan Negara* (Senate). All seventy (70) Senate members sit for three-year terms, to a maximum of two terms. Twenty-six of them are elected by the thirteen (13) state assemblies, and forty-four (44) are appointed by the *Yang di-Pertuan Agong* on the advice of the Prime Minister. The 222 members of the Dewan Rakyat are elected via the General Elections. Article 55 of the Federal Constitution stipulates that only His Majesty the King can summon for the Parliament to be in session. The *Yang di-Pertuan Agong* may dissolve parliament at any time and usually does so upon the advice of the Prime Minister.

1.3.3 Judiciary Body

The Malaysian judiciary is structured with the Chief Justice at its head. The judiciary system in Malaysia is largely centralised with the Federal Court as the supreme court and has the exclusive jurisdiction in constitutional matters and issues. The process of appointing judges involves multiple consultations and recommendations, primarily involving the Prime Minister, the Chief Justice, and the Yang di-Pertuan Agong.

1.3.4 Executive Body

While the *Yang di-Pertuan Agong* is as the Paramount Ruler, the executive power is vested in the Cabinet, which is led by the Prime Minister as the head of government. The Prime Minister is appointed by the Yang di-Pertuan Agong among the members of the Dewan Rakyat, who, in his opinion, is most likely to command the confidence of a majority of the Members of Parliament, though it is largely determined by the election outcomes. The Prime Minister appoints ministers to form the Cabinet, which is responsible for executing federal laws, developing policies, and managing government operations. The Cabinet members are chosen among the members of the Dewan Rakyat and Dewan Negara and are accountable to the Parliament, maintaining a balance of power and ensuring democratic governance.

1.4 Population Profile

Malaysia's population is a relatively dynamic and diverse mix of ethnic groups, languages, and religions. The total population of Malaysia in 2021 was 32.6 million. Malaysia's population has been growing quite steadily in the past 15 years. The population density of the country registered an increase from 79 persons per km^2 in 2005 to 99 persons per km^2 in 2021. Table SIIC1.1 provides a summary of Malaysia's population and population density since 2005.

Table SIIC1.1 **Population and Population Density**

Year	Population (million)	Population Density (km^2)
2005	26.0	79
2015	31.2	94
2016	31.6	96
2017	32.0	97
2018	32.4	98
2019	32.5	99
2020	32.4	98
2021	32.6	99

Source: Department of Statistics Malaysia

1.4.1 Urbanisation

Since the late 20th century, Malaysia has experienced rapid industrialisation and economic growth, leading to increased urban migration. The national urbanisation rate grew from 51.4% in 1990 to 75.3% in 2021. Table SIIC1.2 provides a summary of Malaysia's urbanisation rate by states.

Table SIIC1.2 Urbanisation Rate by States

State	Urbanisation Rate (%)											
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Johor	50.1	56.2	64.8	68.4	71.8	74.7	75.2	75.8	76.3	76.8	77.4	77.9
Kedah	32.9	35.6	39.1	51.4	64.7	66	68.3	66.5	66.8	67.1	67.3	67.6
Kelantan	33	33.5	33.5	37.8	42.3	43.2	43.4	43.5	43.7	43.9	44.1	44.3
Melaka	38.8	51	67.5	77.3	86.4	88.9	89.3	89.7	90.2	90.5	90.9	91.3
Negeri Sembilan	42.9	47.9	54.9	60.4	66.4	67.8	68.1	68.4	68.7	69	69.3	69.6
Pahang	31.5	35.5	42	46.2	50.4	51.6	51.8	52.1	52.3	52.5	52.8	53
Perak	53.9	56.1	59	64.3	69.7	70.9	71.1	71.3	71.6	71.8	72	72.2
Perlis	26.5	29.7	34	42.3	51.1	52.4	52.7	53	53.2	53.5	53.8	54.1
Pulau Pinang	75.2	77.3	79.7	85.2	90.9	91.7	91.9	92.1	92.2	92.4	92.5	92.7
Sabah	33.5	38.8	48.1	51.2	54.3	54.5	54.5	54.6	54.6	54.6	54.7	54.7
Sarawak	37.9	42.4	48.1	51	53.8	55.4	55.7	56.1	56.4	56.7	57	57.3
Selangor	75.9	82.1	87.7	89.7	91.3	94	94.4	94.8	95.2	95.5	95.8	96.1
Terengganu	44.1	46.3	49.4	54	59.1	61.7	62.2	62.7	63.2	63.7	64.2	64.7
Federal Territory of Kuala Lumpur	100	100	100	100	100	100	100	100	100	100	100	100
Federal Territory of Labuan		64.2	76.3	79.5	82.9	86.2	86.8	87.4	88	88.5	88.9	89.4
Federal Territory of Putrajaya					100	100	100	100	100	100	100	100
Malaysia	**51.4**	**56**	**62**	**66.5**	**71**	**73**	**73.4**	**73.7**	**74.1**	**74.5**	**75.1**	**75.3**

Source: Department of Statistics Malaysia

1.4.2 Age Distribution

In 2021, 23.6% of the population was under 15 years old, 69.4% were between the age of 15 and 64, and a smaller percentage of 7% were over 65 years old. Compared to year 2005, the percentage of young and aging population are in inverse relationship, which suggest smaller and older family units have become common. Table SIIC1.3 highlights the changing composition of ages within the Malaysian population.

Table SIIC1.3 **Population and Population Density**

Year	Less than 15 years (%)	15 to 64 years (%)	65 years and above (%)
2005	30.9	64.6	4.4
2015	24.9	69.2	5.9
2016	24.5	69.5	6.0
2017	24.1	69.6	6.3
2018	23.8	69.7	6.5
2019	23.5	69.8	6.7
2020	24.0	69.3	6.8
2021	23.6	69.4	7.0

Source: Department of Statistics Malaysia

Table SIIC1.4 **Summary of Average Life Expectancy at Birth**

Year	Female	Male	Overall
2005	76.0	71.4	73.6
2015	77.1	72.5	74.6
2016	77.0	72.1	74.4
2017	77.1	72.1	74.4
2018	77.2	72.3	74.6
2019	77.4	72.5	74.8
2020	77.2	72.5	74.7
2021	76.5	71.8	74.0

Source: Department of Statistics Malaysia

In 2021, 23.6% of the population was under 15 years old, 69.4% were between the age of 15 and 64, and a smaller percentage of 7% were over 65 years old. Compared to year 2005, the percentage of young and aging population are in inverse relationship, which suggest smaller and older family units have become common. Table SIIC1.3 highlights the changing composition of ages within the Malaysian population.

Table SIIC1.5 **Summary of Healthcare Facilities**

Year	2011		2015		2017		2019		2020		2021	
	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)
Primary Health Care Facilities – Ministry of Health												
Health Clinics [a]	985		1,061		1,085		1,114		1138		1057	
Rural Clinics	1,864		1,808		1,796		1,771		1752		1749	
Mobile Health Clinics (Teams)	184		203		217		230		229		229	
Flying Doctor Services	5 [b]	12 [c]	6 [b]	12 [c]	6 [b]	12 [c]	5 [b]	11 [c]	5 [b]	11 [c]	5 [b]	3 [c]
Standalone Dental Clinics	51	459 [d]	56	493 [d]	54	492 [d]	61	542 [d]	63	525 [d]	63	530 [d]
Dental Clinics in Health Clinics [e]			583	1,446 [d]	586	1,442 [d]	577	1,581 [d]	586	1,616 [d]	592	1617 [d]
Dental Clinics in Hospitals			66	353 [d]	69	407 [d]	74	481 [d]	75	409	75	412 [d]
Dental Clinics in Other Institutes			16	17 [d]	20	17 [d]	21	21 [d]	21	21	20	19 [d]
School Dental Clinics			925	843 [d]	923	832 [d]	930	810 [d]	920	694 [d]	911	656 [d]
Mobile Dental Clinics	27	27 [d]	28	44 [d]	35	53 [d]	34	56 [d]	34	53 [d]	34	53 [d]

Year	2011		2015		2017		2019		2020		2021	
	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)
Registered Private Entities												
Private Medical Clinics	6,589		7,146		7,571		7,988		8,222		8,419	
Private Dental Clinics	1,576		1,867		2,137		2,507		2,798		3,053	
Sub-total	**8,165**		**9,013**		**9,708**		**10,495**		**11,020**		**11,472**	
Secondary and Tertiary Services – Ministry of Health												
Hospitals	132	33,812	134	36,447	135	37,470	135	38,131	135	38,543	135	39,263
Special Medical Institutions	6	4,582	9	4,942	9	4,832	9	4,805	11	5,574	11	5,586
Sub-total	**138**	**38,394**	**143**	**41,389**	**144**	**42,302**	**144**	**42,936**	**146**	**44,117**	**146**	**44,849**
Non-Ministry of Health												
Hospitals	8	3,322	9	3,698	10	3,892	10	4,052	10	4,188	12	4,932
Licensed Private Facilities												
Hospitals	220	13,568	183	12,963	240	15,566	208	16,469	202	17,155	209	17,628
Maternity Homes	25	105	14	50			18	52	17	48	17	51
Nursing Homes	14	362	16	539			21	775	21	821	21	927
Hospice	4	38	3	22			3	29	3	39	9	33
Sub-total	**263**	**14,073**	**216**	**13,574**	**240**	**15,566**	**250**	**17,505**			**256**	**18,639**

Note:
[a] Health clinics include Maternal and Child Health Clinics
[b] Number of helicopters
[c] Number of teams of Air Land Force
[d] Number of dental chairs
[e] Includes dental clinics in Maternal and Child Health Clinics

Source: Health Facts 2012, 2016, 2018, 2020,2021, 2022, Ministry of Health

1.5 Climate Profile

Malaysia experiences an equatorial climate with consistent daily temperatures throughout the year. Malaysia's climate can be characterised by two monsoons which are separated by two shorter inter-monsoon periods. North-eastern winds are relatively strong during the boreal winter monsoon which usually occurs from November to March. The boreal summer monsoon occurs between May to September with south-westerly winds prevailing during this period. During inter-monsoonal periods, the occurrence of heavy rain and thunderstorms in the late afternoons and evenings are relatively common.

1.5.1 Annual Temperature Trends for Malaysia

The average daily temperature ranges from 26°C to 30°C. Over the past 50 years, there has been a noticeable increase in temperatures. The average surface temperature has risen by 0.2°C per decade. Additionally, the maximum surface temperature has increased by 0.3°C per decade, and the minimum temperature has risen by 0.1°C per decade.

Figure SIIC1.3, Figure SIIC1.4 and Figure SIIC1.5 illustrates the annual temperature trends while Figure SIIC1.6 and Figure SIIC1.7 demonstrates the highest daily maximum temperature and lowest daily minimum temperature in Peninsular Malaysia, Sabah and Sarawak respectively.

Figure SIIC1.3 **Annual Temperature Trend (Peninsular Malaysia)**

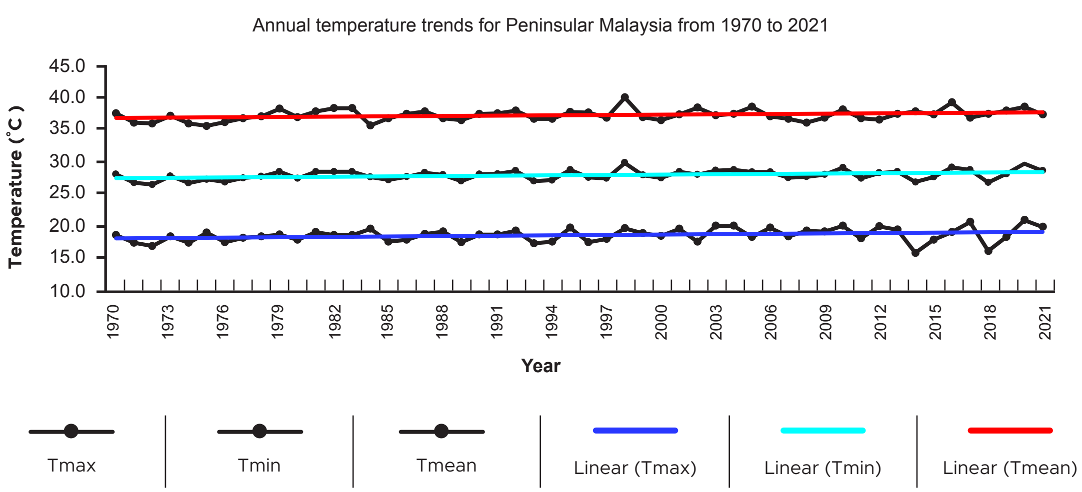
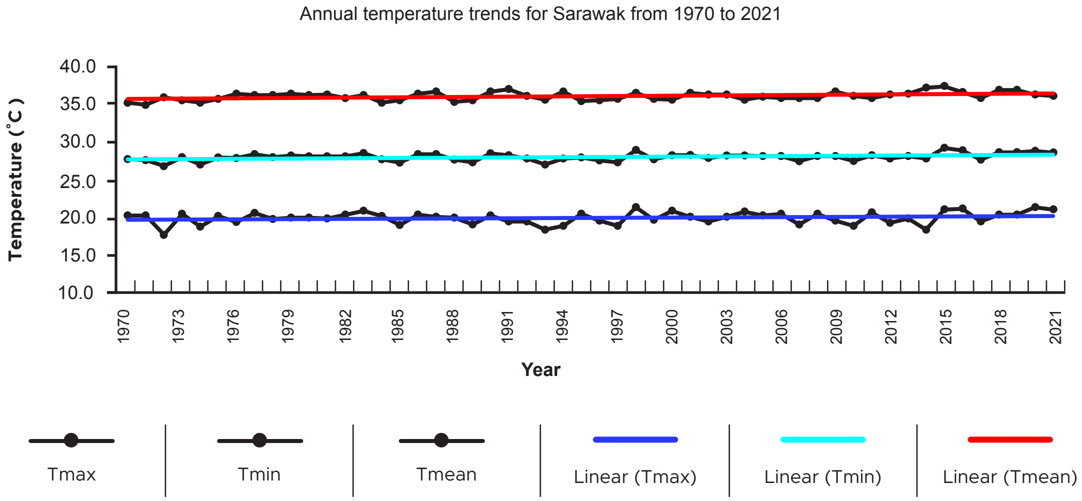
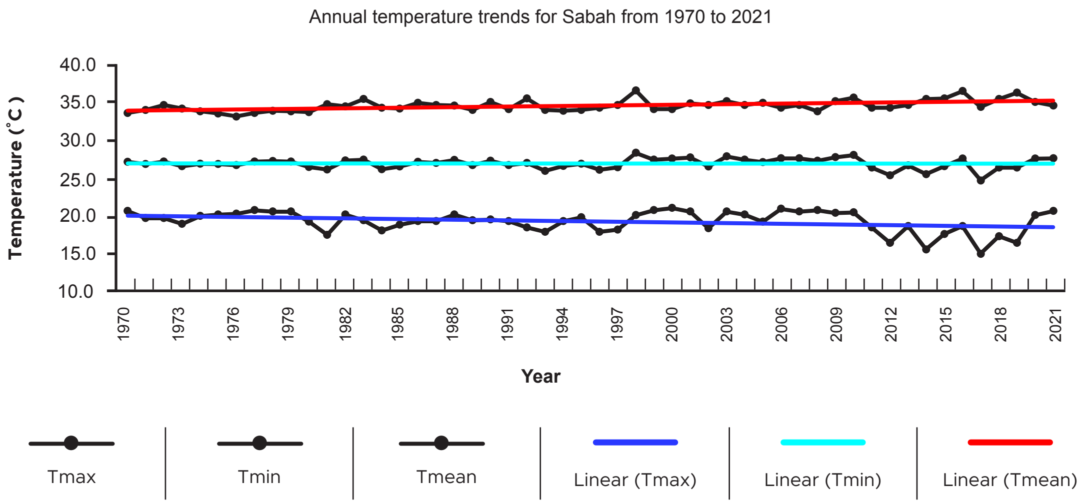


Figure SIIC1.4 **Annual Temperature Trend (Sarawak)**



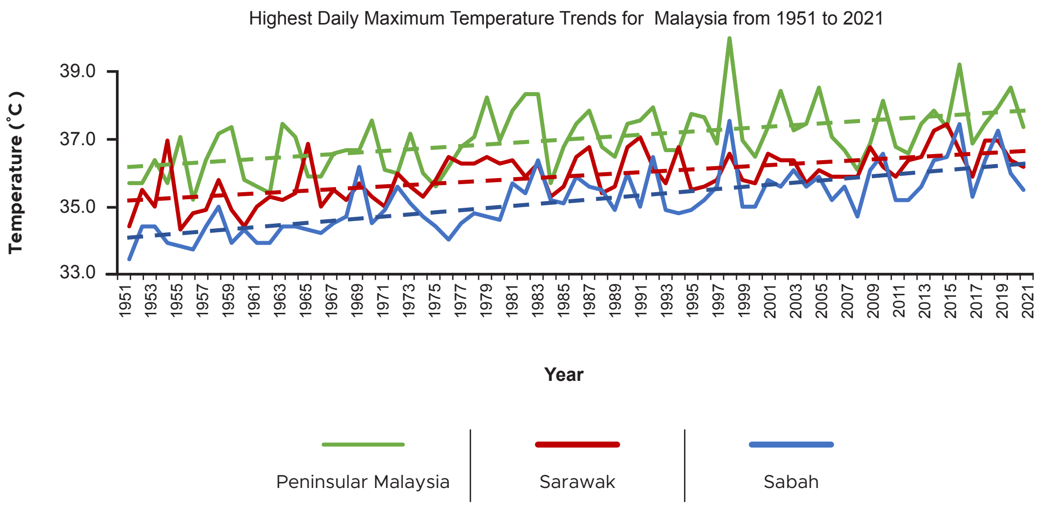
Source: Malaysian Meteorological Department

Figure SIIC1.5 **Annual Temperature Trend (Sabah)**



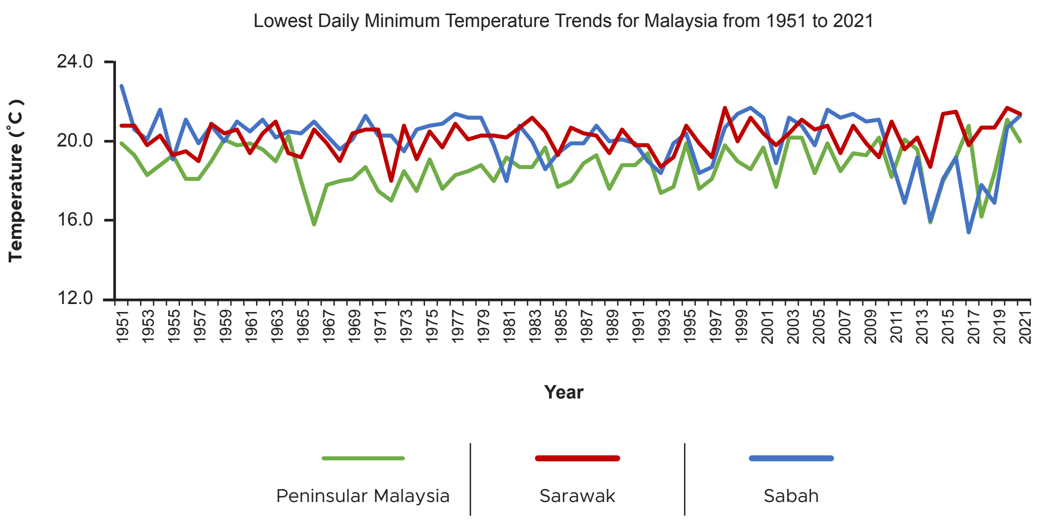
Source: Malaysian Meteorological Department

Figure SIIC1.6 **Annual Temperature Trend (Sarawak)**



Source: Malaysian Meteorological Department

Figure SIIC1.7 **Lowest Daily Minimum Temperature for Peninsular Malaysia, Sabah and Sarawak**



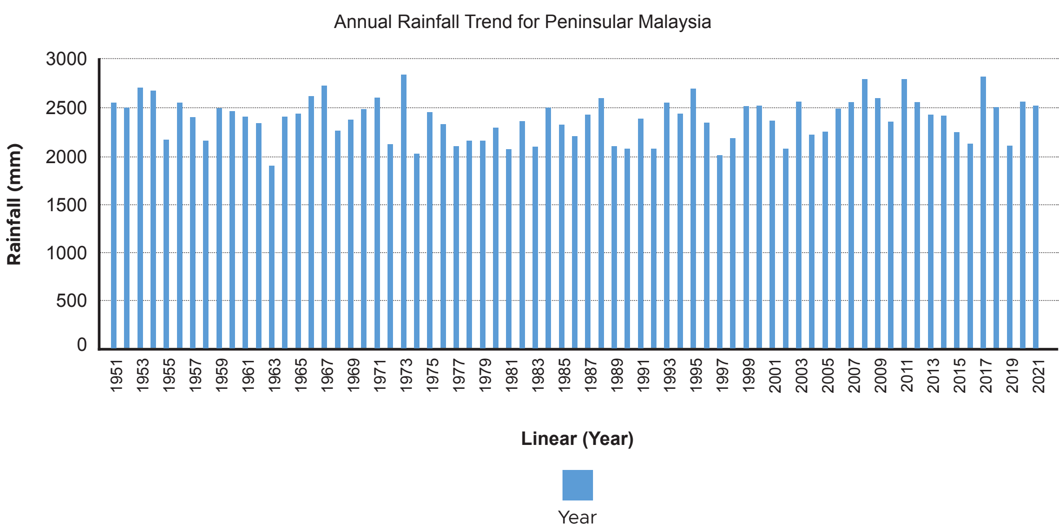
Source: Malaysian Meteorological Department

1.5.2 Annual Rainfall Distribution

The distribution of rainfall in Malaysia is influenced by the country's topography and monsoon winds. As a result, Malaysia experiences abundant rainfall, averaging around 2,400 mm to 3,700 mm annually. During the northeast monsoon, the east coast of Peninsular Malaysia, northeast of Sabah, and southern Sarawak sometimes experience spells of heavy rain lasting about three days, which can cause severe flooding. On the other hand, the southwest monsoon brings lower rainfall. During the inter-monsoon periods, heavy rain from convective showers and thunderstorms occurs in the late afternoons and evenings especially on the west coast of Peninsular Malaysia and interiors of Sabah and Sarawak. Figure SIIC1.8,

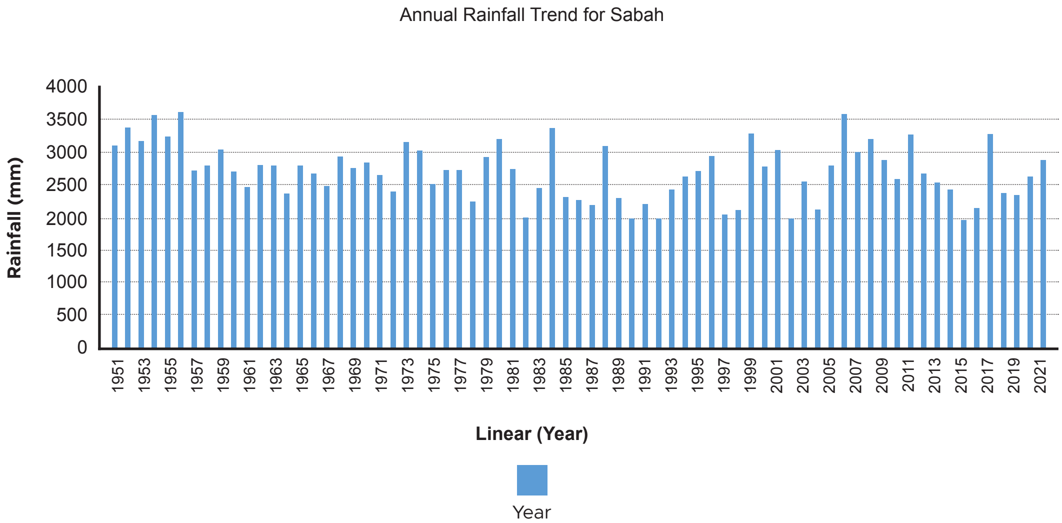
Figure SIIC1.9 and Figure SIIC1.10 displays the annual rainfall for Peninsular Malaysia, Sabah, and Sarawak from 1951 to 2021. Drier years are mainly due to strong El Niño and Indian Ocean Dipole events.

Figure SIIC1.8 **Annual Rainfall Trend in Peninsular Malaysia**



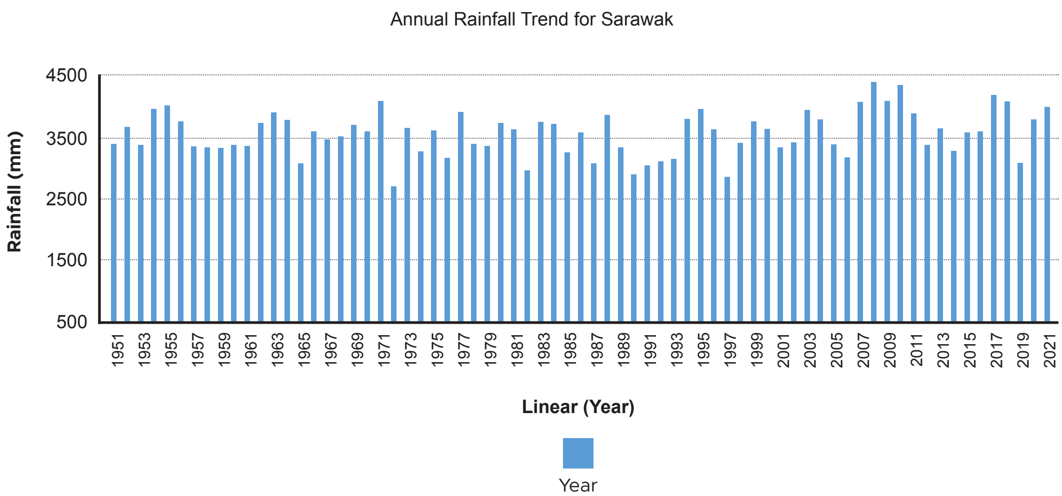
Source: Malaysian Meteorological Department

Figure SIIC1.9 **Annual Rainfall Trend in Sabah**



Source: Malaysian Meteorological Department

Figure SIIC1.8 **Annual Rainfall Trend in Sarawak**



Source: Malaysian Meteorological Department

1.6 Economic Profile

Malaysia is an emerging and developing upper middle-income country. As the fourth largest economy in Southeast Asia, Malaysia economy is diverse and rapidly growing, characterised by a mix of agriculture, manufacturing and services. Although Malaysia has been affected by the impacts of COVID-19 pandemic, Malaysia economy is steadily recovering as the manufacturing, services and exports began to rebound to pre-pandemic growth level.

1.6.1 Gross Domestic Product and Gross National Income

Malaysia ranks the 36th largest in the world in terms of nominal Gross Domestic Product (GDP) and 30th largest when measured by purchasing power parity. GDP and Gross National Income (GNI) of Malaysia have been increasing steadily through-out the years and is expected to grow at the rate of 4.5% annually. As of 2021, Malaysia GDP was RM1,390.88 billion and GNI per capita at RM42,056.00, both at constant 2015 price. Services sector is the largest contributor with over 50% of total GDP, followed by manufacturing sectors which account for about 25% of GDP. Table SIIC1.6 shows a summary of the GDP and GNI of Malaysia from 2005 to 2021.

Table SIIC1.6 GDP and GNI at Current and Constant Prices

Year	Gross Domestic Product (GDP)		Gross National Income (GNI)		GDP per capita	GNI per capita
	RM (billion)				RM	
	Current Prices	Constant Prices (2015 = 100)	Current Prices	Constant Prices (2015 = 100)	Constant Prices (2015 = 100)	Constant Prices (2015 = 100)
2005	543.578	543.518	519.635	519.576	20,868	19,948
2015	1,176.94	1,176.94	1,144.83	1,155.87	37,739	37,063
2016	1,249.70	1,229.31	1,215.11	1,211.30	38,861	38,292
2017	1,372.31	1,300.77	1,333.65	1,281.72	40,620	40,025
2018	1,447.76	1,363.77	1,402.68	1,335.06	42,115	41,228
2019	1,512.74	1,423.95	1,473.24	1,402.10	43,783	43,111
2020	1,418.50	1,346.25	1,389.97	1,332.47	41,490	41,065
2021	1,548.70	1,390.88	1,506.55	1,370.02	42,696	42,056

Source: Department of Statistics Malaysia

1.6.2 International Trade

Trade is a crucial component of Malaysia's economy, as the country practices an open trade policy. In 2021, Malaysia recorded a trade surplus of RM253 billion, with exports totalling to RM1.241 trillion and imports amounting to RM987 billion. Table SIIC1.7 summarises the breakdown of Malaysia's annual trade for certain selected years.

Table SIIC1.7 **Summary of Malaysia's Annual Trade**

Year	Annual Trade (million)			
	Gross Exports	Gross Imports	Total Trade	Balance of Trade
2005	536,234	432,871	969,104	103,363
2015	777,355	685,778	1,463,134	91,577
2016	786,964	698,819	1,485,783	88,145
2017	934,927	836,422	1,771,349	98,505
2018	1,003,587	879,804	1,883,391	123,783
2019	995,072	849,411	1,884,483	145,661
2020	983,826	800,481	1,784,308	183,345
2021	1,241,022	987,344	2,228,366	253,678

Source: Ministry of Economy

In 2021, manufactured goods formed the backbone of Malaysia's export economy, with electrical and electronic products accounted for 36.7% of the total export share. Goods from primary industries made up 14.8% of exports, consisting mainly of petroleum products (7.8%), palm oil and palm oil-based agricultural products (6.1%) and liquefied natural gas (3.1%). In terms of imports, intermediate goods comprised 55.2%, followed by capital goods at 10.5% and consumption goods at 13.2%.

1.6.3 Unemployment

The unemployment rate in Malaysia ranged from 3.5% in 2005 to 3.3% in 2019. However, in 2020 and 2021, Malaysia was placed under a state of emergency due to COVID-19 pandemic, which permitted only essential economic sectors to operate. The Movement Control Order (MCO), in effect from 2020 to 2021, significantly impacted the economy and led to spikes in the unemployment rate, which reached 4.5% in 2020 and 4.6% in 2021.

Table SIIC1.8 **Unemployment Rate**

Year	Unemployment Rate (%)
2005	3.5
2015	3.1
2016	3.4
2017	3.4
2018	3.3
2019	3.3
2020	4.5
2021	4.6

Source: Department of Statistics Malaysia

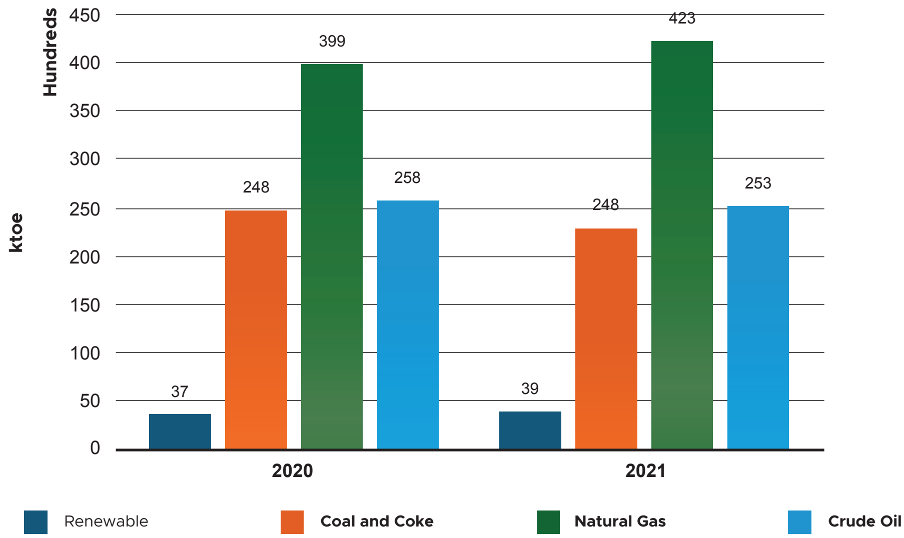
1.7 Energy

The energy sector is anticipated to strengthen access to affordable, reliable and sustainable energy, in line with Sustainable Development Goal 7 of the 2030 Agenda for Sustainable Development. The National Energy Policy 2022-2040 which was introduced in September 2022 underscores the commitment towards energy transformation with a focus to shift from fossil-based systems of production and consumption to RE. The policy aligns the energy sector to the country's long-term plan of Shared Prosperity Vision 2030 and its five Key Economic Growth Activities which are directly related to the energy sector (such as sustainable mobility, renewable energy and green economy). The policy aims to spur new energy-related sectors which will also support the goal of reducing dependence on petroleum-based revenue and commodity trade, enhancing the resilience of the country's fiscal and economic position in the process. The policy also sets the directive towards Low Carbon Nation Aspiration 2040 from the improvement of primary energy mix intensity through increased penetration of clean and renewable sources of energy. This is in line with the Government's target to reach 31% of RE installed capacity mix by 2030.

1.7.1 Energy Balance

Figure SIIC1.11 shows a summary of Malaysia primary energy supply in 2020 and 2021 and Table SIIC1.9 shows the breakdown in selected years from 2005 to 2021.

Figure SIIC1.11 Primary Energy Supply Breakdown from 2020 and 2021



Source: National Energy Balance, 2021, Energy Commission

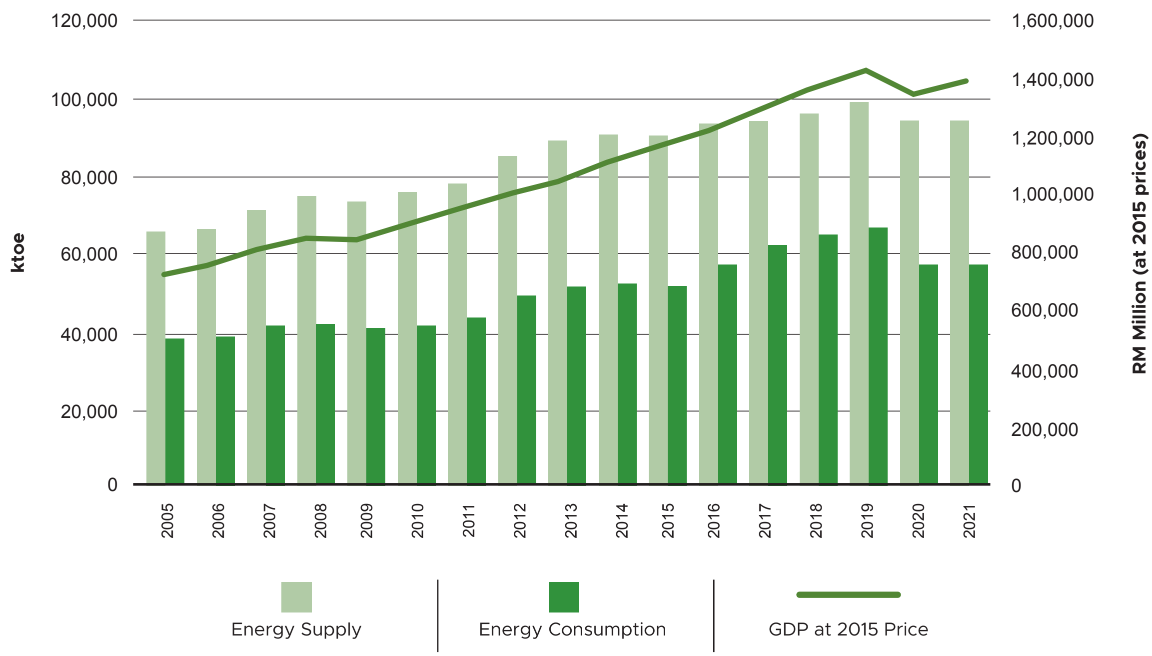
Table SIIC1.9 Primary Energy Supply Breakdown in Selected Years

Year	Primary Energy Supply Breakdown (ktoe)				
	Natural Gas	Crude Oil and Petroleum Products	Coal and Coke	Renewable Energy	Total
2005	33,913	24,096	6,889	446	65,344
2015	41,853	29,165	17,406	2,017	90,441
2016	41,257	31,327	18,744	2,420	93,748
2017	41,200	29,380	20,771	2,994	94,345
2018	40,939	29,429	22,280	3,261	95,909
2019	41,461	32,813	21,057	3,349	98,680
2020	39,939	25,773	24,788	3,693	94,193
2021	42,296	25,251	22,917	3,937	94,401

Source: National Energy Balance 2021

Malaysia's final energy consumption according to sectors is shown in Table SIIC1.10 while the trends in GDP, primary energy supply and final energy consumption are shown in Figure SIIC1.12.

Figure SIIC1.12 **Trends in GDP, Primary Energy Supply and Final Energy Consumption**



Sources: National Energy Balance 2019,
Energy Commission and Economic Planning Unit,
Prime Minister's Department

Table SIIC1.10 **Primary Energy Supply Breakdown in Selected Years**

Year	Final Energy Consumption (ktoe)					
	Transport	Industry	Residential and Commercial	Non-energy use	Agriculture	Total
2005	15,293	15,583	5,134	2,173	101	38,284
2015	23,435	13,971	7,600	5,928	895	51,829
2016	24,004	16,019	8,051	8,729	415	57,218
2017	24,039	17,463	7,796	12,517	674	62,489
2018	23,555	19,046	7,773	13,262	1,021	64,657
2019	25,004	18,921	8,000	13,631	927	66,483
2020	18,660	17,714	8,123	11,805	867	57,169
2021	18,095	19,517	8,084	10,869	1,045	57,610

Note: Transport sector final energy use included international civil aviation fuel.
Source: National Energy Balance 2021

1.7.2 Renewable Energy (RE)

In line with the aim to increase RE share in power generation mix, the Feed-in Tariff (FiT) system has been introduced under National Renewable Energy Act to encourage the generation of electricity from renewable sources by providing fixed payments to the producers. Table SIIC1.11 shows the cumulative installed capacities of grid connected RE projects under FiT programme and Table SIIC1.12 shows the annual amount of power generated by FiT commissioned RE installations.

Table SIIC1.11 Cumulative Installed Capacities of Grid-connected FiT Renewable Energy Projects

Year	Capacity (MW)				
	Biogas	Biomass	Small Hydro	Solar PV	Total
2015	20.23	76.70	18.30	263.87	379.10
2016	35.69	87.90	30.30	341.69	495.58
2017	61.79	95.55	30.30	378.41	566.05
2018	69.94	70.65	50.30	384.62	575.51
2019	102.76	70.65	70.30	386.93	630.64
2020	110.59	70.65	70.3	322.55	574.09
2021	124.30	70.65	87.80	322.52	605.27

Source: SEDA Annual Report 2021

Table SIIC1.12 Annual Power Generation of Commissioned FiT Renewable Energy Installations

Year	Power Generated (GWh)				
	Biogas	Biomass	Small Hydro	Solar PV	Total
2015	63.34	246.73	56.66	277.50	644.23
2016	107.11	248.48	50.28	359.54	765.41
2017	216.33	247.21	75.55	424.16	963.25
2018	251.78	226.09	89.67	467.89	1,035.43
2019	314.29	225.22	220.60	471.90	1,232.01
2020	384.91	149.32	257.27	420.43	1,211.93
2021	454.87	160.39	289.03	449.9	1,354.19

Source: SEDA Annual Report 2021

1.7.3 Transport

The Land Public Transport Agency (APAD) is tasked with 'spearheading the transformation of an integrated, efficient and safe transportation system'. A National Transport Policy (2019-2030) was launched to increase the public transport modal share (40% by 2030) in urban areas while also to implement sustainable measures across all transport modes.

1.7.3.1 Roads

The length of the roads has increased substantially from 90,016km in 2005 to 306,900km in 2021. This is primarily due to the extensive expansion of state roads in the past decades leading to greater intra-state and inter-state accessibility. Table SIIC1.13 highlights the historical change in lengths of road.

Table SIIC1.13 **Length of Roads**

Year	Length of Roads (km)			
	State Roads	Federal Roads	Toll Highways	Balance of Trade
2005	70,749	17,764	1,503	90,016
2015	197,015	19,822	1,984	218,821
2016	218,988	19,802	1,988	240,778
2017	217,072	19,950	2,001	239,023
2018	227,646	19,809	1,960	249,415
2019	236,581	19,912	2,018	258,511
2020	247,028	20,018	2,016	269,062
2021	284,845	20,039	2,016	306,900

Source: Ministry of Works

1.7.3.2 Motor-vehicle

Numbers of registered vehicle has increased by 19% from 2015 to 2021. Total vehicle registered in 2021 was 32,456,297 compared to 26,301,952 in 2015. Table SIIC1.14 shows the number of registered motor-vehicle on a yearly basis.

Table SIIC1.14 **Registered Motor-vehicle**

Year	Motorcars	Motorcycles	Public Transport	Commercial Vehicles	Others Vehicle[38]	Total
2015	12,094,790	11,871,696	239,033	1,197,987	898,446	26,301,952
2016	13,000,358	12,677,220	183,989	1,190,664	561,028	27,613,259
2017	13,582,636	13,173,069	183,231	1,223,396	575,844	28,738,176
2018	14,189,693	13,725,918	186,621	1,262,064	592,229	29,956,474
2019	13,339,173	14,096,847	181,685	1,295,248	717,702	31,214,756
2020	14,891,585	15,240,536	184,474	1,325,680	735,899	32,378,174
2021	15,216,589	14,986,834	174,059	1,347,466	731,349	32,456,297

Source: Department of Statistic Malaysia

1.7.3.3 Urban Rail Transit

The rail network is crucial to the Malaysia's transport system as it enables greater domestic mobility. By the end of 2021, there were five urban rail network lines serving the Greater Kuala Lumpur namely KTM Komuter, LRT Ampang Line, LRT Kelana Jaya Line, KL Monorail and the Mass Rapid Transit (MRT). The total ridership of rail transit and commuter trains is shown in Table SIIC1.15. The KTM Komuter service was first introduced in 1995 and was intended to serve interstate and within Greater Kuala Lumpur's radial corridors. Both the LRT Ampang Line (27 km) and the LRT Kelana Jaya Line (29 km) commenced operations in the city on 16 December 1996 and on 1 September 1998 respectively. The 8.6 km KL Monorail was built over an elevated track and commenced operations on 31 August 2003. In 2002, the KLIA Ekspres and the KLIA Transit were launched. The KLIA Ekspres is a

[38] Includes vehicles such as caravans, government & private fire vehicles, driving school vehicles, hearse, vehicle for disabled, government vehicles, local authority vehicles, ambulance and embassy vehicles

high-speed, non-stop rail connection between KLIA, KLIA2 and the KL Sentral, providing a mass rail transportation option in support of the civil aviation industry. On the other hand, the KLIA Transit is a commuter service that stops at three intermediate stations. To accommodate the highly populated areas, both LRT lines – Ampang and Kelana Jaya – were extended to 45 km in total length for LRT Ampang and 46 km for LRT Kelana Jaya. The extended length went into operation on 30 June 2016. The first MRT line – the 46 km Kajang Line – commenced service in July 2017. Phase One of the 57.7 km second line (Putrajaya Line) began operation on 16 June 2022. Phase Two of the Putrajaya Line is due for completion in the first quarter of 2023.

Table SIIC1.15 **Total Ridership of Rail Transit and Commuter Trains**

	2005	2015	2016	2017	2018	2019	2020	2021
LRT Kelana Jaya Line	60,290,467	82,144,674	79,002,839	83,585,412	87,216,597	94,657,974	45,307,182	25,105,755
LRT Ampang Line	45,636,997	62,809,412	59,192,907	59,462,032	60,960,445	65,147,222	34,715,565	21,916,858
KL Monorail	16,206,441	25,067,866	21,990,242	16,841,630	12,594,377	12,535,738	7,143,534	4,226,204
KTM-Commuter	30,934,651	49,690,000	41,407,104	37,235,410	32,036,271	30,327,420	11,77,022	5,897,764
ERL KLIA Express*	2,075,105	3,470,710	2,419,883	2,275,650	2,195,353	2,155,855	564,585	1,442,393
ERL KLIA Transit	2,331,741	6,496,617	6,485,272	6,443,667	6,541,505	6,788,121	3,384,996	5,143,217
MRT	N.A.	N.A.	N.A.	22,350,508	51,314,240	63,952,805	33,168,335	19,424,705

Source: Ministry of Transport and Public Land Transport Agency

1.7.3.4 Air Traffic Statistics

Between 2020 and 2021, there has been a general decrease of air traffic passengers for both domestic and international air travel due to the MCO by the government. The total number of domestic embarked and disembarked passengers decreased from 17.2 million in 2020 to 9.7 million in 2021. The number of international embarked and disembarked international passengers decrease from 9.55 million to 1.3 million for the same period. Table SIIC1.16 summarises the trend in air travel between 2005 and 2020.

Table SIIC1.16 Yearly Total Number of Domestic and International Passengers Handled by Airports

Year	Domestic			International		
	Embarked	Disembarked	Total	Embarked	Disembarked	Total
2005	10,456,749	11,954,473	22,411,222	8,267,880	8,298,555	16,566,435
2015	22,975,852	22,955,192	45,931,044	20,177,309	19,839,826	40,017,135
2016	13,995,425	23,970,410	37,965,835	22,026,087	21,464,612	43,490,699
2017	24,878,045	24,861,535	49,739,580	25,196,175	24,588,035	49,784,210
2018	25,080,393	25,105,859	50,186,252	26,371,319	25,875,483	52,246,802
2019	27,730,091	27,792,327	55,522,418	27,358,552	26,482,106	53,840,658
2020	8,613,048	8,626,365	17,239,413	4,940,440	4,606,072	9,546,512
2021	4,863,564	4,859,660	9,723,224	884,818	410,896	1,295,714

Sources: Ministry of Transport and Malaysia Airports Holdings Berhad

Between 2005 and 2021, domestic cargo handled has increased from 119,685 tonnes to 271,040 tonnes while international cargo handled has reduced from 775,313 tonnes to 737,034 tonnes. Table SIIC1.17 reflects the trends.

Table SIIC1.17 Yearly Total Domestic and International Cargo Handled by Airports

Year	Domestic (tonnes)			International (tonnes)		
	Loaded	Unloaded	Total	Loaded	Unloaded	Total
2005	61,705	57,979	119,685	421,790	353,523	775,313
2015	99,674	92,876	192,550	373,795	392,698	766,493
2016	95,968	92,981	188,949	331,350	353,134	684,485
2017	97,945	91,346	189,291	367,061	391,839	758,900
2018	104,624	92,741	197,365	361,090	407,345	768,435
2019	99,702	89,698	189,400	347,667	405,559	753,226
2020	91,473	101,065	192,537	314,278	282,322	596,601
2021	133,561	137,480	271,040	375,962	361,071	737,034

Sources: Ministry of Transport and Malaysia Airports Holdings Berhad

1.8 Industrial Processes and Product Use (IPPU)

1.8.1 Growth in Manufacturing

Between 2020 and 2021, growth in manufacturing production was observed despite Malaysia was still experiencing and recovering from the COVID-19 pandemic. In year 2020, annual change for growth manufacturing was -2.7% but in year 2021, the growth increased up to the 9.5% which was higher than the growth in year 2019. Table SIIC1.18 summarises the growth trend in the manufacturing production.

Table SIIC1.18 Growth in Manufacturing Production

Cluster	2019	2020	2021
	Annual Growth Change (%)		
Electrical and electronics products cluster	3.2	2.2	14.7
Primary-related cluster	2.7	-2.0	11.9
Construction-related cluster	4.2	-12.4	3.7
Consumer-related cluster	5.8	-4.0	2.0
Total	**3.6**	**-2.7**	**9.5**

Source: Department of Statistics Malaysia and Bank Negara Malaysia

1.9 Agriculture

In 2011, policies on food production and agro commodities were separated and developed under two distinct policy documents, namely the National Agrofood Policy 2.0 (2021-2030) and the National Agricommodity Policy (2021-2030). Sustainable development is a key principle in both policies besides strengthening the food security and socio-economic development.

1.9.1 Agricultural Crops

Paddy is also an important agricultural crop, and the planted areas involve double cropping. Table SIIC1.19 reflects the planted areas of major agricultural crops in selected years between 2005 and 2021.

Table SIIC1.19 **Planted Areas of Major Agricultural Crops**

Year	Crops (thousand ha)			
	Rubber	Oil Palm	Cocoa	Paddy
2005	1,271.3	4,051.4	34.0	666.8
2015	1,074.5	5,642.9	18.1	681.6
2016	1,078.0	5,738.0	17.4	688.8
2017	1,081.7	5,811.1	17.5	685.5
2018	1,127.0	5,849.3	15.6	699.9
2019	1,131.9	5,900.1	5.9	672.1
2020	1,139.1	5,865.30	5.7	644.91
2021	1,139.1	5,737.73	5.98	647.94

Source: Ministry of Agriculture and Food Industries and
Ministry of Plantation Industries and Commodities

1.9.2 Livestock

Livestock population size fluctuation across all animal types has relatively remain stable between 2015 and 2021 (Table SIIC1.20).

Table SIIC1.20 **Selected Livestock Populations**

Year	Livestock							
	Buffalo	Cattle	Goat	Sheep	Swine	Horse*	Chicken	Duck
2005	133,232	790,065	287,670	115,922	2,035,647	2,367	174,694,165	8,052,997
2015	118,569	742,338	431,651	147,033	1,886,823	3,608	286,620,834	9,897,115
2016	119,133	737,827	416,529	138,479	1,654,381	4,145	289,666,002	9,633,185
2017	114,013	703,832	385,304	130,658	1,849,351	4,306	293,301,558	9,283,900
2018	106,988	676,686	359,200	128,298	1,967,538	4,204	260,826,321	9,780,573
2019	101,695	657,407	312,571	121,677	1,888,460	3,095	285,063,636	9,376,456
2020	64,250	699,424	324,355	124,674	1,869,772	4,069	293,495,861	9,511,085
2021	66,571	717,431	323,994	136,769	1,672,995	4,111	284,570,907	9,525,321

Source: National Inventory Report

1.10 Land Use, Land Use Change and Forestry (LULUCF)

1.10.1 Forest

Malaysia's forests are comprised of complex ecosystems and are home to a wide range of species. Malaysia has consistently maintained more than 50% of its landmass as forest following its voluntary pledge at the Earth Summit in 1992. This includes Permanent Reserved Forests (PRFs), state land forests (SLF) and Totally Protected Areas (TPA/PA). In 2021, 17.99 million ha, or approximately 54.37% of the total land area of Malaysia was under forest cover. The remaining land area comprised of agricultural and commodity crops, settlements, wetlands and grasslands. Table SIIC1.21 below presents a breakdown of the total forested areas in Malaysia according to the three regions.

Table SIIC1.21 Total Forested Areas

Year	Forested Area (million ha)			
	Peninsular Malaysia	Sabah	Sarawak	Total
2005	5.83	4.36	7.62	17.82
2015	5.79	4.56	8.05	18.39
2016	5.77	4.56	7.91	18.24
2017	5.77	4.77	7.80	18.34
2018	5.76	4.77	7.75	18.27
2019	5.73	4.68	7.72	18.14
2020	5.70	4.68	7.67	18.05
2021	5.73	4.61	7.65	17.99

Source: Ministry of Energy and Natural Resources

1.10.2 Biodiversity

Malaysia is rich in biodiversity in terms of estimated species in the respective flora and fauna groups as shown in Table SIIC1.22.

Table SIIC1.22 **Summary of Malaysia's Overall Biodiversity Richness**

Group	Estimated Species
Mammals	306
Birds	742
Reptiles	567
Amphibians	242
Marine Fishes	1,619
Freshwater Fishes	449
Invertebrates	150,000
Vascular Plants	15,000
Fungi	>4,000
Mosses	522
Hard corals	612

Sources: Sixth National Report (of Malaysia) to the Convention on Biological Diversity

Malaysia's terrestrial biodiversity is concentrated within tropical rainforests that extend from coastal plains to mountainous areas and wetlands, such as lakes and rivers. Marine biodiversity is primarily located among islands and coastal ecosystems, especially in mangrove/tidal mudflats, coral reefs and seagrass meadows. Agricultural biodiversity is conserved in plantations, rice fields, fruit orchards, and farms. Table SIIC1.23 represents an overview of different ecosystems across Malaysia.

Table SIIC1.23 **Overview of Ecosystems**

Thematic Area	Ecosystem
Forest Biodiversity	Lowland dipterocarp forest Heath forest Limestone forest Mixed dipterocarp forest Hill dipterocarp forest Hill mixed dipterocarp forest
Mountain Biodiversity	Montane forest Subalpine forest
Inland Waters Biodiversity	Peat swamp forest Freshwater swamp forest Riparian forest Rivers, ponds, lakes
Marine and Coastal Biodiversity	Coastal hill dipterocarp forest Mangrove forests Mudflats Coral reef Sea grass
Agricultural Biodiversity	Plantations Rice fields Fruit orchards and vegetable farms Livestock rearing and aquaculture farms

Sources: Sixth National Report (of Malaysia) to the Convention on Biological Diversity

1.11 Waste

Waste generation increases in proportion with population growth. Table SIIC1.24 provides a breakdown of average daily waste generation by region, and on the other hand, Table SIIC1.25 presents the number of both sanitary and non-sanitary landfills according to states in 2021.

1.11.1 Solid Waste Generation

An information on the average waste generations per day for 2007 and 2012 is provided in Table SIIC1.24.

Table SIIC1.24 **Average Waste Generations Per Day in 2007 and 2012**

Region	Year	
	2007	2012
Peninsular Malaysia (tonnes/day)	20,500	27,802
Sabah (tonnes/day)	1,210	2,984
Sarawak (tonnes/day)	1,988	2,344
Total (tonnes/day)	**23,698**	**33,130**

Source: Survey on Solid Waste Composition,
Characteristics and Existing Practice of Solid Waste Recycling in Malaysia 2012,
National Solid Waste Management Department

A list of landfills according to the states in Malaysia in 2021 is depicted in the following table.

Table SIIC1.25 **Number of Landfills in Malaysia in 2021**

State	Landfills in operation		Total
	Sanitary	Non-Sanitary	
Johor	1	8	9
Kedah	3	1	4
Kelantan	0	10	10
Melaka	1	0	1
Negeri Sembilan	1	2	3
Pahang	3	7	10
Perak	1	15	16
Perlis	1	0	1
Pulau Pinang	1	0	1
Sabah	1	21	22
Sarawak	3	43	46
Selangor	3	2	5
Terengganu	1	8	9
W.P. Labuan	1	0	1
W.P. KL/ Putrajaya	0	0	0
Total	**21**	**116**	**137**

Source: National Solid Waste Management Department

The solid waste composition of Malaysia for the years 2004 and 2012 (latest date of last survey of the Solid Waste sector) is shown in Table SIIC1.26.

Table SIIC1.26 **Solid Waste Composition**

Composition	Percentage (%)	
	2004 (JICA Study)	2012
Food waste	49.3	44.5
Garden Waste	6.6	5.8
Paper	17.1	8.5
Wood	0.2	1.4
Textiles	3.7	5.2
Diapers	5.1	12.1
Plastic and Other Inert Inserts	18.1	22.2

Note: JICA – Japan International Cooperation Agency
Source: Survey on Solid Waste Composition, Characteristics and Existing Practice of Solid Waste Recycling in Malaysia 2012, National Solid Waste Management Department

1.12 Impact of National Circumstances on Nationally Determined Contributions (NDCs)

The Malaysia's economy has transitioned from an agricultural and commodity-based to manufacturing and services since the 1980s. Malaysia's economy is mainly driven by the services, agriculture, manufacturing, oil and gas and construction sectors. As a developing country, the economic growth experienced is intended to be beneficial to the Rakyat through the creation of jobs and improvement of quality of life.

As the national's economy is estimated to grow and rebound after the COVID-19 pandemic, the energy demand is expected to increase in tandem as well. With the energy sector as the largest emitter of GHG gasses, the increase of energy demand will directly impact the total GHG emission and removals level, which will affect the progress of achieving Malaysia's NDC. According to the National Energy Policy, Malaysia's final energy demand has been growing at an average of six per cent per annum between 2010 and 2018. Seventy-five per cent of the total final energy demand came from transportation, power and industry sectors and growing at the rate of four per cent per annum. Fossil fuel which constitutes natural gas, crude oil and petroleum products and coal, dominates 93% of Malaysia's Total Primary Energy Supply (TPES) and the seven per cent balance are from renewables, comprising mainly hydroelectric, solar and bioenergy. Driven by demand from power sector in Peninsular Malaysia, energy security and affordability objective, usage of coal in the primary energy mix has increased.

In order to reduce the reliance on fossil fuel, reducing emissions and evolving the primary energy supply to be more environmentally sustainable, RE has been the focus under National Energy Policy and National Energy Transition Roadmap. However, as Malaysia transitioning into cleaner source of energy, the limitations on source of RE available has put on a challenge to increase RE shares in meeting future energy demand reliably. Most of Malaysia's renewable came from hydroelectric and solar. Although Malaysia is blessed with long daylight hours with consistent solar radiance, frequent cloud cover reduces the efficiency of solar irradiance per day. As such, large lands are needed to build solar farm that can generate enough power to cater peak electricity demand. The same goes to hydroelectric as the construction of hydroelectric dam will flood large tract of land, impacting the country's forest. Apart from solar and hydroelectric, other RE source such as wind, tidal and geothermal energy have been studied but none of them have much potential for a large-scale energy generation. As a way forward, Malaysia is looking towards innovation to reduce energy demands such as clean combustion process using hydrogen, energy efficiency and bioenergy.

Apart from energy sector, IPPU sector is the second largest emitter of GHG gasses. With global economy and trade recovering post-COVID-19 pandemic, Malaysia's industrial manufacturing and production are expected to grow exponentially and targeted to increase 15 per cent of its share in National GDP in 2030 compared to year 2021 under the New Industrial Masterplan (NIMP). However, emission reductions under IPPU sector are mostly technology intensive and facility based. Although decarbonisation pathways were introduced under NIMP, the sectoral uptake is quite slow as most of the technologies to reduce emission are still expensive and unattractive to industry players. Nonetheless, some of the industries have put some effort in reducing emission by improving their process efficiency. For example, cement industry has shifted towards low carbon cement production by substituting part of the clinker with other cementitious materials while aluminium industry has improved their anodising process resulting in reduction of PFC emission in aluminium production. In addition, Malaysia will introduce carbon tax for iron and steel industry by 2026 as part of the national effort to reduce emissions.

The impact from agriculture and waste sector towards the total GHG emissions and removals are quite small compared to energy and IPPU sectors. However, with the increase of population, growing demand for food and increase of commodities productions, the emissions from these sectors are expected to increase. As the population and GNI increases, more solid wastes are expected to be generated per capita. In addition, the availability of cheap and disposable products in the market have put the pressure on Malaysia's waste management system. The increase of population also means that demand for food production will grow. Food security is one of the primary objectives under the National Agrofood Policy (NAP 2.0). Hence the production of live-stocks meat and rice is expected to increase in line with the self-sustenance ratio target stated under NAP2.0. As for agricultural crop, the total planted areas have decreased due to urbanization and lack of labour. However, the implementation of National Agricommodity Policy (DAKN) action plans to revive agri-commodity sector may result in an increase of major commodity planted areas.

The effort to reduce waste generation have been taken through the establishment of Solid Waste Management and Public Cleanliness Act (Act 672) which give the mandate to a national authority to implement the action plans stated in the National Cleanliness Policy. However, half of the state did not adopt the act and thus reduces the effectiveness of the policy in reducing emissions from solid waste especially in regard to separation of waste and landfill management. Currently, some steps have been taken by the Federal Government to push the remaining states to adopt Act 672 and the results are positive. As for agriculture, emission reduction efforts are mainly focused on the reduction of synthetic fertilizer usage under MyOrganic initiative. Apart from that, Malaysia is also looking towards innovative way to reduce emission from rice cultivation such as reducing the flooding cycle from 120-days to 100-days.

1.13 Malaysia's Institutional Arrangements Towards Measurement, Reporting, and Verification System in Tracking Progress and Achievements of NDCs

Malaysia's commitment to support climate change endeavour includes establishing robust Measurement, Reporting, and Verification (MRV) systems. These systems are essential for ensuring transparency, accuracy and accountability in tracking GHG emissions, tracking the implementation of mitigation actions and monitoring the GHG intensity reductions. The details of the institutional arrangements can be referred in Chapter 1 of the NID.

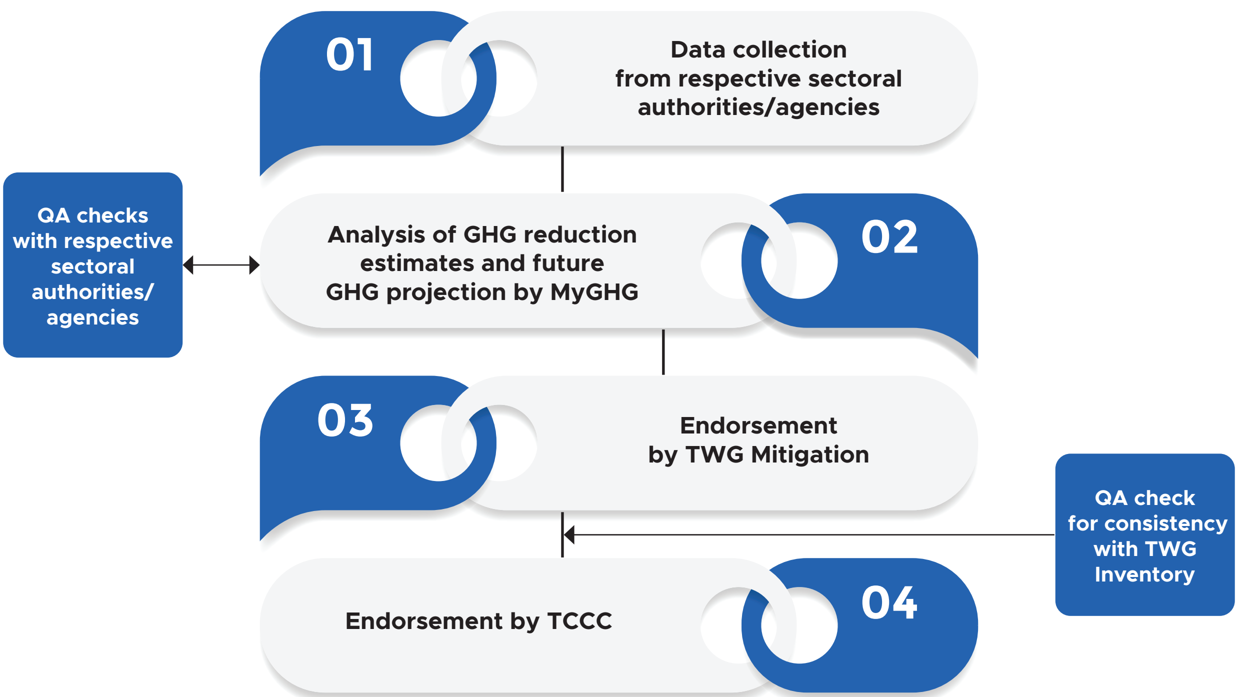
1.14 Monitoring and Evaluation of Policies and Measures and the QA/QC Process

Each sectors have their own mandated authorities/agencies tasked in monitoring, verifying and publishing data from their sectoral/sub-sectoral policies and initiatives based on their respective acts or legal frameworks. As such, NRES through MyGHG will collect the data from the respective sectoral authorities/agencies and perform technical analysis by utilisation of spreadsheets to assess the amount of emission reductions achieved under each sector. In addition, indicative projection of future GHG emissions and removal will also being done by MyGHG, using assumption obtained from technical analysis. Furthermore, QA checks of the overall assessment and projection are done by MyGHG together with respective sectoral authorities/agencies through workshops and discussion sessions.

The end result then will be reported to the TWG Mitigation that will discuss upon those policies and initiatives that have the most impact on GHG emission and removals and perform further technical checks on the assessment and projections. The result will also be presented to the TWG on GHG inventory as part of the QA process to ensure consistencies with inventory data.

Upon thorough consideration and endorsement of TWG Mitigation, the assessment of policies and initiative GHG emission reduction and projection of future indicative GHG emissions and removals will be presented to the Technical Committee on Climate Change for further technical recommendation and feedback. The National Steering Committee on Climate Change (NSCCC) endorses the final BTR document inclusive of the assessment and projection before it is tabled to the Cabinet meeting for approval. The cabinet-approved BTR document will then be submitted by NRES to the UNFCCC secretariat as an official submission. Figure SIIC1.13 illustrates the process schematically.

Figure SIIC1.13 **Monitoring and Evaluation of Policies and Measures and the QA/QC Process**



2
CHAPTER

DESCRIPTION OF A MALAYSIA'S NATIONALLY DETERMINED CONTRIBUTION UNDER ARTICLE 4 OF THE PARIS AGREEMENT

2.1 Introduction

As part of its commitment under the Paris Agreement, Malaysia has articulated its NDCs for year 2030 in order to reflect a balanced approach between economic growth and environmental stewardship. A cornerstone of Malaysia's climate strategy is the goal of reducing GHG carbon intensity of GDP by 45% by year 2030 relative to year 2005 levels. This requires a commitment to decouple the economic development from GHG emissions.

Malaysia's 2030 NDCs represent its commitment to climate action. The country is working towards a sustainable and resilient future by focusing on emission reductions at the economy wide scale that include the energy, IPPU, agriculture, LULUCF and waste sectors while also considering the overall growth of Malaysia's economy. The successful attainment of these targets will hinge on effective policy implementation, strong governance, and active stakeholder engagement.

2.2 Malaysia's Nationally Determined Contribution (NDCs)

The description of Malaysia's NDCs under Article 4 of the Paris Agreement is shown in Table SIIC2.1.

Table SIIC2.1 Description of a Party's NDCs Under Article 4 of The Paris Agreement

Description of a Party's NDCs Under Article 4 of the Paris Agreement	
	Description
Target(s) and description, including target type(s), as applicable	Economy-wide carbon intensity reduction (against GDP) of 45% in 2030 compared to 2005 level.
Target year(s) or period(s), and whether they are single-year or multi-year target(s), as applicable	Single year target in 2030
Reference point(s), level(s), baseline(s), base year(s) or starting point(s), and their respective value(s), as applicable	The reference indicator will be quantified based on national GHG emissions and removals, and GDP in 2005
Time frame(s) and/or periods for implementation, as applicable	1st January 2021 - 31st December 2030
Scope and coverage, including, as relevant, sectors, categories, activities, sources and sinks, pools and gasses, as applicable	**Sectors:** Energy Industrial Processes and Product Use Waste Agriculture LULUCF **GHGs:** Carbon dioxide (CO_2) Methane (CH_4) Nitrous oxide (N_2O) Hydrofluorocarbons (HFCs) Perfluorocarbon (PFCs) Sulphur hexafluoride (SF_6) Nitrogen trifluoride (NF_3)
Intention to use cooperative approaches that involve the use of ITMOs under Article 6 towards NDCs under Article 4 of the Paris Agreement, as applicable	Malaysia does not intend to use voluntary cooperation under Article 6 of the Paris Agreement to achieve its NDC

3
CHAPTER

INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NDCs

3.1 Indicators, Baseline and Target (CTF Table 1 and 2)

In tracking the progress in implementing and achieving Malaysia's NDCs, the indicator selected to track progress is the carbon intensity. Carbon intensity in this context is the ratio of two key parameters:

(i) total economy-wide GHG emissions and removals including LULUCF per year measured in million tonnes CO_2 eq.; and
(ii) GDP at constant year price

The details of the selected indicators are shown in Table SIIC3.1 and the definition of the selected indicators are shown in Table SIIC3.2.

Table SIIC3.1 **Description of Selected Indicators**

Description of selected indicators	
Indicator(s) selected to track progress	**Description**
Carbon Intensity	The ratio of total GHG emission and removal including LULUCF against GDP
Information for the reference point(s), level(s), baseline(s), base year(s) or starting point(s), as appropriate	Base year: 2005
Relation to NDC	Directly related to NDC

Table SIIC3.2 **Definition needed to understand NDC**

Definitions needed to understand NDC	
Term	**Description**
Carbon Intensity	The ratio of total GHG emission and removal including LULUCF using net-net approach against GDP at constant 2015 price.
	Total annual economy-wide GHG emissions and removals including LULUCF per year measured in Million tonnes CO2eq., which are quantified and reported in NIR.
	Annual GDP in 2015 constant price is obtained from Department of Statistic and annual Economic and Monetary Review publish by Bank Negara Malaysia.

3.1.1 Methodology and Accounting Approach (CTF Table 3)

In accounting for the NDCs, the carbon intensity values are measured against the baseline of 2005. Carbon intensity is the ratio of total economy-wide emissions and removals reported in the NIR Section of this report and put against the GDP value of the inventory year in 2015 constant price. This is consistent with the inventory guidance contained in the Annex to decision 18/CMA1. Malaysia uses the 2006 IPCC Guidelines for National GHG Inventories to estimate anthropogenic GHG emissions and removals, and the 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories: Wetlands. The 100-year time horizon GWP values from the IPCC's Fifth Assessment Report or any future updates will be used to calculate the CO2 equivalent emissions and removals in accordance with Decision 18/CMA.1. GDP values at 2015 constant price are obtained from Values published by Department of Statistic. As for baseline year, the GDP value at constant 2015 price was calculated by NRES using methodology provided by Department of Statistic.

This accounting approach is also used to account for anthropogenic emissions and removals in assessing the implementation and achievements of the target and for the construction of baseline. The key parameters are the total GHG emission and removal including LULUCF and GDP. The GDP value is obtained from the Department of Statistic and annual Economic and Monetary Review published Bank Negara Malaysia where service and manufacturing sectors are the prime movers aside the domestic demand. For the total GHG emissions and removals, the value is obtained from the national GHG inventory report.

Specific to the LULUCF sector, Malaysia has applied net-net accounting approach to calculate LULUCF sector's contribution to the NDC. In line with para 75(d)(i), 75(d)(ii) and 75(d)(iii), the following information are provided:

(i) Currently, natural disturbances on managed lands are due to periodic incidence of forest fires. Emissions from natural disturbances that exceed the average emissions between 2001 to 2020 caused by natural disturbances will not be accounted;
(ii) Malaysia is undertaking a study to consider the relevant approach to account emissions and removals from harvested wood products; and,
(iii) Activity data and emission factors would take into consideration the management type of forest land remaining forest land.

Information provided for para 75(d)(i), 75(d)(ii) and 75(d)(iii) are based on current policies and knowledge and Malaysia reserve the right to update the information as appropriate.

Malaysia will follow the methods and guidance in accordance with the 2006 IPCC Guidelines for National GHG Inventories consistent with decision 18/CMA.1 as appropriate in accounting for anthropogenic emissions and removals for its NDC. The same method and guidance also used to ensure methodological consistency, including on baseline, between communication and implementation of NDC. Malaysia will continue to improve its methodologies to account for historical emissions. Adopting future improvements may affect historical emissions, including 2005 emissions.

Information from the National Inventory Report will be used to calculate NDC progress and achievements. This information includes the estimates of economy-wide GHG emission and removal. Malaysia does not intend to use voluntary cooperation under Article 6 of the Paris Agreement to achieve its NDCs. Table SIIC3.3 summarise the methodologies and accounting approaches – consistency with Article 4, paragraphs 13 and 14, of the Paris Agreement and with decision 4/CMA.1

Table SIIC3.3 **Structured Summary of Methodologies and Accounting Approaches – Consistency with Article 4, Paragraphs 13 and 14 of the Paris Agreement and with Decision 4/CMA.1**

Reporting requirement	Description or reference to the relevant section of the BTR
For the first NDC under Article 4:	
Accounting approach, including how it is consistent with Article 4, paragraphs 13–14, of the Paris Agreement (para. 71 of the MPGs)	In accounting for the NDCs, our carbon intensity values are measured against the base year of 2005. Carbon intensity is the ratio of total economy-wide emissions and removals reported in the inventory and put against the GDP value of the inventory year in 2015 constant price. This is consistent with the inventory guidance contained in the Annex to decision 18/CMA1. Malaysia uses the 2006 IPCC Guidelines for National GHG Inventories to estimate anthropogenic GHG emissions and removals, and the 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories: Wetlands. The 100-year time horizon GWP values from the IPCC's Fifth Assessment Report or any future updates will be used to calculate the CO_2 equivalent emissions and removals in accordance with Decision 18/CMA.1. GDP values at 2015 constant price are obtained from values published by Department of Statistic. As for baseline year, the GDP value at constant 2015 price was calculated by NRES using methodology provided by Department of Statistic
For each NDC under Article 4:	
Accounting for anthropogenic emissions and removals in accordance with methodologies and common metrics assessed by the IPCC and adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement:	
Each methodology and/or accounting approach used to assess the implementation and achievement of the target(s), as applicable (para. 74(a) of the MPGs)	In accounting for the NDCs, our carbon intensity values are measured against the base year 2005. Carbon intensity is the ratio of total economy-wide emissions and removals reported in the inventory and put against the GDP value of the inventory year in 2015 constant price. This is consistent with the inventory guidance contained in the Annex to decision 18/CMA1. Malaysia uses the 2006 IPCC Guidelines for National GHG Inventories to estimate anthropogenic GHG emissions and removals, and the 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories: Wetlands. The 100-year time horizon GWP values from the IPCC's Fifth Assessment Report or any future updates will be used to calculate the CO2 equivalent emissions and removals in accordance with Decision 18/CMA.1. GDP values at 2015 constant price are obtained from values published by Department of Statistic and Bank Negara Malaysia. As for the baseline year, the GDP value at constant 2015 price was calculated by NRES using methodology provided by Department of Statistic.

Reporting requirement	Description or reference to the relevant section of the BTR
Each methodology and/or accounting approach used for the construction of any baseline, to the extent possible (para. 74(b) of the MPGs)	n/a
Key parameters, assumptions, definitions, data sources and models used, as applicable and available (para. 75(a) of the MPGs)	The key parameters are the total GHG emission and removal and GDP values. The GDP value is obtained from annual Economic and Monetary Review published Bank Negara Malaysia where service and manufacturing sectors are the prime movers aside the domestic demand. For the total GHG emissions and removals, the value is obtained from the national GHG inventory report.
IPCC Guidelines used, as applicable and available (para. 75(b) of the MPGs)	Malaysia uses the 2006 IPCC Guidelines for National GHG Inventories to estimate anthropogenic GHG emissions and removals, and the 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories: Wetlands.
Report the metrics used, as applicable and available (para. 75(c) of the MPGs)	The 100-year time horizon GWP values from the IPCC's Fifth Assessment Report or any future updates will be used to calculate the CO_2 equivalent emissions and removals in accordance with Decision 18/CMA.1.
Where applicable to its NDCs, any sector-, category or activity-specific assumptions, methodologies and approaches consistent with IPCC guidance, taking into account any relevant decision under the Convention, as applicable (para. 75(d) of the MPGs)[40]	
For Parties that address emissions and subsequent removals from natural disturbances on managed lands, provide detailed information on the approach used and how it is consistent with relevant IPCC guidance, as appropriate, or indicate the relevant section of the national GHG inventory report containing that information (para. 1(e) of annex II to decision 4/CMA.1, para. 75(d)(i) of the MPGs)	Currently, natural disturbances on managed lands are due to periodic incidence of forest fires. Emissions from natural disturbances that exceed the average emissions between 2001 to 2020 caused by natural disturbances will not be accounted.
For Parties that account for emissions and removals from harvested wood products, provide detailed information on which IPCC approach has been used to estimate emissions and removals (para. 1(f) of annex II to decision 4/CMA.1, para. 75(d)(ii) of the MPGs)	Malaysia is undertaking a study to consider the relevant approach to account emissions and removals from harvested wood products

[40] Information provided for para 75(d)(i), 75(d)(ii) and 75(d)(iii) are based on current policies and knowledge. Malaysia reserves the right to update the information as appropriate. Malaysia will apply the net-net accounting approach for the LULUCF sector.

Reporting requirement	Description or reference to the relevant section of the BTR
For Parties that address the effects of age-class structure in forests, provide detailed information on the approach used and how this is consistent with relevant IPCC guidance, as appropriate (para. 1(g) of annex II to decision 4/CMA.1, para. 75(d)(iii) of the MPGs)	Activity data and emission factors would take into consideration the management type of forest land remaining forest land.
How the Party has drawn on existing methods and guidance established under the Convention and its related legal instruments, as appropriate, if applicable (para. 1(c) of annex II to decision 4/CMA.1)	Malaysia will follow the guidance in accordance with the 2006 IPCC Guidelines for National GHG Inventories consistent with decision 18/CMA.1 as appropriate. When information is not available, flexibility is to be applied. Malaysia will continue to improve its methodologies to account for historical emissions. Adopting future improvements may affect historical emissions, including 2005 emissions.
Any methodologies used to account for mitigation co-benefits of adaptation actions and/or economic diversification plans (para. 75(e) of the MPGs)	n/a
Describe how double counting of net GHG emission reductions has been avoided, including in accordance with guidance developed related to Article 6 if relevant (para. 76(d) of the MPGs)	Malaysia does not intend to use voluntary cooperation under Article 6 of the Paris Agreement to achieve its NDC.
Any other methodologies related to the NDC under Article 4 (para. 75(h) of the MPGs)	n/a
Ensuring methodological consistency, including on baselines, between the communication and implementation of NDCs (para. 12(b) of the decision 4/CMA.1):	
Explain how consistency has been maintained in scope and coverage, definitions, data sources, metrics, assumptions and methodological approaches including on baselines, between the communication and implementation of NDCs (para. 2(a) of annex II to decision 4/CMA.1)	Malaysia follows the guidance in accordance with the 2006 IPCC Guidelines for National GHG Inventories consistent with decision 18/CMA.1 as appropriate. When information is not available, flexibility is to be applied. Malaysia will continue to improve its methodologies to account for historical emissions. Adopting future improvements may affect historical emissions, including 2005 emissions. Information from the National Inventory Report will be used to calculate NDCs progress and achievements.
Explain how consistency has been maintained between any GHG data and estimation methodologies used for accounting and the Party's GHG inventory, pursuant to Article 13, paragraph 7(a), of the Paris Agreement, if applicable (para. 2(b) of annex II to decision 4/CMA.1) and explain methodological inconsistencies with the Party's most recent national inventory report, if applicable (para. 76(c) of the MPGs)	Malaysia will follow the guidance in accordance with the 2006 IPCC Guidelines for National GHG Inventories consistent with decision 18/CMA.1 as appropriate. When information is not available, flexibility is to be applied. Malaysia will continue to improve its methodologies to account for historical emissions. Adopting future improvements may affect historical emissions, including 2005 emissions. Information from the National Inventory Report will be used to calculate NDCs progress and achievements.

Reporting requirement	Description or reference to the relevant section of the BTR
For Parties that apply technical changes to update reference points, reference levels or projections, the changes should reflect either of the following (para. 2(d) of annex II to decision 4/CMA.1):	
Technical changes related to technical corrections to the Party's inventory (para. 2(d)(i) of annex II to decision 4/CMA.1)	n/a
Technical changes related to improvements in accuracy that maintain methodological consistency (para. 2(d)(ii) of annex II to decision 4/CMA.1)	n/a
Explain how any methodological changes and technical updates made during the implementation of their NDC were transparently reported (para. 2(e) of annex II to decision 4/CMA.1)	n/a
Striving to include all categories of anthropogenic emissions or removals in the NDC and, once a source, sink or activity is included, continuing to include it (para. 3 of annex II to decision 4/CMA.1):	
Explain how all categories of anthropogenic emissions and removals corresponding to their NDCs were accounted for (para. 3(a) of annex II to decision 4/CMA.1)	In accounting for the NDCs, the estimates of economy-wide emissions and removals reported in the inventory
Explain how Party is striving to include all categories of anthropogenic emissions and removals in its NDCs, and, once a source, sink or activity is included, continue to include it (para. 3(b) of annex II to decision 4/CMA.1)	In accounting for the NDCs, the estimates of economy-wide emissions and removals will be reported in the inventory
Provide an explanation of why any categories of anthropogenic emissions or removals are excluded (para. 4 of annex II to decision 4/CMA.1)	n/a

3.2 Tracking NDCs Progress

Year 2005 is selected as the reference base year in tracking Malaysia's NDCs progress. In 2005, the total economy-wide GHG emissions and removals including LULUCF using net-net is at 255.507 million tonnes of CO_2 eq. and the value of GDP in that year at constant 2015 price is RM729,851 million, resulting a carbon intensity of 0.3501 kg CO_2 eq./RM.

Year 2021 is the first year of in Malaysia's NDCs implementing period. As per the latest inventory year (2021), Malaysia's total GHG emission including LULUCF using net-net is at 306.105 million tonnes of CO_2 equivalent and the GDP at constant 2015 price for that year is RM1,390,664 million. This has resulted in carbon intensity level of 0.2206 kg/RM compared to 0.3501 kg/RM in year 2005 with the total carbon intensity reduction is at 37.12%. Based on current projection, total GHG emission including LULUCF in 2030[41] is estimated at 335.423 million tonnes of CO_2 equivalent and with GDP value is estimated at RM2,131,853 million, the estimated carbon intensity level of 0.1551 kg/RM. Table SIIC3.4 summarises Malaysia's NDCs progress.

Table SIIC3.3 **Tracking Progress Made in Implementation and Achievement of Malaysia's NDCs (CTF Table 4)**

Indicators	Unit	Baseline Year (2005) Values	Implementation Period 2021	Target level	Target year	Progress made towards the NDCs
Carbon Intensity	kg/RM	0.3501	0.2201	0.1925	2030	By 2021, Malaysia has reduced its carbon intensity by 37.12% compared to base year 2005
Total GHG emission and removals including LULUCF	MT CO_2 eq.	255.507	306.105	N/A	2030	
National GDP at constant 2015 price	million RM	729,851	1,390,664	N/A	2030	
Total GHG emissions and removals[42]	MT CO_2 eq.	255.507	327.672			
Contribution from the LULUCF sector using net-net approach	MT CO_2 eq.	0	21.566			

[41] The projection is indicative as per the paragraph 93 of the 18/CMA.1
[42] Total GHG emissions and removal excluding LULUCF

4
CHAPTER

MITIGATION POLICIES AND MEASURES, ACTIONS AND PLANS, INCLUDING THOSE WITH MITIGATION CO-BENEFITS RESULTING FROM ADAPTATION ACTIONS AND ECONOMIC DIVERSIFICATION PLANS, RELATED TO IMPLEMENTING AND ACHIEVING A NATIONALLY DETERMINED CONTRIBUTION UNDER ARTICLE 4 OF THE PARIS AGREEMENT

4.1 Introduction

Malaysia has continued its effort to mainstream the mitigation actions into its development and implementation of policies, actions plan, initiatives and programmes that have mitigation co-benefits and at the same time meet the development needs of the country. Under the 12th Malaysian Plan, the emphasize on reducing GHG emissions is highlighted through green growth implementation, energy efficiency enhancement and green mobility promotion, under "Advancing Green Growth to Enhance Environmental Sustainability" thrust. Additional efforts have been taken to meet the target of Malaysia's NDCs commitment to reduce 45% of its carbon intensity by year 2030 relative to the year 2005 level.

This section including CTF Table 5 in Annex III will provide information on the current and newly adopted policies, measures, and action plans including those related to the implementation and achievement of Malaysia's NDCs.

4.2 National Policy on Climate Change 2.0

National Policy on Climate Change 2.0 is the main policy to guide Government agencies, industries, communities and other stakeholders in addressing the challenges of climate change effectively and holistically. The policy that was launched in October 2024 sets out the direction and an updated framework for Malaysia to pursue a transition to a low-carbon economy and enhance climate resilience in line with the national sustainable development agenda and international climate commitments through its five (5) strategic thrusts:

- To strengthen climate governance and institutional capacity for effective planning, regulation and implementation of climate action;
- To achieve low carbon development that aligns with the national sustainable development agenda and international climate commitment;
- To emphasise adaptation and climate resilience measures that benefit socio-economic and development goals;
- Scale up blended financing and enable a sustainable market to increase the involvement of private sectors; and
- Foster collaborative climate action through domestic partnerships and international cooperation.

4.3 Energy Sector

The Energy sector comprises 75.68% of Malaysia’s total GHG emissions in the year 2021. As the main driver for Malaysia's socio-economic development, it is important that the energy sector remains future-proof to domestic and global developments to ensure the sector’s sustainability and competitiveness.

4.3.1 National Energy Policy

National Energy Policy (DTN) sets the vision of energy sustainability towards achieving shared prosperity, reflecting the role of energy as a significant contributor which enables other key sectors of the economy to thrive on the country's economic development.

Launched in September 2022, it aims to enhance macroeconomic resilience and energy security, achieving social equality and affordability, and ensuring environmental sustainability via four strategic thrusts:

- Optimise energy resources to stimulate sustainable economic growth;
- Stimulate growth, market opportunities and cost advantage for the economy and people;
- Enhance energy sector contribution towards environmental sustainability; and,
- Ensure energy security towards fiscal sustainability.

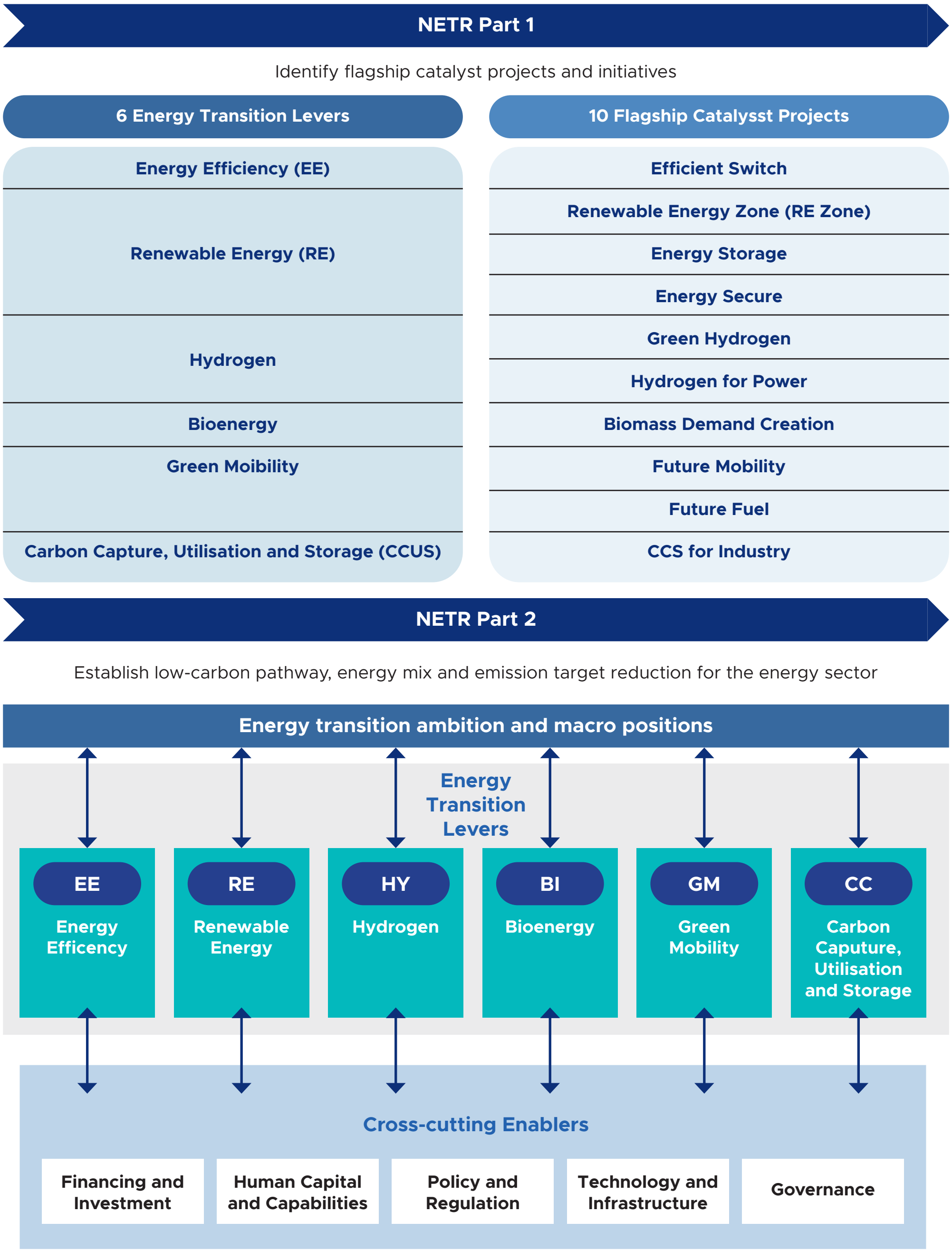
4.3.2 Low Carbon Aspiration 2040

As a part of DTN, Malaysia has developed the Low Carbon Aspiration 2040 based on the existing plans in the energy sector. Under this aspiration, the government will take a more proactive role by identifying and developing selective leadership in the areas of the low carbon economy and aligning it with the areas where the country has high potential and competitive advantage. This aspiration targets a higher level of urban public transport modal share, electric vehicle (EV) penetration, share of alternative lower carbon fuels in heavy vehicles and marine transport and enhanced energy efficiency in industrial and commercial as well as residential sectors. In addition, the aspiration entails a higher level of RE penetration in the installed capacity and total primary energy supply (TPES).

4.3.3 National Energy Transition Roadmap

The National Energy Transition Roadmap (NETR) was launched in July 2023 to power the future by unlocking potential in new growth areas and delivering progress and prosperity to Malaysian households and businesses. The plan aspires to steer Malaysia’s shift from a traditional fossil fuels-based economy to a high-value green economy. NETR sets the goal to accelerate energy transition and change the way energy is generated to improve climate resilience. The development of the NETR is divided into two parts (Figure SIIC4.1).

Figure SIIC4.1 **Development of the National Energy Transition Roadmap (NETR)**



Source: National Energy Transformation Roadmap Documents

4.3.4 Responsible Transition (RT) Pathway 2050

Responsible Transition (RT) Pathway 2050 was developed under NETR to help Malaysia shift from traditional, fossil fuel-based energy systems to a greener, low-carbon energy framework. It is designed to accelerate Malaysia's energy transition journey while balancing the energy trilemma by achieving the following in the year 2050. The highlights of RT Pathway 2050 include:

- Increased use of RE in the power generation mix;
- Phase-out of coal from the power generation mix;
- Broad-based energy efficiency initiatives pursued, particularly from the demand side management that includes optimising energy consumption across key sectors, namely residential, commercial, industrial, and transport to prevent wastage and indirectly prolong the lifespan of Indigenous resources; and
- The shift to electrification and biofuels to be expedited in the transportation sector.

4.3.5 National Energy Efficiency Action Plan

The National Energy Efficiency Action Plan is an energy efficiency programme which has been implemented since year 2016. The NEEAP sets a target to save 52,233 GWh amount of electricity over 10 years from 2016 to 2025 at the end of the plan through five initiatives, namely:

Initiative 1 ▸ Promotion of 5-Star Rated Appliances;

Initiative 2 ▸ Minimum Energy Performance Standards (MEPS);

Initiative 3 ▸ Energy Audits and Energy Management in Buildings and Industries;

Initiative 4 ▸ Promotion of Co-generation;

Initiative 5 ▸ Energy-Efficient Building Design.

With the implementation of DTN and NETR, NEEAP is in the process of updating and the new NEEAP 2.0 is expected to be launched in 2025.

4.3.6 National Renewable Energy Policy

The National Renewable Energy Policy is a strategic framework for the development and promotion of renewable energy in Malaysia. This policy aims to increase RE contribution in the national power generation mix and facilitate the growth of the RE industry while ensuring reasonable RE generation costs and conserving the environment. Among the initiatives under this policy are Net Energy Metering (NEM), Solar Leasing, Large Scale Solar Programme (LSS3), and Non-Solar RE projects. With the implementation of NETR, some of the targets stated in this policy have been updated and included into the RT Pathway 2050.

4.3.7 National Renewable Energy Act

The National Renewable Energy Act 2011 was established to promote the development and utilisation of RE sources in Malaysia. As an extension of the National Renewable Energy Policy, this act introduces mechanisms such as the Feed-in Tariff (FiT) system, which encourages the generation of electricity from renewable sources by providing fixed payments to the producers. The act also outlines the regulatory framework for licensing and promoting investment in renewable energy technologies, ensuring that Malaysia can transition towards a more sustainable energy future.

4.3.8 National Transport Policy

The National Transport Policy (NTP) 2019-2030 was developed to lay the policy thrusts and strategies for the transportation sector in order to that accelerate Malaysia's economic growth and support the well-being of the rakyat, in line with an advanced national status by adhering three principles, namely economic competitiveness, social impact and environmental impact.

It provides an overarching policy to guide relevant federal ministries and agencies as well as State Governments and Local Authorities (PBT) to develop and streamline transport initiatives towards achieving policy objectives under five (5) policy thrusts. Among the NTP policy thrust is to advance towards a green transport ecosystem with the aim to minimise environmental impact from transportation sector growth, reducing GHG emissions, increasing adoption of energy-efficient vehicles (EEVs) as the preferred mode of transport and encouraging modal shift from private vehicles to public transport.

4.3.9 Low Carbon Mobility Blueprint

Low Carbon Mobility Blueprint (LCMB) is another policy framework that focuses on the transportation sector. LCMB seeks to reduce emissions from the transportation sector by mainstreaming the shift towards electrification in the transportation industry and contributing towards the achievements of the country's NDCs. The focus of this blueprint is the reduction of GHG emissions and energy consumption via fuel economy and emission improvement, electric mobility adoption and alternative fuel adoption. Furthermore, LCMB also aiming for 10,000 EV charging points throughout Malaysia by year 2025.

4.3.10 National Biofuel Policy

The National Biofuel Policy was launched in year 2006 by the Ministry of Plantation Industries and Commodities, followed by the Malaysian Biofuel Industry Act in year 2007 to regulate the biofuel sector and mandate the use of palm-based biodiesel blended with petroleum diesel. The B5 program, which introduced a blend of 5% palm-based biodiesel with 95% petroleum diesel, was implemented in year 2011. By the end of 2014, this program had successfully established over 1,500 retail stations to support biodiesel consumption across Peninsular Malaysia's transport sector. In 2015, the B7 program expanded nationwide, and it was succeeded by the B10 program in 2019 and the introduction of the B7 program for the industrial sector. In 2020, the implementation of B20 biodiesel blends in the transport sector began with a phased nationwide rollout. B30 biodiesel blending target for transportation and B10 biodiesel blending target for industry is targeted to be implemented by year 2030.

4.4 Industrial Processes and Product Use

Before year 2020, the development of industries in Malaysia was guided by the Third Industrial Master Plan 2006-2020. That policy guided Malaysia's long-term global competitiveness and innovation in the manufacturing and non-government services sectors during that period. It covered 12 industries namely electrical and electronics, medical devices, textile and apparel, machinery and equipment, metals, transport equipment, petrochemicals, pharmaceuticals, wood-based, rubber-based, oil-palm based and food processing. A new industrial master plan 2030 was launched to replace the Third Industrial Master Plan as described in the following sub-chapter.

4.4.1 New Industrial Master Plan 2030 (NIMP 2030)

The New Industrial Master Plan 2030 (NIMP 2030) is an industrial policy for the manufacturing and manufacturing-related services sector. Launched in September 2023, it is formulated with the intent to transform the industry to greater heights, capitalising on emerging global trends and takes on a mission-based approach for industrial development. Among the missions of the policy is to push towards net zero GHG emissions in the industrial sector through:

(i) Accelerating transition towards sustainable practices in the industrial sector;
(ii) Transition to renewable and clean energy;
(iii) Catalysing new green growth areas; and
(iv) Shifting towards green infrastructure.

The plan would help to quicken the early peaking of GHG emissions from the industrial sector and thereafter guide its GHG emissions reduction towards net zero as early as 2050.

4.5 Waste Sector

In the year 2021, the waste sector contributes around 5.8% of Malaysia's total GHG emissions. As the GHG emissions from this sector come mainly from methane emissions from solid waste disposal sites and Palm Oil Mill Effluents (POME), rapid urbanisation and high demand for crude palm oil have increased the level of emissions.

4.5.1 Malaysia's National Cleanliness Policy

The Malaysia Cleanliness Policy which was launched in year 2019 to achieve a vision of national socio-economic development focusing on cleanliness and hygiene by year 2030. This policy emphasises environmental sustainability and the circular economy as two main clusters. In alignment with this vision, the policy targets diverting waste from disposal sites through a 40% recycling rate in the year 2025. The policy also envisages that all six types of waste (food waste, plastic, diapers, paper, garden waste and others) shall be managed holistically based on a life-cycle approach, with an increased investment to channel waste away from waste disposal sites to be used as a resource, either as input for other products or converted to energy. Such processes would help to reduce waste generation and contribute to GHG emissions reduction.

4.5.2 Biogas Recovery from Palm Oil Mill Effluent (POME)

Biogas Recovery from Palm Oil Mill is one of the initiatives under Palm Oil National Key Economic Areas during the implementation of Malaysia's Economic Transformation Programme (ETP) 2010-2020. This initiative aims to capture methane release during milling process, reducing methane emissions from POME. Through this initiative, palm oil mills are encouraged to install biogas trapping facilities to capture methane as fuel for their use or to generate electricity for sale to the national grid. In year 2014, the Government mandated a directive that the new palm oil mills and old mills that plan to expand their capacity are required to install methane avoidance facilities. There were 135 biogas capture plants installed out of 451 Palm Oil Mills in 2021.

4.6 Agriculture Sector

Agricultural sector is a dynamic and essential sector, contributing significantly to the economy, food security, and rural livelihoods. Balancing productivity with sustainability remains a key challenge, as the country seeks to modernise its agricultural practices while preserving its rich natural resources. The development of the agriculture sector in Malaysia is guided by the National Agrofood Policy and the National Agricommodity Policy, which respectively aim to increase food production and exports of industrial commodities.

4.6.1 National Agrofood Policy 2021-2023

As a continuation of National Agrofood Policy 1.0 (NAP1.0) which ended in the year 2020, National Agrofood Policy 2.0 (NAP2.0) was developed as a succeeding national policy document that lays down the development pathway of the agrofood sector for the period 2021-2030. This policy is targeted to explore new focused areas and mitigation measures to enhance the agrofood sector's economic contribution, competitiveness, inclusiveness, and sustainability, as well as its resilience to shocks of detrimental global events.

NAP2.0 is formulated with the vision of developing a sustainable, resilient, and high-technology agrofood sector in efforts to drive economic growth, enhance the well-being of the people, and prioritize food and nutrition security. Its focuses are on two main aspects namely food security and economic growth. The objectives of the National Agrofood Policy are to ensure food security, and that the food produced is safe to eat; to make the agrofood industry competitive and sustainable; and to increase the agro-based entrepreneur's level of income.

Two certification schemes guide sustainable agriculture implementation in Malaysia under NAP2.0. The Malaysian Good Agricultural Practices (MyGAP) was launched in year 2013 is a comprehensive certification scheme for the agricultural, aquaculture and livestock sectors. The Malaysian Organic Scheme (currently known as MyOrganic), was launched in 2007, is a certification program to recognise organically cultivated farms which do not use chemical pesticides and synthetic fertilisers.

4.6.2 National Agricommodity Policy 20303

The National Agricommodity Policy 2030 (DAKN2030) was established as a way forward for agricommodity sector by year 2030. DAKN2030 covers eight (8) major commodities, namely palm oil, rubber, harvested wood product, cacao, pepper, plant-based fibre (kenaf), biomass and biofuel with an emphasis on increasing agrocommodity-based circular economy. In line with global development and national agenda, DAKN2030 establishes the framework to advance agricommodity sector through five (5) policy cores:

- Leading sustainable production and consumption;
- Increasing productivity through R&D&C&I and technological adoption;
- Intensifying value generation through product diversification and complexity;
- Developing the market by utilising global supply chain; and
- Expanding inclusivity and fair wealth distribution.

Under DAKN2030, environmental performance regulations and sustainability criteria are complied with through the Malaysian Sustainable Palm Oil (MSPO), Roundtable on Sustainable Palm Oil (RSPO) and other sustainability certification schemes. Currently, all big oil palm plantations are MSPO or RSPO certified to ensure environmental sustainability. DAKN2030 targets all oil palm plantations to be MSPO certified by 2030.

4.7 Land Use, Land- Use Change and Forestry Sector (LULUCF)

The LULUCF sector plays an important role in Malaysia's action to address climate change. This sector remains a net sink. Hence, it is necessary to continue to strengthen the sustainable forest management efforts of the country and enhance the forest reserves.

4.7.1 Malaysia Policy on Forestry (MPF)

The management of all types of forests is enshrined in the Malaysia Policy on Forestry (MPF) or other relevant State Forests Policy. It provides greater uniformity in implementing strategies for achieving forest conservation, management, and social and educational needs. MPF represents an important policy framework, which is unequivocal in maintaining that forest management must fulfil environmental and conservational needs besides meeting rational economic production goals. It provides a reference, guidelines and strong emphasis on the necessity for sound management, conservation, utilisation, development and protection of the forests for the three regions namely Peninsular, Sabah and Sarawak. This commitment is duly recognised and given specific attention by the National Forestry Act 1984 (Amendment 2022) (NFA). In Sabah, the necessary legal backing is provided by the Sabah Forest Enactment 1968, Forest Rules 1969 and Forest (Timber) Enactment 2015 while in Sarawak the Sarawak' Forests Ordinance 2015 (Cap.71), provides the necessary legal framework.

4.7.2 Sustainable Forest Management

To ensure sustainable forest management, a National Committee on Sustainable Forest Management in Malaysia comprising representatives from various agencies in the forestry sector, was formed in year 1994 to ensure that the International Tropical Timber Organisation's (ITTO) Criteria and Indicators on sustainable forest management are fully implemented. The standard used to measure Forest Management Units (FMUs) for certification is the MC&I Standard of Performance for Forest Management [MC&I (2001)] which is based on the 1998 ITTO Criteria and Indicator for Sustainable Management of Natural Tropical Forest. The key elements for sustainable forest management would cover economic, social, environmental and conservational aspects.

To ensure sustainable harvesting of timber, a forest certification scheme was commenced in year 2002 with the adoption of the Malaysian Criteria and Indicators (MC&I) for Sustainable Forest Management (SFM) certification. The maximum cutting limit has been capped at 85 m^3/ha. The Malaysian Timber Certification Council was established in October 1998 as an independent organisation to develop and operate the Malaysian Timber Certification Scheme (MTCS). It provides for independent assessment of forest management practices, to ensure the sustainable management of Malaysia's natural forest as well as to meet the demand for certified timber products. In year 2020, a total of 5,139,745.36 ha of natural forests and 132,989.48 ha of forest plantations have been certified under the MTCS Programme for the Endorsement of Forest Certification (PEFC) Scheme.

4.7.3 Malaysia REDD+ Strategy

A REDD+ Strategy was developed and adopted in year 2017. The strategy outlines policy actions to ensure at least 50% of Malaysia's land mass remains as forest. This is achieved through enhancing sustainable forest management, conservation activities and seeking synergies with activities under the National Policy on Biological Diversity 2016-2025.

4.8 Private Initiatives

4.8.1 Reduction of Venting and Flaring

In the Oil & Gas industry, methane is the primary source of GHG emission with most of it coming from venting and flaring activities. In line with its Pathway to Net Zero Emission 2050, PETRONAS as the key player in the oil & gas industry has implemented flare gas recovery projects, improvements in compressor capacity, vent-to-flare conversion and vent recovery projects. PETRONAS also have pledged to avoid routine flaring in new oil field developments and end routine flaring at existing oil production sites by year 2030 thus reducing its operation's GHG emission by significant amount.

4.8.2 Material Substitutions in Cement Production

In the cement industry, process emissions are primarily generated from raw material calcination (98%) and raw meal organic carbon (2%). While mitigation efforts in the industrial sector often focus on reducing energy consumption—such as utilising renewable energy and improving energy efficiency in plants—this initiative is specifically aimed at reducing emissions from cement making processes. The cement industry has shifted towards lower-carbon production methods by partially replacing clinker with other cementitious materials, such as pulverised fly ash from coal-fired power plants and granulated blast furnace slag. As such, the process emission is reduced without affecting cement production.

4.9 Detail of Mitigation Actions

The following section describes the details of identified mitigation actions based on the policy mentioned in the previous sections 4.2 until 4.8.

4.9.1 Energy Sector

The following sub-section describes the details of each sector's mitigation action in the energy.

4.9.1.1 Renewable Energy (RE)

The development of RE has gained momentum since the launch of the National Renewable Energy Policy and Action Plan in 2010. As reported in the previous BUR4, RE has remained one of the main contributors to the emissions reduction for Malaysia. Reported under RE in this section in Table SIIC4.1, Table SIIC4.2 and Table SIIC4.3.

Table SIIC4.1 **Mitigation Action Energy Sector I**

Mitigation Action	Renewable Energy (RE) implementation through Feed-in Tariff (FiT) mechanism				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	PETRA & SEDA	CO_2	National Level	2021: 1618.44 2020: 1504.16	2030: NA
Objective					
To increase the proportion of renewable energy in the fuel mix for grid electricity to enhance national electricity supply security and sustainable socioeconomic development.					
Description					
Generation of RE power for supply to the grid network from Indigenous RE sources, namely biogas (agroindustrial waste and landfill gas), biomass (agro-waste and municipal solid waste), solar photovoltaic and small hydropower which is below 30MW.					
Methodologies and Assumptions					
Emissions avoidance is quantified based on the displacement and/or reduction of the consumption of grid electricity. In this regard, three grid-electricity emission factors were used for Peninsular Malaysia, Sabah and Sarawak which were reported by the Energy Commission. Emission leakage is not considered.					
Progress Indicator					
Total electricity generation for each of the programmes (GWh).					

Table SIIC4.2 Mitigation Action Energy Sector II

Mitigation Action	Generation of Electric by Hydropower Stations				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved ($Gg\ CO_2$ eq.)**	**Expected ($Gg\ CO_2$ eq.)**
Implemented	EC, TNB, SESB, SEB	CO_2	National Level	2021: 5437.77 2020: 4219.66	2030: NA
Objective					
Diversification of sources for the generation of grid-connected electricity.					
Description					
To enhance energy security, hydroelectric power stations were incorporated as one of the sources for grid-connected electricity generation under the Four-Fuel Diversification Policy in 1981.					
Methodologies and Assumptions					
The capacity of electricity generated by each hydroelectric power is reported by EC under the Energy Balance report. Emissions avoidance is quantified based on the displacement and/or reduction of the consumption of grid electricity. In this regard, three grid-electricity emission factors were used for Peninsular Malaysia, Sabah and Sarawak which were reported by EC.					
Progress Indicator					
Total electricity generation for each of the programmes (GWh).					

Table SIIC4.3 Mitigation Action Energy Sector III

Mitigation Action	RE by public and private licensees				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	EC, TNB, SESB, SEB & Private Sector	CO_2	National Level	2021: 1618.44 2020: 1504.16	2030: NA
Objective					
To promote the use of RE resources in electricity generation.					
Description					
Power generation from RE resources such as biomass, biogas and solar photovoltaic by the private sector for both on-site and offsite consumption, including supply to the grid not under the existing RE programmes including FiT scheme and hydropower.					
Methodologies and Assumptions					
Total units of RE generated are captured by annual reports made by public and private licensees to the Energy Commission and Sarawak Energy Berhad published in the respective annual National Energy Balance and SESB Annual Report. Emissions avoidance is quantified based on the displacement and/or reduction of the consumption of grid electricity. In this regard, three grid-electricity emission factors were used for Peninsular Malaysia, Sabah and Sarawak which were reported by EC.					
Progress Indicator					
Total electricity generation for each of the programmes (GWh).					

4.9.1.2 National Energy Efficiency Action Plan (NEEAP)

The National Energy Efficiency Action Plan (NEEAP), introduced in year 2016, targeting the residential, commercial and industrial sectors to save electricity over 10 years from 2016 to 2025.

Table SIIC4.4 **Mitigation Action Energy Sector IV**

Mitigation Action	National Energy Efficiency Action Plan (2016-2025)				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved ($Gg\ CO_2$ eq.)**	**Expected ($Gg\ CO_2$ eq.)**
Implemented	EC, TNB, SESB, SEB & Private Sector	CO_2	National Level	2021: 5993.84 2020: 4869.63	2030: NA

Objective

Enhancing energy efficiency by targeting the residential, commercial and industrial sectors.

Description

The target is set to save 52,233 GWh of electricity over 10 years from 2016 to 2025, corresponding to an electricity demand growth reduction at the end of the plan about 8.0%. The key initiative is as per below: -

- **5-star rated appliances:** Promotion of 5-star rating and label for refrigerators to transform the market via more efficient models
- **Minimum Energy Performance Standards (MEPS):** Promotion of 5-star rating and label for air- conditioners to transform the market via more efficient models

Energy audits and energy management in buildings and industries: Matching grants will be provided to large and medium-sized industries and commercial buildings where free energy audit is offered and building owners are obliged to invest in energy-saving measures equal to or more than the amount of grant received. Meanwhile, large Government facilities will be retrofitted through allocation provided or Energy Performance Contract mechanism.

Co-generation: To promote co-generation in industries and commercial buildings by implementing key strategic measures to reduce barriers

Energy Efficient Building Design: Incorporating Energy Efficiency in new building designs and constructions

Methodologies and Assumptions

The data for Annual electricity savings under NEEAP programmes is compiled by the Energy Commission.

Emissions avoidance is quantified based on the displacement and/or reduction of the consumption of grid electricity. In this regard, three grid-electricity emission factors were used for Peninsular Malaysia, Sabah and Sarawak which were published by the Energy Commission.

Progress Indicator

Total electricity generation for each of the programmes (GWh).

4.9.1.3 Urban Rail-base Public Transport

As mentioned, the objective of the National Transport Policy in the previous section, the table shows the identified mitigation measures.

Table SIIC4.5 **Urban Rail- Base Public Transport**

Mitigation Action	Urban Rail-Base Public Transport				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	MoT, APAD, Prasarana, Express Rail Link Sdn Bhd, KTM Bhd	CO_2	West Peninsular	2021: 98.08 2020: 115.80	2030: NA
Objective					
To expand and integrate the urban rail public transport system. To promote reduced use of private transport and demand on road infrastructure through increasing public rail transport modal share.					
Description					
Public-private sector investment in rail-based urban mass transit infrastructure in the Klang Valley in the form of the LRT, MRT, KTM Komuter and KLIA Express Rail Link.					
Methodologies and Assumptions					
Annual ridership and average length travelled on the LRT, Monorail and KLIA Express Rail Link and KTM Komuter networks are compiled. 66.5% of the ridership is assumed to have shifted from cars to rail and 33.5% from motorcycles to rail. The number of cars and motorcycles and their corresponding commuting distance avoided are computed. The emissions avoided are calculated based on the carbon emission factor for the passenger vehicle category as reported by DEFRA, United Kingdom, or equivalent. Annual data on the operational electricity consumption of the LRT, Monorail and KLIA Express Link networks are compiled and aggregated for the years 2020 and 2021. Emissions from electricity consumption are quantified using the grid-electricity emission factor published by EC and the net emission reduction achieved is the difference between avoided emissions from not using private vehicles and emissions from rail-based public transport.					
Progress Indicator					
Daily ridership volumes on the LRT, Monorail, KLIA ERL and MRT Network.					

4.9.1.4 Promoting the use of energy-efficient vehicles (EEVs)

Table SIIC4.6 are the identified mitigation measures for the usage of energy-efficient vehicles.

Table SIIC4.6 **Promoting the use of energy-efficient vehicles (EEVs)**

Mitigation Action	Promoting the use of energy-efficient vehicles (EEVs)				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved ($Gg\ CO_2$ eq.)**	**Expected ($Gg\ CO_2$ eq.)**
Implemented	MITI, MARii	CO_2	West Peninsular	2021: 5993.84 2020: 4869.63	2030: NA

Objective

To increase the number of on the-road EEVs in Malaysia

Description

EEVs are defined as vehicles that meet a set of defined specifications in terms of carbon emission level (g CO2eq/km) and fuel consumption (L/100 km). EEVs include fuel-efficient internal combustion engine (ICE) vehicles, hybrid and electric vehicles, and alternative-fuelled vehicles.

Methodologies and Assumptions

Information on the number of registered EEV vehicles i.e. hybrid cars and electric cars are obtained from the DOSM. The difference in emissions of total EEVs on the road and the corresponding categories of conventional vehicles is then computed based on fuel requirement. Default average km driven per year per passenger vehicle in Malaysia as reported by the Malaysian Institute of Road Safety Research (MIROS) is used. Default vehicle emission factors for hybrid and electric vehicles as reported by the Department for Environment, Food and Rural Affairs (DEFRA).

Progress Indicator

Total electricity savings for each of the programmes (GWh).

4.9.1.5 Use of Palm-Based Biodiesel in Blended Petroleum Diesel

Table SIIC4.7 show identified the mitigation measures for the usage of palm oil bases in petroleum diesel.

Table SIIC4.7 Use of Palm-Based Biodiesel in Blended Petroleum Diesel

Mitigation Action	Use Of Palm-Based Biodiesel in Blended Petroleum Diesel				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	KPK	CO_2	West Peninsular	2021: 1399.19 2020: 1362.62	2030: NA

Objective

To increase the use of palm oil-based biodiesel as a renewable clean-burning petroleum diesel replacement to contribute towards reducing Malaysia's dependence on fossil fuel and enhancing sustainable socio-economic development.

Description

Blending 5% of the palm methyl ester with 95% petroleum diesel under the B5 programme, increasing to 7% palm biodiesel blended with 93% petroleum diesel under the B7 programme.

Methodologies and Assumptions

Monthly data on the quantity of biodiesel supplied to the domestic consumer market is captured from the records of the respective ministry/implementing agencies and aggregated annually.

The annual GHG emissions of displaced petroleum diesel is calculated by applying the IPCC default carbon emission factor. Leakage emission relating to the production of biodiesel is not considered.

Progress Indicator

Nationwide biodiesel consumption data compiled monthly and aggregated to annual amount.

4.9.1.6 Use of natural gas as fuel in vehicles

Table SIIC4.8 show identified mitigation measures in the usage of natural gas.

Table SIIC4.8 Use of Natural Gas as Fuel in Vehicles

Mitigation Action	Use of Natural Gas as Fuel in Vehicles				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	ME, MoF	CO_2	West Peninsular	2021: 19.31 2020: 35.86	2030: NA
Objective					
To promote the use of compressed natural gas as an alternative fuel in automobiles for enhancing environmental quality and reducing carbon emissions.					
Description					
Recognising the environmental benefits of using natural gas as a fuel source, the Natural Gas for Vehicle (NGV). The programme was initiated in 1986 as a pilot program and expanded in 1991 with an initial focus on the public transportation sector.					
Methodologies and Assumptions					
Computation of the difference in emissions between the use of alternative fuels and motor gasoline. Default emission factors of fuels based on 2006 IPCC Guidelines for National GHG Inventories.					
Progress Indicator					
Sale and consumption of NGV in the transport sector.					

4.9.1.7 Wastepaper recycling

Wastepaper recycling is one of the mitigation actions identified under the Malaysia Cleanliness Policy. Table SIIC4.9 show the mitigation measures identified.

Table SIIC4.7 **Wastepaper Recycling**

Mitigation Action	Waste paper recycling				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved ($Gg\ CO_2$ eq.)**	**Expected ($Gg\ CO_2$ eq.)**
Implemented	KPKT, JPSPN & Paper products industry	CH_4	National	2021: 4187.05 2020: 1384.01	2030: NA
Objective					
Methane avoidance through recycling of wastepaper.					
Description					
Sustainable waste management through recycling and utilisation of wastepaper for the manufacture of paper products.					
Methodologies and Assumptions					
Data on the amount of wastepaper recycled each year provided by the Solid Waste Management and Public Cleansing Corporation. The methane emissions avoided are calculated based on the total wastepaper recycled using the methodology described in the 2006 IPCC Guidelines for National GHG Inventories and IPCC default emissions factors. Methane emission is converted to CO_2 eq. using a Global Warming Potential of 28.					
Progress Indicator					
The annual amount of wastepaper recycled in tonnes.					

4.9.1.8 Biogas Recovery from Palm Oil Mill Effluent (POME) Treatment

Table SIIC4.10 Biogas Recovery from Palm Oil Mill Effluent (POME) Treatment

Mitigation Action	Biogas Recovery from Palm Oil Mill Effluent (POME) Treatment				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved ($Gg\ CO_2$ eq.)**	**Expected ($Gg\ CO_2$ eq.)**
Implemented	KPK, MPOB	CH_4	National	2021: 3702.12 2020: 3717.11	2030: NA
Objective					
To avoid the release of methane from the treatment of POME through biogas capture and destruction.					
Description					
Installation of biogas capture facilities in palm oil mills and utilisation of methane recovered for energy generation or destruction through flaring. GHG emission reductions are accounted for by methane combustion/d destruction only.					
Methodologies and Assumptions					
Data on monthly Crude Palm Oil production is reported by MPOB and aggregated. Data on the total number of palm oil mills with biogas capture facilities and the method used to recover the biogas is monitored and recorded by MPOB. The total methane emissions captured are computed based on the 2006 IPCC Guidelines for National GHG Inventories and specific parameter values established by MPOB through research. Methane emission is converted to CO_2 equivalent by using the AR5 Global Warming Potential. Emission reduction from biogas projects under FiT and Other RE by public and private licensees are excluded to avoid double counting.					
Progress Indicator					
The number of palm oil mills equipped with on-site biogas capture facilities and the annual amount of biogas captured.					

4.9.1.9 Reduction of Venting and Flaring

Table SIIC4.11 Reduction of Venting and Flaring

Mitigation Action	Reduction of Venting and Flaring				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved ($Gg\ CO_2$ eq.)**	**Expected ($Gg\ CO_2$ eq.)**
Implemented	PETRONAS	CO_2 & CH_4	Sub-National	2021: 3,937.01 2020: 1,446.92	2030: NA
Objective					
Minimise flaring and venting to decrease carbon dioxide and methane emissions associated with oil and gas production.					
Methodologies and Assumptions					
Annual GHG emissions reduction was published by PETRONAS in its PETRONAS Annual Report.					
Progress Indicator					
Emissions reduction achievement for Vent-to-flare conversion projects, compressor reliability improvement efforts, and the enhancement of leak detection and repair (LDAR) programmes.					

4.9.1.10 Material substitution in cement production

Table SIIC4.12 Material substitution in cement production

Mitigation Action	Reduction of Venting and Flaring				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	Cement Industry	CO_2	Sub-National	2021: 1542.12 2020: 1296.46	2030: NA

Objective

Replacing traditional materials with more sustainable alternatives to reduce environmental impacts.

Methodologies and Assumptions

Data on the annual amount of other cementitious materials to replace clinker in cement production.

The quantification of GHG emission reduction follows the 2006 IPCC guideline, where the amount of clinker substituted using other cementitious and alternative materials was multiplied with the emission factor for clinker calculated in the national inventory.

Progress Indicator

Amount of other cementitious materials.

4.9.1.11 MyOrganic Certification Programme

Table SIIC4.13 MyOrganic Certification Programme

Mitigation Action	Biogas Recovery from Palm Oil Mill Effluent (POME) Treatment				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	KPK, MPOB	CH_4 & N_2O	National	2021: 7.35 2020: 7.22	2030: NA

Objective

Promoting organic practices and ensuring that products meet specific organic standards.

Description

Aims to ensure the integrity and authenticity of organic products by adhering to stringent standards that prohibit synthetic pesticides, fertilizers, and GMOs. This program promotes sustainable agricultural practices that protect the environment, enhance soil health, and foster biodiversity. By providing consumers with assurance that certified products are genuinely organic, the program builds trust in the MyOrganic brand. Additionally, it supports local farmers in transitioning to organic practices through resources and education, while enhancing their access to markets for organic goods

Methodologies and Assumptions

The estimation of emission reduction from organic farming is adapted to agriculture GHG inventory, following the 2006 IPCC Guideline to quantify emissions reduction from the displacement of synthetic chemical and urea fertilizer use. Emission reduction is quantified through the reduction of CO_2 emission and the direct N_2O emission in managed soil from no use of synthetic fertilization practice.

Progress Indicator

Area of certified farms under MyOrganic programme.

4.9.1.12 Forestry (Sustainable Forest Management)

Table SIIC4.14 Forestry (Sustainable Forest Management)

Mitigation Action	Biogas Recovery from Palm Oil Mill Effluent (POME) Treatment				
Status	**Implementing Entity**	**Gas Coverage**	**Geographical scope**	**Achieved (Gg CO_2 eq.)**	**Expected (Gg CO_2 eq.)**
Implemented	NRES, KPK, State Forest Department	CO_2	National	2021: -21,872	2030: NA
Objective					
To promote sustainable forest management and conservation.					
Description					
Sustainable forest management is practised in Malaysia to ensure that the complex ecosystems rich in flora and fauna are conserved, ecosystem services provided by the forest are maintained and at the same time allowing for continuity of forest product harvest.					
Methodologies and Assumptions					
The Gain-Loss methodology from the IPCC 2006 Guidelines is used to quantify the removals and emissions from forest remaining forest category. National emission factors from National Forest Inventories and published literature are used as per the UNFCCC decisions, the results achieved are subtracted from the Forest Reference Level. The harvesting intensity is subjected to the regulatory framework.					
Progress Indicator					
Net-net approach.					

5
CHAPTER

SUMMARY OF GREENHOUSE GAS EMISSIONS AND REMOVALS

Since the Malaysia's BTR1 incorporates the NIR section and the NDC Tracking section, the summary of GHG emissions and removals is provided in the earlier/former section (Section I: National Inventory Document).

6
CHAPTER

PROJECTIONS OF GHG EMISSIONS AND REMOVALS

6.1 Introduction

In this chapter, the Malaysia's indicative GHG emissions and removals projections are presented. The projections were prepared according to paragraph 92 to 101 of the 18/CMA.1 decision. The projection year starts after latest inventory year (2021) until the end point of Malaysia's NDC implementation period (2030). The projections were prepared for all five (5) economy-wide sectors: Energy, IPPU, Waste, Agriculture and LULUCF. Malaysia reports the 'with measures' projection (named hereafter as WEM) that takes into account the currently implemented and adopted policies and measures. As the paragraph 93 of the 18/CMA.1, the projections are indicative of the impact of mitigation policies and measures on future trends in GHG emissions and removals.

6.2 Methodology

Projection of GHG emissions and removals for all sectors are done using Microsoft Excel based model. Same approach was used in all sectors where all the factors that affecting the activity data were identified and calculated using functions created based on the input from sectoral experts and information obtained from past studies to produce projected activity data in each sector. The yearly GHG emissions and removals projections were then calculated from the projected activity data using the same methodology to quantify GHG emissions and removals reported in the NIR. The assumption used for sectoral GHG emissions and removals projections are sectoral specific and explained in each sectoral projection.

6.3 Total GHG Emissions and Removals

The projection of WEM scenario is shown in Figure SIIC6.1 indicates that in year 2030, Malaysia's total projected emissions without LULUCF is estimated at 374,814 Gg CO_2 eq.

Figure SIIC6.1 **Malaysia's Total Projected Emission until 2030**

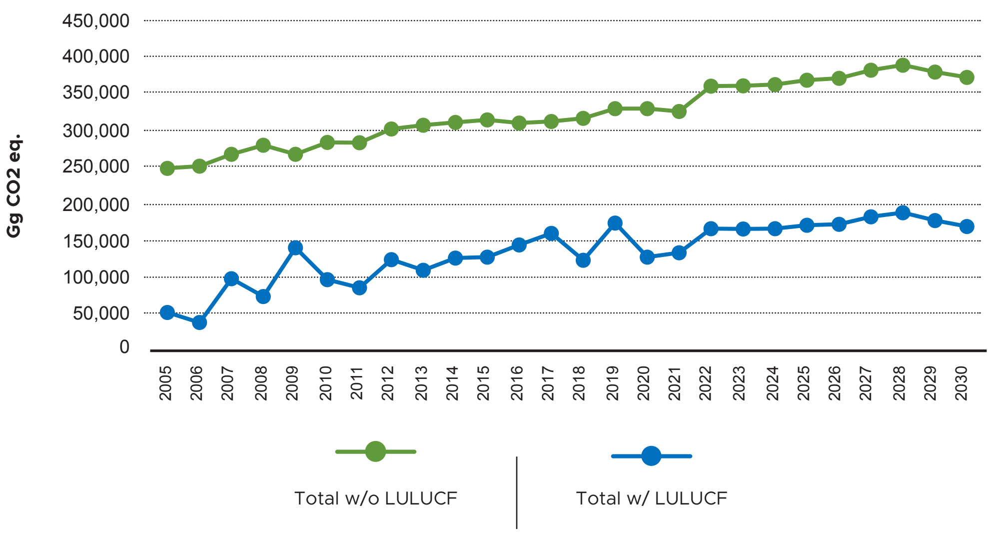
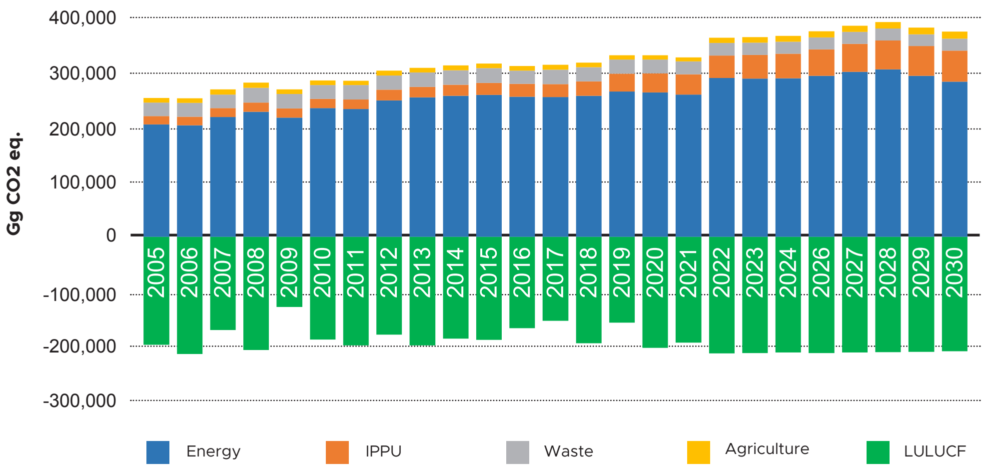


Figure SIIC6.2 **Total Projected Emission until 2030 by Sector**



The energy sector is projected to continue to be the largest contributor of GHG emissions in year 2030 followed by the IPPU and waste sectors as shown in Figure SIIC6.2. The GHG emissions from the energy sector contributes about 76% of the total emissions in year 2030. This is followed by the IPPU sector at around 14%, the waste sector at about 6% and the agriculture sector at 3%. All sectors excluding waste indicate an increase of GHG emissions in 2030 compared to GHG emissions compared the respective sector in year 2021. However, when compared to projected emissions in year 2025, the emissions from energy sector in 2030 are estimated to be relatively lower; this may indicate that the mitigation actions in the sectors e.g. the increase of RE share, increase of EVs, energy efficiency measures and reduction of flaring and venting activities contribute to the emissions reduction. Table SIIC6.1 shows the summary of the projected GHG emissions and removals by sectors for year 2021, 2025 and 2030.

Table SIIC6.1 **Projected GHG Emissions by Sector under WEM Scenarios in 2020, 2025 and 2030 (Gg CO_2 eq.)**

Sector	2021	2025	2030
Energy	259,667	290,797	283,668
Industrial Processes and Product Use (IPPU)	37,028	46,365	56,517
Agriculture	7,310	10,824	12,832
Waste	23,667	22,241	21,797
Land Use, Land-Use Change and Forestry (LULUCF)	-212,284	-228,674	-230,107
Total emissions without LULUCF	**327,672**	**372,845**	**374,814**
Total emissions with LULUCF	**115,383**	**144,170**	**144,706**

6.4 Energy Sector

6.4.1 Key Summary

The energy sector has been integral to Malaysia's socio-economic development. The emission projection of the energy sector by year 2030 shows an overall increasing trend. The overall GHG emissions from energy industries category may fluctuate as the GHG emissions in year 2030 are estimated to be relatively lower compared to year 2025. For transportation sector, the GHG emissions are estimated to increase. That said, the related mitigation actions in transportation sector are estimated to contribute to curb the GHG emissions from increasing even higher. For the industrial manufacturing and construction categories, the GHG emissions are estimated to increase provided the growth of industrial activity. The GHG emissions for fugitive emissions are projected to decrease as the flaring and venting activities are expected to reduce. Other categories are projected to increase but the magnitude may be relatively small compared to the energy industries, transportation, manufacturing industries and construction and fugitive emissions categories.

6.4.2 Assumption

Table SIIC6.2 summarises the assumptions used for the energy sector projection. Some of the assumptions are derived from the mitigation actions listed in Chapter 3 (in this section) above while others were derived from existing and planned policies after consultation with the implementing ministries and agencies.

Table SIIC6.2 List of Assumption Used for Energy Sector Projection

Policies and Initiative	Assumption
Electricity Demand Forecast	• Demand growth for electricity stay constant at 3.1% per annum for Peninsular Malaysia 2021 onwards. • Sabah electricity demand growth at 4.8% per annum until 2026 and 1.4% onwards.
Renewable Energy Initiatives	• Sarawak electricity demand growth at 1.4% per annum. • By 2030, RE installed capacity for Peninsular Malaysia increased to 30 % share of total installed capacity. • Hydro power capacity in Sarawak increased to at 4,743 MW

Policies and Initiative	Assumption
Generation of Power from Coal Power Plant	▸ Reduced dependency on coal. ▸ Installed capacity of coal power plants reduced to 29% in year 2030 for Peninsular Malaysia. ▸ No new coal power plant planned.
Energy Efficiency Initiatives in Electricity Consumption	▸ Energy savings assumed 8% by year 2025 based on NEEAP projection in policy implementation and further improvement of 11 % energy savings by year 2050.
Fuel Shifting Initiative in Industry Sector	▸ Mandate on B7 biodiesel in the industrial sector from 2019 onwards. ▸ Assume 20% biomass/waste fuel mix in cement production from 2023 onwards.
Energy Efficiency Initiatives in Fuel Consumption	▸ Assume technology improvements for heating lead to 1.5% improvement in energy usage per annum in commercial and industrial sectors.
Road Vehicle Trend	▸ New passenger vehicle growth at 1.2% per annum. ▸ New commercial vehicle growth at 0.6% per annum. ▸ Vehicle retirement rate is at 5% for passenger vehicle and 7% for the rest of vehicle categories. ▸ Average VKT for passenger vehicle (21,000 km/year) and commercial vehicle (65,000 km/year). ▸ Average fuel consumption is 0.06 L/km (passenger vehicle) and 0.11 L/km (commercial vehicle).
Low Carbon Mobility	▸ Assume progressive introduction of electrical vehicles to by targeting 15% of vehicles sales are electric vehicles in year 2030 and 38% by year 2040. ▸ Public transportation modal share assumed to reach 40% by 2040.
Biofuel Initiative (Reduce diesel dependence and emissions by blending petroleum diesel with biodiesel)	▸ Mandate on B10 biodiesel in the transportation sector from year 2019 onwards and improve to B30 from year 2025 onwards.
Oil & Gas Production Forecast	▸ Oil production growth at -7.5% per annum until year 2040. ▸ Gas production growth at -6.8% per annum until year 2040.
Improvement in Natural Gas Transformation	▸ Improvement of 1% in plant operations and plant energy efficiency.
Improvement in Oil Refining Industries	▸ Improvement of 1% in plant operations and plant energy efficiency.
Reduction of Fugitive Emissions	▸ Zero routine flaring and 30% venting emission reduction by year 2030. ▸ 30% methane emission reduction in natural gas supply chain by year 2030.

6.4.3 Energy Sector Emission Projection

The total projected emission in energy sector is 283,668 Gg CO_2 eq. in year 2030. Half of the emission projected come from energy industries activities, followed by transportation and manufacturing industries and construction which constitute 24.24% and 17.82% of the total emission each. The balance of 7.92% includes fugitive emissions, other fuel combustion and non-specified activities.

Figure SIIC6.3 shows the trend of projected emissions for energy sector to the year 2030. As the largest contributor to the overall economy-wide emission, the trend for energy sector emission relatively influences the trend of economy-wide emissions.

Figure SIIC6.3 **Energy Sector Projected Emission up to 2030**

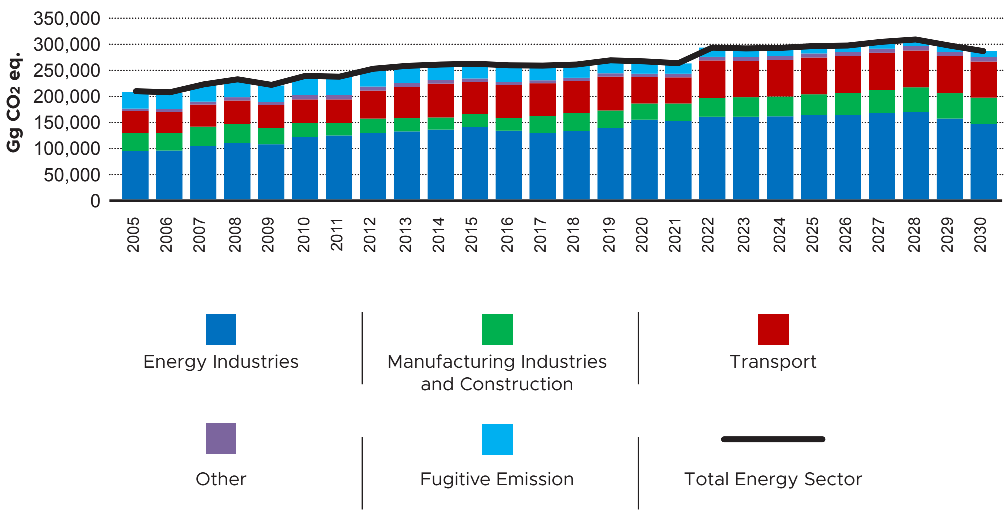


Table SIIC6.3 **Energy Sector Projected Emissions by Sub-Sectors (Gg CO_2 eq.)**

Sector	2021	2025	2030
Energy Industry	146,319.88	158,052.74	142,628.73
Manufacturing Industries and Construction	33,702.95	39,703.18	50,533.48
Transport	49,575.98	70,088.99	68,810.49
Others	7,032.23	7,591.56	8,670
Fugitive	19,746.12	15,055.53	12,021.49
Total Emissions	**259,666.05**	**290,796.85**	**283,668.10**

6.4.4 Energy Sector Emission by Gas

Figure SIIC6.4 to SIIC6.6 shows the projection of emissions in energy sector by gasses.

Figure SIIC6.4 **Projected CO_2 Emission in Energy Sector**

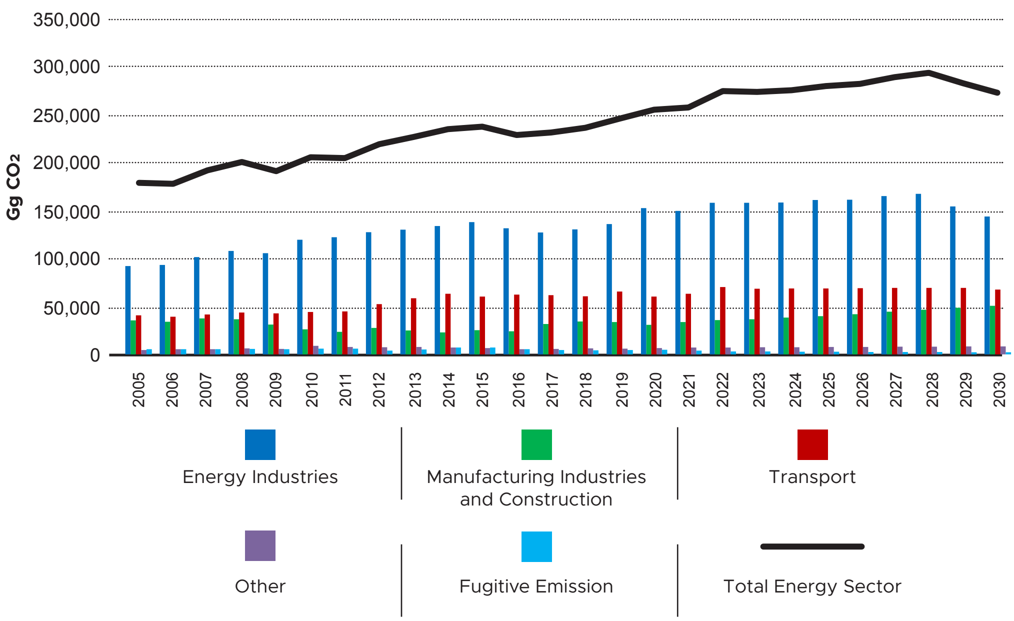


Figure SIIC6.5 **Projected CH_4 Emission in Energy Sector**

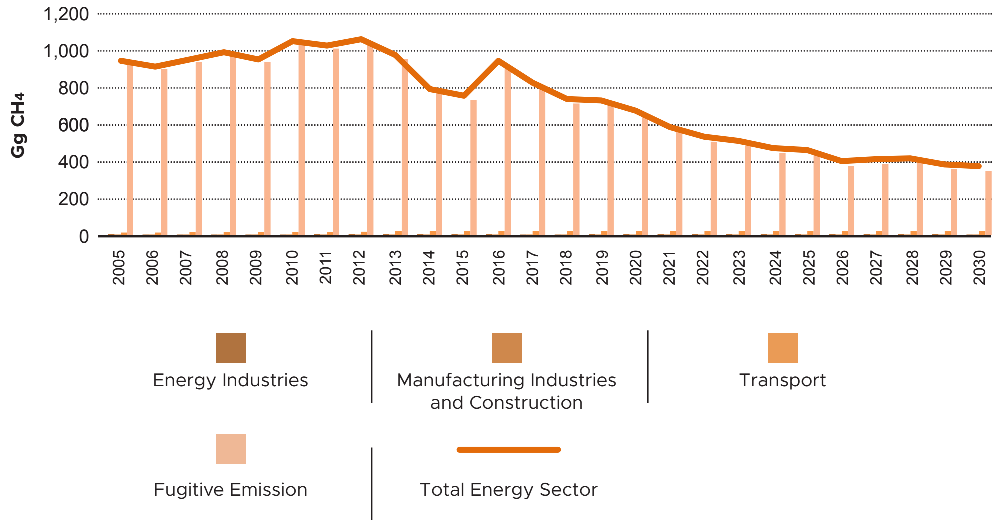
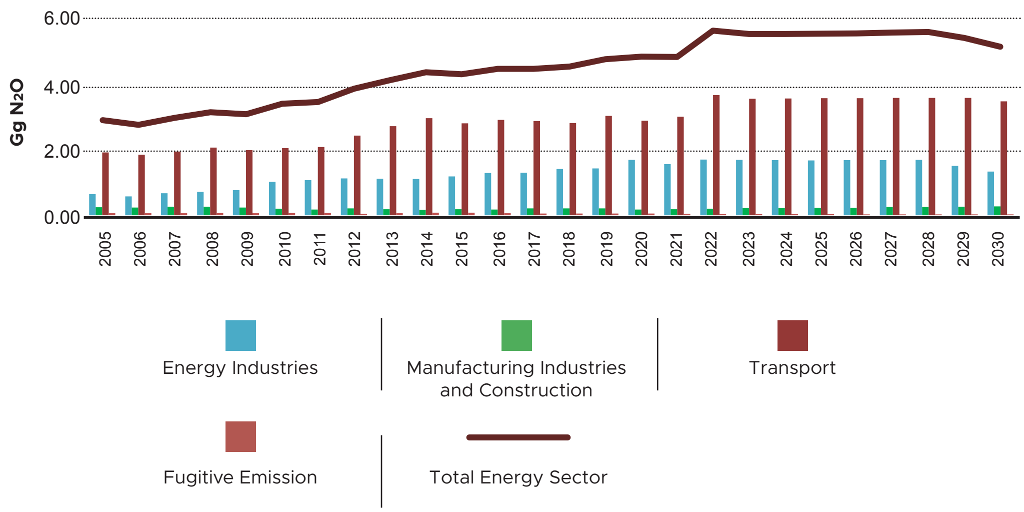


Figure SIIC6.6 **Projected N_2O Emission in Energy Sector**



From Figure SIIC6.4, CO_2 emission is projected to be at 271,727 Gg CO_2 in year 2030. Energy industries contribute the most CO_2 gas emission in the energy sector with 143,179 Gg CO_2 or 52.71% of total CO_2 emission.

As for CH_4 emission, Figure SIIC6.5 shows that most of the CH_4 emission come from the fugitive emission which constitute 94% of overall CH_4 gas emitted in energy sector, mainly from flaring and venting activities. As the number of routine flaring and venting reduced through mitigation actions, overall CH_4 emission is projected to decreases to 376.20 Gg CH_4 in year 2030.

Transportation sectors remain as the main source of N_2O emissions in the energy sector as shown in Figure SIIC6.6 with 67.48% or 3.44 Gg N_2O in year 2030, followed by energy industries with 25.9% or 1.31 Gg N_2O. There slight decrease of N_2O projected emission after year 2028 is estimated due to the declining numbers of coal power plants in energy industries.

6.5 Industrial Processes and Product Use (IPPU) Sector

6.5.1 Key Summary

The industrial sector in Malaysia is one of key drivers of the nation’s economy. As a relatively major contributor to GDP and employment, this sector's activities—ranging from electronics and automotive manufacturing to machinery and chemicals—result in substantial energy consumptions[43] and process emissions.

GHG emissions from industrial processes were projected to increase by year 2030 due to expansion of production capacity, especially in the iron and steel industry[44]. Estimated GHG emissions from the mentioned industry would depend on control on the number and capacity of mills approved for production.

[43] The projected energy emissions for the industries are classified according to the 2006 IPCC Guidelines i.e under energy sector.
[44] For the iron and steel industry in Malaysia, there are two (2) types of steelmaking production technology pathways utilised i.e. EAF and BOF. The BOF method emits relatively higher amount of GHG compared to the EAF. Hence, the GHG emissions from the iron and steel industry projected are estimated to be mainly from the BOF production pathway.

6.5.2 Methodologies and Assumption

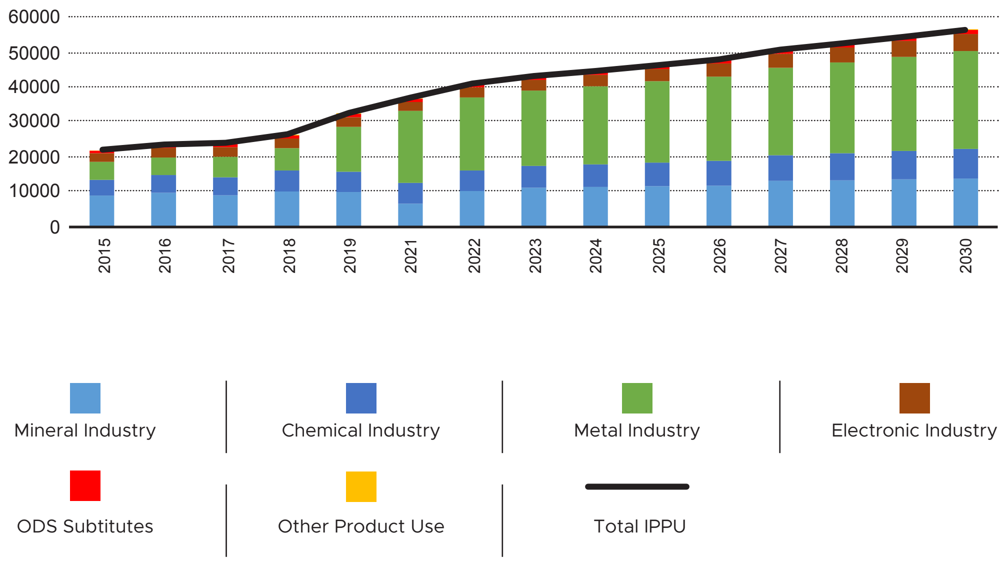
In this projection, the GHG emissions of the sub-sectors except for cement and iron and steel industries were basically based on production growth rates. Table SIIC6. 4 summarise the assumption of growth used for this projection. Since reduction of emissions from energy usage has been taken into account in the energy sector calculations, this section shall only concentrate on the reduction of process emission from various IPPU sub-sectors.

Table SIIC6.4 **List of Assumption Used for IPPU Sector Projection**

Policies and Initiative	Assumption
Industry Growth Rates	▸ Chemical Industry – 4.6% per annum ▸ Aluminium Industry – no additional capacity plan up to year 2030 ▸ Ferroalloy industry – 4.6% per annum ▸ Electronics manufacturing industry – 6.5% per annum ▸ Power Industry – 4% per annum ▸ Food industry – 5.1% per annum ▸ Petro chemical industry – 4.1% per annum
Material Substitution in Cement Production	▸ Clicker substitution ratio 15% by year 2030
Iron and Steel Demand Growth	▸ 1.9% per annum

6.5.3 IPPU Sector Emission Projection

Figure SIIC6.7 **IPPU Sector Projected Emission**



Based on the aforementioned assumptions, the projected GHG emission growths for the IPPU sector are as shown in Figure SIIC6. 7. From the figure, the GHG emission in the IPPU sector is projected to increase from 37,028 Gg CO_2 eq. in 2021 to 56,516 Gg CO_2 eq. in year 2030. The increment of GHG emission in IPPU sector is largely contributed by iron and steel industries due to the expansion of production capacity after year 2019 onwards. Table SIIC6.5 shows the GHG emissions for each sub-sector for year 2021, 2025 and 2030.

Table SIIC6.5 IPPU Sector Projected Emissions by Sub-Sectors (Gg CO_2 eq.)

Sector	2021	2025	2030
Mineral Industry	6,757.89	11,692.25	13,881.06
Chemical Industry	6,080.95	6,742.38	8,515.58
Metal Industry	20,542.76	23,241.51	27,916.13
Electronics Industry	2,563.66	3,491.30	4,859.29
Product Uses as Substitute for ODS	928.04	1,016.78	1,122.60
Other Product Manufacture & Use	155.05	183.03	221.88
Total Emissions	**37,028.25**	**46,367.23**	**56,516.53**

Note: ODS refers to Ozone Depleting Substances

6.5.4 Emission Projection by Gas

Figure SIIC6.8 to Figure SIIC6.11 shows the projection of emissions in IPPU sector by gasses including f-gasses.

Figure SIIC6.8 IPPU Sector Projected CO_2 Emission

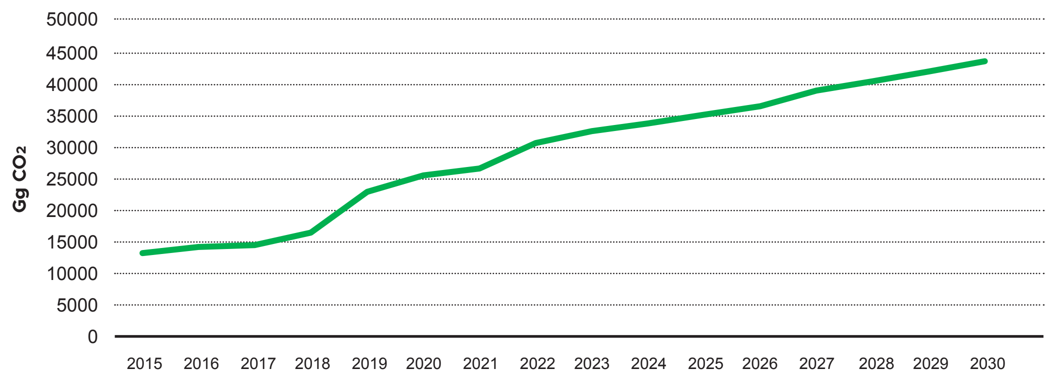


Figure SIIC6.9 **IPPU Sector Projected CH_4 Emission**

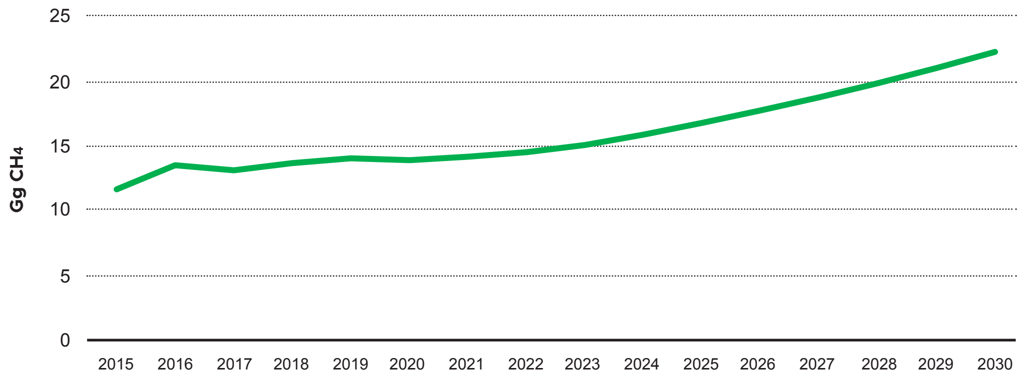
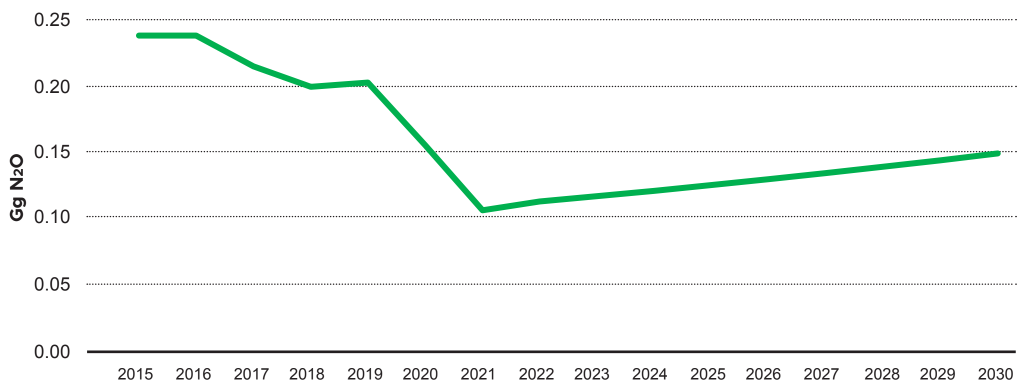
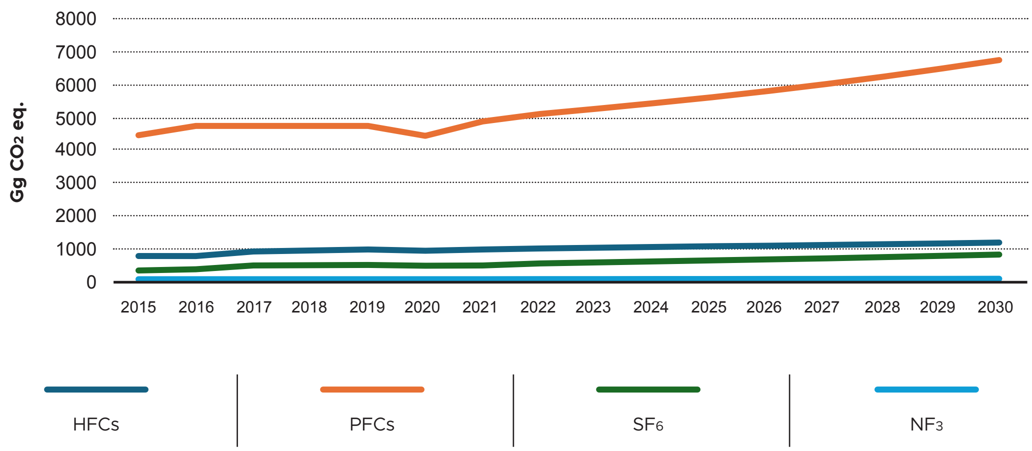


Figure SIIC6.10 **IPPU Sector Projected N_2O Emission**



CO_2, CH_4 and N_2O emissions in IPPU sector are projected to increase steadily towards the year 2030. The increase of emissions especially CO_2 and CH_4 was due to the expansion of iron and steel industry and also the increased production across all industrial sector where it is assumed that the growth will be as same as pre-COVID-19 period, from year 2022 onwards.

Figure SIIC6.11 **IPPU Sector Projected F-Gasses Emissions**



As for the f-gasses, the amount of emission is also projected to increase as semiconductor manufacturing industries are expected to expand. The increase of aluminium and photovoltaics production capacity also contributes to the relatively higher PFC emissions projected.

6.6 Waste Sector

6.6.1 Key Summary

The waste sector in Malaysia plays a significant role in the country's environmental management and sustainability efforts. It encompasses the collection, treatment, and disposal of various types of waste, including municipal solid, industrial, hazardous and others.

As reported in the inventory section, total waste sector emissions in the year 2021 are 23,667.15 Gg CO_2 eq. The primary significant sources of emissions were solid waste disposal and wastewater treatment and discharge (domestic and industrial). Using year 2021 emissions as a baseline for the projection, the waste sector emissions were estimated to decrease in year 2025 to 22,241.48 Gg CO_2 eq. and for 2030 is approximately 21,796.55 Gg CO_2 eq. The primary source of emission includes the solid waste disposal and wastewater treatment and discharge (domestic and industrial).

6.6.2 Waste Projection Methodology

The waste emission projections for year 2022 to 2030 are based on methodologies in accordance with the IPCC guidelines. It considers the categories classified under the sector which include solid waste disposal, wastewater treatment, incineration and open burning.

Compared to other sectors, the waste sector emits relatively more amounts of methane gas compared to other gasses. Therefore, in the projection scenario, mitigation efforts will primarily focus on reducing methane emissions from solid waste disposal sites and Palm Oil Mill Effluent (POME). Table SIIC6.6 provides a summary of the mitigation action scenarios projected for the period 2022 to 2030.

Regarding methane recovery from POME, there were 135 out of 451 mills were fully equipped with biogas capture facilities in 2021. According to the Fourth National Communication (NC_4), the projected yearly increase of mills with biogas capture facilities is expected to be five (5) per year.

Table SIIC6.6 **Summary of Mitigation Actions by Scenarios for the Waste Sector**

Mitigation Action	Scenario
Increased solid waste recycling rate consists of encouraging waste separation at source, paper recycling activities, reduction of organic waste generation, and encouraging 3R and using waste as a resource of other industries.	The national recycling rate will increase from 37.5% in 2021 to 38% in the year 2025; and is considered constant at 38% until 2030.
Increase proper treatment of industrial wastewater by increasing capture of methane from POME by installation of biogas facilities in existing palm oil mills.	The number of biogas capture facilities at POME treatment sites increased by five per year. Methane captured in POME biogas treatment facilities is 50% for flaring and 50% for energy in 2021 and increase to 75% for energy and 25% for flaring from 2022 onwards. The flaring efficiency of methane increased from 50% in year 2021 and 89% in year 2022 onward.

6.6.3 Waste Sector Projection Trend

As per Figure SIIC6.12,the overall trend for waste emission projection is estimated to generally decrease as the year 2022 with 22,743.96 Gg CO_2 eq. and end year 2030 projected about 21,798.13 Gg CO_2 eq. The overall trend indicates the mitigation actions to be conducted may contribute to the GHG emissions reduction.

Figure SIIC6.12 **Overall Projected GHG Emission for the Waste Sector**

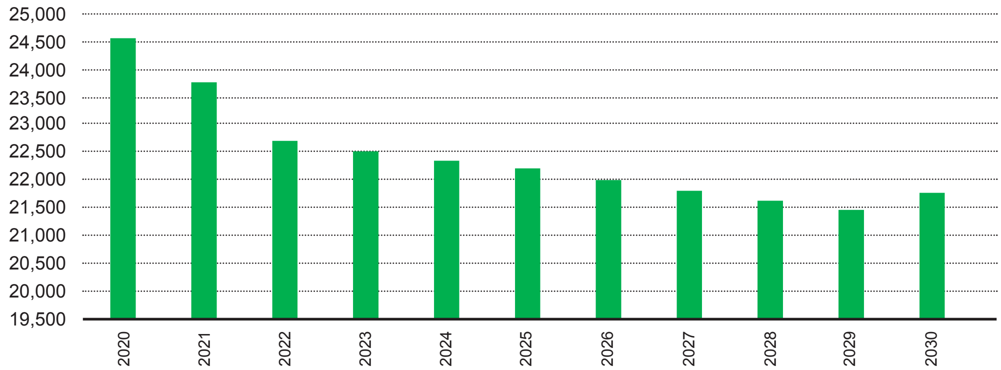
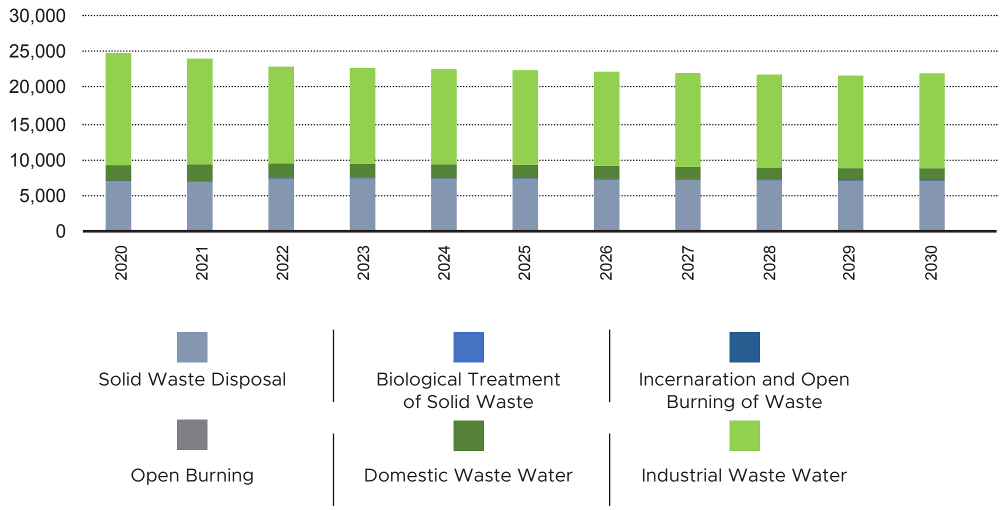


Figure SIIC6.13 **Overall Projected GHG Emission for the Waste Sector**



Additionally, based on Figure SIIC6.13 above, wastewater and solid waste disposal was identified as the largest emitter for the waste sector as it is also associated with other economic activities. However, with the mitigation actions undertaken, the emissions can be reduced. Table SIIC6.7 shows that the emissions of each category under the waste sector.

Table SIIC6.7 **Projected GHG Emission for the Waste Sub-Sectors year 2021, 2025 & 2030**

Sub-sector	2021	2025	2030
Solid Waste Disposal Sites	6,847.50	7,245.37	7,002.18
Biological Treatment of Solid Waste	0.31	0.36	0.43
Incineration	64.89	92.13	140.67
Open Burning	2.89	2.39	1.58
Domestic Wastewater	2,304.24	1,812.99	1,530.82
Industrial Wastewater	14,590.84	13,090.63	13,122.45
Total Emissions (Gg CO_2 Eq.)	**23,810.67**	**22,243.86**	**21,798.13**

6.6.4 Waste Sector Projection Trend by Gasses

Based on the type of gasses, CO_2 and N_2O shows the increasing trend by end of 2030. However, for methane, the emissions trend is estimated to decrease although the amount will be still relatively high compared to other gasses by end of 2030. Figure SIIC6.14 shows the projected GHG emission for the waste sector by gasses. Table SIIC6.8 provides the projected GHG emissions by gasses for 2021, 2025 and 2030.

Figure SIIC6.14 Projected GHG Emission for the Waste Sector by Gasses

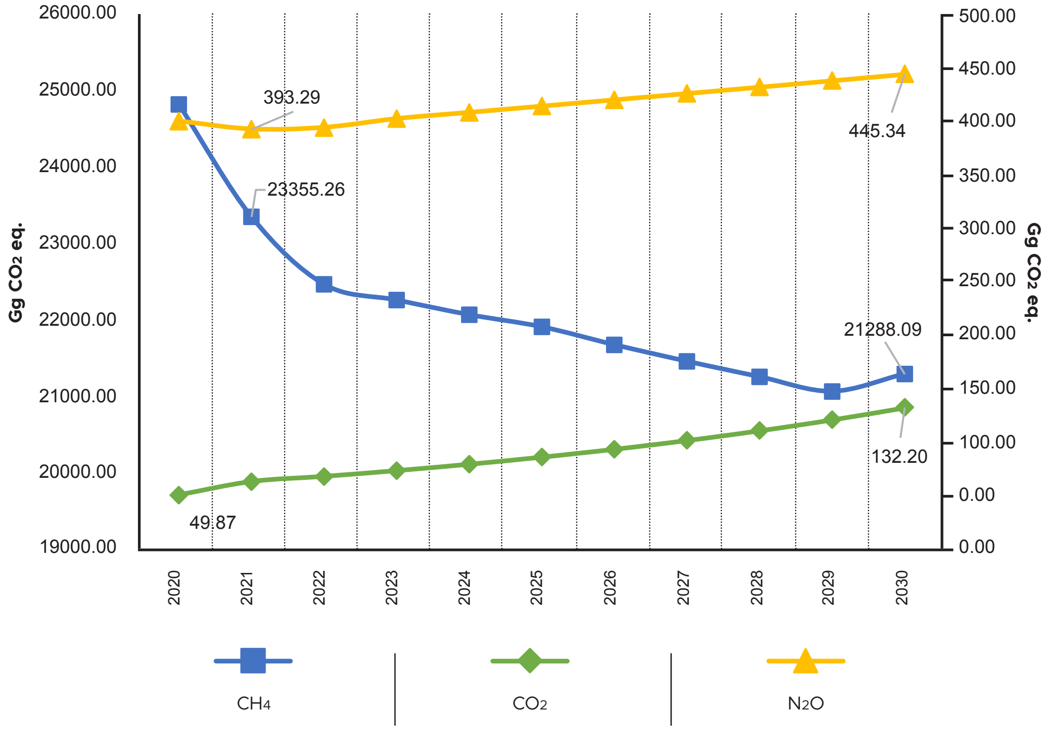


Table SIIC6.8 Projected GHG Emissions by Gasses for 2021, 2025 & 2030

Gasses	2021	2025	2030
Total Emissions for Methane (CH_4)	23,355.26	21,908.65	21,288.09
Total Emissions for Nitrous oxide (N_2O)	393.29	415.06	445.34
Total Emissions for Carbon Dioxide (CO_2)	62.48	85.53	132.20
Total Emissions (Gg CO_2 eq.)	**7,310.04**	**10,369.75**	**11,010.04**

6.7 Agriculture Sector

6.7.1 Key Summary

The agricultural sector contributes to the food security, employment, and export revenue in year 2021, the sector contributed RM98.9 billion (7.1%) to the total GDP of RM1,386.7 billion, underscoring its pivotal role in the Malaysian government's revenue. This sector is relatively vital considering the increasing demand for food due to the population growth, urbanisation, changing consumption patterns and the looming threat of climate change.

As reported in the inventory chapter, in the year 2021 agricultural sector contributed total emissions of 7,310.04 Gg CO_2 eq. By using year 2021 emissions as baseline for the projection, the agriculture sector emissions were estimated to increase in 2025 to 10,823.73 Gg CO_2 eq. in year 2025, and approximately 12,832.36 Gg CO_2 eq. five year later. Based on the projection, the manure management and indirect N_2O Emissions from managed soil sectors were identified as the main contributors to the emissions.

6.7.2 Agriculture Projection Methodology

The National Agrofood Policy 2.0 (NAP 2.0) 2021-2030 is the important reference pertains to food and nutrition security. The framework is designed to promote sustainable agricultural practices, boost productivity, and ensure food security. One of its central goals is to achieve the self-sufficiency rate (SSR) targets for various food commodities as outlined in Table SIIC6.9. With NAP 2.0, the government is taking proactive steps to secure the nation's food future.

Table SIIC6.9 Summary of the Self-sufficiency Rate (SSR)

Food Commodities	Self-sufficiency Rate (SSR) Target	
	2025	2030
Rice	75%	80%
Beef	25%	25%
Poultry Meat	120%	140%

Achieving these SSR targets is closely linked to agriculture emission projections, as higher SSR levels will affect activities data. Malaysia's agricultural emission projections for the period of 2022 to 2030 were aligned with the SSR targets and based on methodologies according to the IPCC guidelines. Malaysia, which also prioritises food security, may regard the SSR targets are required to be met as the planned policy while minimizing emissions from the agricultural sector.

Reducing emissions, particularly from agriculture, is an important part of this strategy. Good agricultural practices will include optimising the use of synthetic fertilizers for crop yields and applying the 4R principles to manage fertilizer use efficiently, which are listed below:

- Right N application rate
- Right formulation (fertilizer type)
- Right timing of application, and
- Right placement

The projection for the agriculture sector also considers a potential reduction of synthetic fertilizer application by 10% through the 4R strategy, particularly in oil palm cultivation, which is the largest crop in the country. Table SIIC6.10 outlines the scenario for improved nitrogenous fertilizer management in oil palm cultivation:

Table SIIC6.10 **Mitigation Scenarios Oil Palm Cultivation**

Mitigation Action	Scenario
Improved nitrogenous fertilizer management for oil palm cultivation.	The application rate of fertilizer usage is 90 kg N per year per hectare for young oil palms and 105 kg N per year per hectare for mature oil palms.

Additionally, KPK plays a key role in regulating oil palm cultivation by restricting land usage to a maximum of 6.5 million ha by year 2030. This restriction also was used as an input for the emission modelling scenarios.

For rice cultivation, NAP 2.0 and its action plan aim to increase productivity per hectare, particularly in the irrigated granaries. The target is to reach seven (7) tonnes of paddy yield per hectare by year 2030. However, for modelling purposes, a mid-value of 5.7 tonnes per hectare was used based on the historical average productivity yield of 4.576 tonnes per hectare from 2005 to 2019.

6.7.3 Agriculture Sector Projection Trend

The projected GHG emissions for the agriculture sector are shown in Figure SIIC6.15 and Table SIIC6.11. The projections indicated that the GHG emissions for the agriculture sector would grow from 7,310.04 Gg CO_2 eq. in year 2021 to 12,832.36 Gg CO_2 eq. in year 2030.

Figure SIIC6.15 **Projected GHG Emissions for the Agriculture Sector**

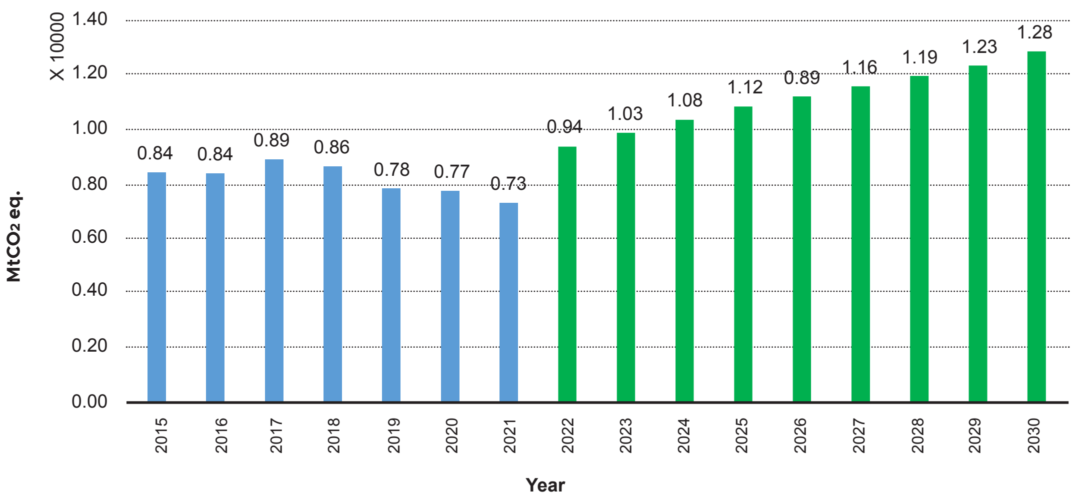


Table SIIC6.11 **Projected GHG Emission for the Agriculture Sub-Sectors Mitigation Scenarios in 2020, 2025 and 2030 (Gg CO_2 eq.)**

Sub-sector	2021	2025	2030
Enteric Fermentation	1,247.65	2,183.06	3,445.42
Manure Management Biomass burning in Croplands	287.84	366.97	460.16
Liming	17.18	13.97	16.46
Urea Application	394.47	31.69	32.55
Direct N_2O Emissions from managed soils	2,201.35	554.01	590.83
Indirect N_2O Emissions from managed soils	542.71	3,564.61	3,920.13
Indirect N_2O Emissions from manure management	108.71	1,017.16	1,127.06
Rice cultivations	2,499.50	138.08	186.27
Total Emissions	**7,310.04**	**7,869.55**	**9,778.88**

6.7.4 Agriculture Sector Projection Trend by Gasses

The biggest emission is released from CH_4 gasses, followed by N_2O gas and CO_2 Gas. CH_4 is the highest gas increase due to activity from rice cultivation and manure management compared to other categories. Figure SIIC6.16 and Table SIIC6.12 provide the projected GHG emissions for agriculture by gasses in graphical and tabular format each.

Figure SIIC6.15 Projected GHG Emissions for the Agriculture Sector

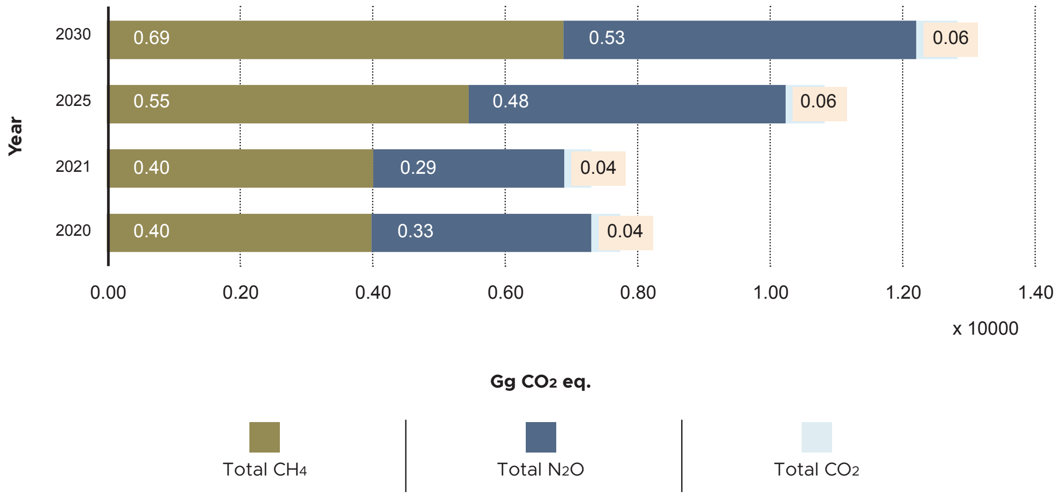


Table SIIC6.12 Projected GHG Emission for Agriculture by Gasses (Gg CO_2 eq.)

Sub-sector	2021	2025	2030
Total Emissions for Methane (CH_4)	4,016.39	5,459.85	6,887.94
Total Emissions for Nitrous oxide (N_2O)	2,882.00	4,778.19	5,321.05
Total Emissions for Carbon Dioxide (CO_2)	411.65	585.70	623.38
Total Emissions	**7,310.04**	**10,823.73**	**12,832.36**

6.8 LULUCF Sector

6.8.1 Key Summary

As of 2020, 54.6% of Malaysia's total land area, equivalent to 18.05 million ha , is covered by forests. Additionally, 8.3 million ha (25%) are designated as cropland, while 2.5 million ha (8%) are allocated for settlement purposes, with the remaining four (4) million ha comprising wetland and grassland areas.

Inland forests represent the largest portion of Malaysia's forest cover at 70%, followed by peatlands at 14%, plantation forests at 13%, and mangrove forests at 3%. Sarawak holds the highest forest cover, accounting for 7.7 million ha (42%), followed by Sabah with 4.7 million ha (26%), and the remaining 5.7 million ha situated in Peninsular Malaysia (32%).

In year 2021, total GHG emissions and removal under LULUCF sector was -212,284 Gg CO_2 eq. and projected to be at -230,107 Gg CO_2 eq. in year 2030.

6.8.2 Key Assumption

Malaysian forest plays a major role in removing the country emission. As such, reducing deforestation and maintaining forest cover is the key driver to maintain the volume of carbon sink available. However, the increase of population together with increased demand for cropland, energy and transportation infrastructure has put the forest under pressure. Under Malaysia Forestry Policy and REDD+ Strategy, the absolute minimum forest cover is pegged at 50% of the total land area and the rate of deforestation is to be reduced to 55,000 ha per year. Apart from maintaining the carbon stock, forest also is one of the sources of economic activities. To ensure that commercial harvesting does not give negative impact towards forest sustainability, the amount of wood harvested is limited to 85m^3/ha under Sustainable Forest Management.

By putting everything in perspective and based on historical data, the key assumptions used are summarised in Table SIIC6.13.

Table SIIC6.13 **Summary LULUCF Projection Assumption**

Key Driver	Assumption
Deforestation rate	Assumed 0.14% per annum (limited at 55,000 ha annually)
Cropland expansion	Palm oil area cap at 6.5million ha by year 2030 Rubber plantation area growth rate 1% per annum Cocoa plantation area 10,000 ha by year 2030
Built up area expansion	1.4% p.a for Peninsular 20,000ha p.a for Sabah and Sarawak
Commercial harvesting	Growth rate 1.77% p.a

6.8.3 LULUCF Sector Projection Trend[45]

Figure SIIC6.17 shows the projected GHG emissions and removals for the LULUCF sector will be –230,107 Gg CO_2 eq. in year 2030. The overall trend of LULUCF sector is largely flat from year 2021 to year 2030. Although the total number of forest land decreased as some of the state forests were converted into settlements and cropland, the expansion of cropland especially rubber plantation area does help in reducing the loss of carbon stock. Moreover, based on historical data, the amount of area under Total Protected Area has increased by 8% from total forested area in year 2021 compared to year 2000 and projected to increase another 3% by year 2030.

[45] Projection values does not include item 3C.4 – Direct N_2O and CH_4 as it has been projected under Agriculture Sector

Figure SIIC6.17 PProjected GHG Emission for the LULUCF Sector

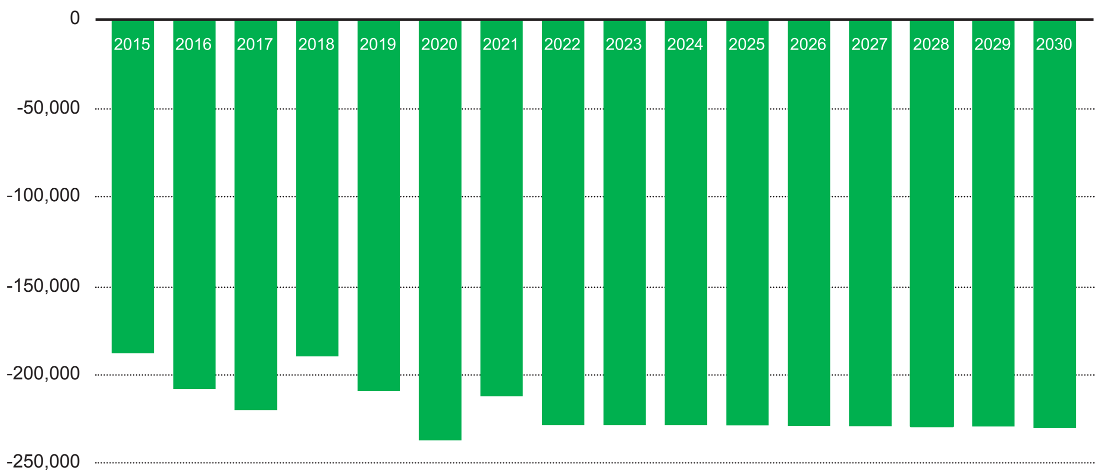


Table SIIC6.14 Projected GHG Emissions for the LULUCF in 2025 & 2030

Sub-sector	2021	2025	2030
Forest Land Remaining Forest Land	-248,823.48	-245,370.36	-242,482.15
Cropland Remaining Cropland	-278.04	-2,013.10	-6,407.18
Grassland	105.08	105.08	105.08
Wetlands	0.65	0.66	0.67
Settlements	34,795.51	18,311.92	18,676.19
Total Emissions	**-214,200**	**-228,674**	**-230,107**

7
CHAPTER

OTHER INFORMATION

7.1 Introduction

In this chapter, information on the recent development that occur during the preparation of this section relevant to tracking progress made in implementing and achieving Malaysia's NDCs under Article 4 of the Paris Agreement will be provided.

7.2 Voluntary Cooperation Under Article 6 of the Paris Agreement

Malaysia has started to establish voluntary cooperation under Article 6 with parties and it is expected to be implemented during Malaysia's NDCs implementation period. Based on Malaysia's updated NDCs (2021), it is stated that Malaysia does not intend to use voluntary cooperation under Article 6 of The Paris Agreement for its NDCs. Therefore, voluntary cooperation under Article 6 established between Malaysia and other parties will deliver additional mitigation outcome beyond the NDCs. Information related to the voluntary cooperation will be communicated in the future reports.

7.3 Projections of GHG Emissions and Removals

The data sets that were used for projections of GHG emissions and removals was recently updated with new sets of data and parameters that have a significant impact on the future emissions and removals projection, specifically under energy and IPPU sector. The updated data and parameters are yet to be endorsed under the respective sectoral institutional arrangements and legal framework. Therefore, the updated data and parameters are not included as part of GHG emissions and removals in this report.

III

SECTION

INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT

3.1 National circumstances, institutional arrangements and country-driven strategies

Effectively addressing climate change requires a multi-dimensional approach that integrates financial, technical, and human resources. For countries like Malaysia, achieving meaningful progress hinges on access to financial capital, technology, and capacity-building initiatives that enable the adoption of low-carbon solutions and enhance resilience to climate impacts.

Malaysia has embedded climate considerations into its national development plans, reflecting a commitment to a sustainable, low-carbon future. This strategic approach ensures that climate actions are not treated as standalone efforts but are integrated into broader economic and social development programmes. Through these actions, Malaysia seeks to balance its economic growth aspirations with its responsibility to reduce GHG emissions and strengthen adaptive capacity.

Despite national efforts, Malaysia continues to seek international support to bolster its climate action, especially in areas where local expertise, technologies, and financing mechanisms are limited. The country actively pursues support from multilateral and bilateral sources, particularly for projects involving the development of carbon markets, pricing mechanisms, and sustainable financing tools. These initiatives are crucial not only for meeting Malaysia's NDCs targets but also for progressing towards the long-term goal of net-zero GHG emissions by year 2050.

Malaysia recognises the need for further technical and financial assistance to enhance its capability to accurately estimate GHG emissions and removals. Additionally, there is a continuous need for capacity-building and technical support to improve national systems for tracking and implementing mitigation and adaptation actions.

To ensure a systematic approach to climate issues, Malaysia has established an intricate institutional arrangement as part of the BTR1 framework. As shown in the institutional structure diagram (refer to Figure SIC1.2), the highest level of the institutional structure sits the Majlis Tindakan Perubahan Iklim Negara (MTPIN), which oversees the national climate agenda. Beneath it, the National Steering Committee on Climate Change (NSCCC) sets strategic directions for climate action. Reporting to the NSCCC is the Technical Committee on Climate Change (TCCC), which manages and coordinates various technical aspects of climate initiatives across Malaysia. Within this hierarchical structure, the TWG on Finance, Technology and Needs operates under the TCCC, underscoring its role in providing technical support while ensuring alignment with national climate objectives.

3.2 Information on financial support needed by developing country Parties under Article 9 of the Paris Agreement

Malaysia continues to face significant challenges in implementing its climate change commitments. These challenges span across securing adequate financing, especially in light of competing demands from other development programmes, post-pandemic recovery, technological gaps, and limitations in technical and human capacity.

The government's recent initiatives, including the Ekonomi MADANI framework, the Mid-Term Review of the Twelfth Malaysia Plan (2021–2025), the National Energy Transition Roadmap (NETR), the New Industrial Master Plan 2030 (NIMP 2030), and the National Climate Change Policy 2.0, demonstrate Malaysia's commitment to addressing these issues. These policies and roadmaps aim to transform Malaysia into a sustainable and thriving nation where economic growth, social equity, and environmental sustainability are in harmony. On the environmental front, Malaysia is committed to advancing low-carbon, climate-resilient policies.

In response to the complexities of energy transition—balancing energy security, affordable access, and environmental sustainability—the government introduced the NETR in August 2023. The roadmap, in alignment with the National Energy Policy (DTN) 2022–2040 and NIMP 2030, strengthens Malaysia's goal of achieving net-zero emissions by year 2050. However, achieving this vision presents key challenges, including the high cost of energy transition, low public awareness and demand, technical and commercial viability issues, and economic risks from reducing reliance on fossil fuels, particularly in the face of global uncertainties.

The estimated financing for the energy transition, which amounts to RM1.2 trillion, poses a significant hurdle. Approximately 63% of this amount is required for RE and green mobility. Investments in RE will focus on expanding solar PV and hydropower generation while upgrading grid infrastructure. Green mobility initiatives will include expanding public transportation, boosting domestic EV production, and increasing EV charging infrastructure. Additionally, scaling up nascent technologies like hydrogen and carbon capture, utilisation, and storage (CCUS), improving energy efficiency, advancing sustainable aviation and marine transport, and launching green-skilling programmes will require substantial investments. For a developing country like Malaysia, the investment burden is immense.

Despite progress, gaps remain in Malaysia's GHG inventory reporting and tracking of its NDCs. These gaps include incomplete data, lack of country-specific emission factors, and limited activity data. Malaysia has only recently begun reporting on NDCs achievements, which highlights the need for additional technical capacity building and financial support. This will be crucial in developing robust systems for tracking NDCs implementation and cooperative approaches under Article 6 of the Paris Agreement. Malaysia's needs for external financial support are summarised in Table SIII.1. These needs have been identified by proponent agencies, nationally agreed upon through workshops, and endorsed by the NSCCC.

Table SIII.1 **Summary of Financial Support Needs for Malaysia**

Sector	Type of Support	Activity	Status/ Duration	Finance (USD)	Contribution to Technology Development and Transfer Objectives	Contribution to capacity building objectives	Whether the activity is anchored in a national strategy and/or an NDC
Energy	Mitigation	Funding Decarbonisation for emissions reductions through Carbon Capture Utilisation Storage, Energy Efficiency, Electrification & Zero Flaring Venting.	4 years	5,000,000	Yes	Yes	Yes
Energy	Mitigation	Utilising xEV Battery as Rechargeable Electric Energy Storage System (REESS).	2 years	639,897	Yes	Yes	Yes
Energy	Cross-cutting	Green Hydrogen Energy Generation.	3 years	2,700,000	Yes	Yes	Yes
Energy	Cross-cutting	Electrical Generation using Ammonia via Turbine Combustion.	3 years	2,500,000	Yes	Yes	Yes
Energy	Cross-cutting	National Centre of Excellence for Hydrogen Mobility (NCHM) in Sarawak	5 years	10,676, 900	Yes	Yes	Yes
Transport	Mitigation	Incentive and funds to finance decarbonisation strategies for land transport, maritime and aviation sectors.	7 years	20,000,000	Yes	Yes	Yes
Transport	Cross-cutting	Reskilling and Upskilling Next Generation Vehicle (NxGV) – Battery Electric Vehicle (BEV)	2 years	2,740,000	No	Yes	Yes
Transport	Mitigation	Accelerating the adoption and scale-up of climate-smart transport in Malaysia	5 years	1,776,484	No	Yes	Yes
	Cross-cutting	Development and deployment of sustainable agriculture solutions	3 years	3,200,000	Yes	Yes	Yes

Sector	Type of Support	Activity	Status/ Duration	Finance (USD)	Contribution to Technology Development and Transfer Objectives	Contribution to capacity building objectives	Whether the activity is anchored in a national strategy and/or an NDC
Agriculture	Cross-cutting	Estimation on the liming uses in agriculture	2 years	100,000	No	Yes	No
Agriculture	Cross-cutting	Development of country specific Emission Factors (CSEFs) for key categories	3 years	200,000	No	Yes	No
Agriculture	Cross-cutting	Field estimation on the biomass burning from rice cultivation (by satellite)	2 years	200,000	Yes	Yes	Yes
Agriculture	Mitigation	Feasibility Study on Carbon Market for Rubber Plantation in Malaysia	2 years	10,700	Yes	Yes	Yes
Industry	Mitigation	Belt conveyor system from Prai Whaves to RMY	2 years	15,000	No	Yes	No
Industry	Mitigation	Natural Gas system for PCSB Reheating Furnace	2 years	200,000	No	Yes	No
Industry	Mitigation	Waste heat recovery system	2 years	20,000	Yes	Yes	No
Industry	Mitigation	Recycle of Waste Product (e.g. EAF Slag) to produce building material	2 years	200,000	Yes	Yes	No
Forestry	Cross-cutting	Project development carbon project (forestry sector) including preparation of project design document, review and verification.	5 years	10,000,000	Yes	Yes	Yes
Forestry	Cross-cutting	Development of National Crediting System (Forest Carbon Offset)	3 years	1,250,000	Yes	Yes	Yes
Forestry	Cross-cutting	Development of non-market based project/activities (Forest Conservation Certificate)	3 years	625,000	Yes	Yes	Yes
Waste	Mitigation	Supply of Anaerobic Digester (AD) Machine including infrastructure with 2.5tonne/day capacity.	3 years	646,551	Yes	Yes	Yes
Waste	Mitigation	Development of material recovery facility (MRF) with 160 TPD capacity	5 years	2,813,200	Yes	Yes	Yes
Cross-cutting	Cross-cutting	Development of Carbon Capture and Utilisation Technologies towards Green Environment and Applications	3 years	3,200,000	Yes	Yes	Yes
Cross-cutting	Cross-cutting	Funding for Capturing Opportunities in Energy Transition (non-carbon offset)	5 years	5,000,000	Yes	Yes	Yes
Cross-cutting	Cross-cutting	Climate data management and Carbon Market/Offsetting Project	3 years	250,000	Yes	Yes	Yes

Sector	Type of Support	Activity	Status/ Duration	Finance (USD)	Contribution to Technology Development and Transfer Objectives	Contribution to capacity building objectives	Whether the activity is anchored in a national strategy and/or an NDC
Cross-cutting	Mitigation	Grant to develop (1) National Carbon Registry and (2) Domestic ETS, including technology infrastructure and capacity building programmes needed to achieve the agenda.	3 years	3,500,000	Yes	Yes	Yes
Cross-cutting	Cross-cutting	NGO/CSO Engagement of the Development and Review of National Policy, Plans and Programme on Climate Change	1 year	35,000	No	Yes	Yes
Cross-cutting	Cross-cutting	Development and Implementation of Capacity Development Programmes on Climate Action Planning with Malaysian Local Authorities, Private Sector, and youth and women.	2 years	200,000	No	Yes	Yes
Cross-cutting	Mitigation	Scaling Sustainable Consumption and Production (SCP) Ecolabelling and Sustainable Public Procurement (SPP) for a Low-Carbon Pathway in ASEAN	2 years	292,860	No	Yes	Yes

3.3 Information on financial support received by developing country Parties under Article 9 of the Paris Agreement

As one of the three operating entities of the financial mechanism of the UNFCCC, the Global Environment Facility (GEF) has been the main source of funding. Table SIII.2 shows the funding allocated and received by Malaysia from GEF cycles 1 to 7 (June 1994 - June 2022) for climate change activities. The funding provided by GEF, other multilateral agencies and bilateral sources was allocated through specific projects.

Table SIII.2 **Summary of Global Environment Facility (GEF) Funding**

GEF Cycle	Period	Indicative Allocation (USD)	Amount Utilised (USD
1	July 1994 – June 1998	7,770,600	N/A
2	July 1998 – June 2002	4,000,000	N/A
3	July 2002 – June 2006	8,699,420	N/A
4	July 2006 – June 2010	11,800,000	10,768,500
5	July 2010 – June 2014	14,240,000	14,234,249
6	July 2014 – June 2018	11,964,400	7,262,500
7	July 2018 – June 2022	5,765,635	6,033,001

Note: N/A - data is not available

3.3.1 Global Environment Facility (GEF)

During the GEF-7 cycle (June 2018 - June 2022), Malaysia received an indicative allocation of USD 5,765,635. In addition to this allocation, the country received extra support of USD 784,000 to prepare the BTR1 report during the initial rollout of BTR support. The funding from GEF was primarily utilised to enhance technical and technological capacities in sectors such as transport, forestry and community empowerment initiatives.

Furthermore, Malaysia leveraged its GEF funding to implement the Capacity Building Initiative for Transparency (CBIT), aimed at strengthening its capacity to track and implement ambitious climate change actions. The United Nations Development Programme (UNDP), the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Programme (UNEP) facilitated these actions.

3.3.2 Green Climate Fund (GCF)

Malaysia is actively exploring opportunities to access the Green Climate Fund and has received readiness support to identify national projects focused on adaptation and mitigation in the agriculture sector. In this regard, Malaysia is currently developing the Malaysia National Adaptation Plan (MyNAP), with the support of EUR 2.8 million recently allocated from GCF, approved in 2024. The details will be reported in the next BTR.

3.3.3 Adaptation Fund (AF)

Malaysia has initiated its first Adaptation Fund project, focusing on implementing nature-based solutions to enhance climate resilience. This includes the Nature-Based Climate Adaptation Programme, which seeks to strengthen resilience through urban greening, flood control, and community-based initiatives in one of Malaysia's cities. The project approved in 2022, serves as a key part of Malaysia's Nature-Based Climate Adaptation Programme and a scalable model for other regions. The details of this project will be reported in the next BTR.

3.3.4 Multilateral and Bilateral Funding and Support

Table SIII.3 provides the information on financial support received from various sources since those reported in BUR4 from year 2020 onwards.

Table SIII.3 Financial Support Received for All Sectors

Channel	Project Title	Implementing Entity	Amount received (USD	Mitigation	Financial Instrument	Sector	Contribution		Status of Activity
							Technology Development and Transfer	Capacity Building	
GEF	Food Systems, Land Use and Restoration (FOLUR) Impact Program: Integrated Landscape Management of Heart of Borneo Landscapes in Sabah	UNDP	5,500,000	2020-2026	Grant	Mitigation	No	Yes	Ongoing
GEF	Malaysia Small Grant Programme (SGP)	UNDP	2,846,729	2020-2024	Grant	Cross-cutting	No	Yes	Ongoing
GEF	Development of BTR1	UNEP	784,000	2020-2024	Grant	Cross-cutting	No	Yes	Ongoing
GEF	Capacity-building Initiative for Transparency (CBIT)	UNEP	1,826,484	2020-2024	Grant	Cross-cutting	No	Yes	Ongoing
GCF	ASEAN Catalytic Green Finance Facility (ACGF) Green Recovery Program	ASEAN Infrastructure Fund & ADB	300,000,000 (Grant: 20,000,000; Loan: 280,000,000)	2020-2024	Grant/Loan	Mitigation	No	Yes	Ongoing
GCF	Agriculture Sector Readiness for Enhanced Climate Finance and Implementation of Koronivia Joint Work on Agriculture Priorities in Southeast Asia	FAO	450,000	2019-2023	Grant	Agriculture	Yes	Yes	Ongoing
Multi-lateral	Malaysia Climate Action Simulator (MCAS)	Dept for Energy Security and Net Zero (DESNZ)	187,267	2015-2022	Grant	Cross-cutting	Yes	Yes	Completed
Multi-lateral	Energy Efficient Low-carbon Transport	United Nations Industrial Development Organization (UNIDO)	2,000,000	2019-2020	Grant	Transport	No	Yes	Completed

Channel	Project Title	Implementing Entity	Amount received (USD	Mitigation	Financial Instrument	Sector	Contribution		Status of Activity
							Technology Development and Transfer	Capacity Building	
Multi-lateral	Government Green Procurement (GGP) Pilot Project for Local Authorities through Lighting Energy Efficiency in Supporting Low Carbon Cities Initiatives	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	261,471	2019-2020	Grant	Energy	No	Yes	Completed
Multi-lateral	"Market and Environmental Analysis of Data Centres and on Financial Instruments for Promoting Green Data Centres in Malaysia" study	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	28,651.48	2021-2023	Grant	Energy	No	Yes	Completed
Multi-lateral	Collaboration Action Plan for Single-Use Plastic (SUP) Prevention in Southeast Asia (CAPSEA)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	131,089.01	2019-2023	Grant	Waste	No	Yes	Completed

3.4 Information on technology development and transfer support needed by developing country Parties under Article 10 of the Paris Agreement

To address climate challenges and support sustainable development, Malaysia has identified a range of technological needs across multiple sectors. These needs are essential for advancing Malaysia's goals of reducing GHG emissions, adapting to climate impacts, and strengthening resilience across key areas such as energy, waste management, agriculture, water resources, and transportation. The focus on technology also aligns with Malaysia's broader efforts to achieve its NDCs under the Paris Agreement.

As a developing country, Malaysia faces considerable challenges in technology development, particularly regarding the technical and commercial feasibility of transitioning to greener energy systems. A need for additional experts, especially in green technologies, coupled with high capital expenditures and limited resources, further impedes progress toward net-zero emissions. For example, hydrogen production faces constraints due to the limited availability of electrolysers essential for water splitting, complicating large-scale production efforts. Additionally, the development of CCUS technologies in Malaysia is still in its infancy, with significant commercialisation barriers due to high costs and the early stage of the technology.

Malaysia's identified technology needs (Table SIII.4) are critical for building a sustainable and climate-resilient nation. By investing in advanced technologies across key sectors, Malaysia is positioning itself to meet both its domestic and international climate obligations. These technological initiatives, supported by a combination of domestic expertise and international cooperation, aim to enhance Malaysia's capacity to reduce emissions, adapt to climate impacts, and secure a low-carbon future across all sectors.

Table SIII.4 Support Needed for Technology Development and Transfer

Sector	Type of Support	Activity	Lead Agencies	Status/ Duration	Technical/Technology
Cross-cutting	Cross-cutting	Development of digitalised ESG reporting platform for internal use include GHG accounting for Scope 1,2 and 3	Financial Sector	2 years	Technical expertise for the development of the digital dashboard
Cross-cutting	Mitigation	Identify and develop technological tools required to operationalise National Carbon Registry.	Bursa Malaysia	3 years	1. IT experts for the development of technical platforms to ensure transparency and integrity of the National Carbon Registry. 2. International experts who are familiar with international requirements on Party registry to ensure that, through technological solutions, the operation of the National Carbon Registry adhere to international requirements (transparent credit tracking, measurements to avoid double counting/ double issuances) 3. Continuous upgrade of the systems/ platforms/ database to ensure the National Carbon Registry is aligned with the latest development of international & domestic carbon markets (e.g. Art 6, additional labelling, changes in domestic CPI).
Cross-cutting	Mitigation	ETS Mechanism	Bursa Malaysia	3 years	1. IT experts to develop an integrated system as part of the ETS mechanism. The system shall include MRV platform, issuance/trading/auctioning of allowances, and system to surrender allowances/carbon credits. 2. Potential functions to allow the integration with ETS systems within ASEAN region.
Agriculture	Adaptation	Development of smart irrigation system for proper AWD management.	MARDI	5 years	Smart irrigation system.
Transportation	Cross-cutting	Technology to developed hydrogen refuelling station.	MOSTI	3 years	Technical expertise to developed hydrogen refuelling station in two prospecting pilot sites in Selangor and Kelantan.
Energy	Mitigation	Adoption Renewable Energy (RE) in Healthcare Facilities.	MOH	5 years	Installation of RE system such as solar PV, hydrogen fuel cells and wind energy.
Agriculture	Adaptation	Development of Climate Ready Rice for sustaining Rice Food Security (Climate Ready (CR).	UPM	5 years	Expertise and basic equipment related to Plant Physiology requirement.
Agriculture	Cross-cutting	Development of Climate Ready Rice for sustaining Rice Food Security (Climate Ready (CR).	UPM	5 years	Expertise and basic equipment related to Plant Physiology requirement.
Waste	Mitigation	Supply of Anaerobic Digester (AD) Machine including infrastructure with 2.5tonne/day capacity.	SWCorp	3 years	Treat food waste in anaerobic environment and convert them into liquid fertilizer and biogas.

Sector	Type of Support	Activity	Lead Agencies	Status/ Duration	Technical/Technology
Waste	Mitigation	Development of material recovery facility (MRF) with 160 TPD capacity.	SWCorp	5 years	Recyclable waste sorting, segregation and baling.
Water	Adaptation	Development the most effective renewable energy for selected hydromechanical infrastructures.	JPS	5 years	Technical expertise and related technologies
Water	Cross-cutting	Technology transfer on flood mitigation, water resource management and climate change adaptation.	JPS	5 years	Technical support/ infrastructure support
Water	Cross-cutting	Water Management Curricula.	JPS	5 years	Technical support/ infrastructure support
Water	Cross-cutting	Ecohydrology Guidelines in Tropical Region.	JPS	5 years	Technical support/ infrastructure support
Water	Cross-cutting	Research on climate change impacts, nature-based solutions, and water security in humid tropics.	JPS	5 years	Technical support/ infrastructure support
Water	Cross-cutting	Acquisition of integrated databases for water resources, climate data, and biodiversity.	JPS	5 years	Technical support/ infrastructure support

3.5 Information on technology development and transfer support received by developing country Parties under Article 10 of the Paris Agreement

Malaysia has been receiving various forms of technology support across sectors to strengthen its climate action and sustainable development goals. In the industry sector, the HCFC Phase-out Management Plan (HPMP) Stage-II addresses the reduction of ozone-depleting substances as mandated under Annex-C, Group-I substances. This mitigation project, led by the Department of Environment (DoE) with support from the United Nations Development Programme (UNDP), is currently ongoing and aims to help Malaysia meet its international obligations. Additionally, a cross-cutting project titled "Achieving the 2030 Agenda for Sustainable Development – 2.3 Business and Human Rights" (2020-2024) focuses on adaptation strategies to support sustainable development. This project is implemented by UNDP, providing essential technical support to advance Malaysia's sustainability objectives. Together, these programmes contribute significantly to Malaysia's efforts in both mitigation and adaptation, aiding the country in meeting environmental targets and enhancing resilience (Table SIII.5).

Table SIII.5 **Technology Development and Transfer Support Received for All Sectors**

Sector	Title	Programme, project description	Time Frame	Recipient Entity	Implementing Entity	Type of Supports	Status of Activity
Industry	HCFC Phase-out Management Plan (HPMP) Stage-II for compliance with post 2015 control targets for Annex-C, Group-I substances*	Technical	2017-2024	DoE	DoE & UNDP	Mitigation	Ongoing
Cross-cutting	Achieving 2030 Agenda for Sustainable Development – 2.3 Business and Human Rights	Technical	2020-2024	UNDP	UNDP	Adaptation	Ongoing

3.6 Information on capacity building support needed by developing country Parties under Article 11 of the Paris Agreement

Table SIII.7 outlines the capacity-building requirements needed to strengthen Malaysia's ability to track NDCs implementation and participate in cooperative approaches to meet the obligation under the Paris Agreement. These include enhancing technical skills for GHG inventory development, understanding carbon market mechanisms, and creating systems to monitor progress on NDCs targets. Building human resource capacity across government agencies and industries is vital to ensuring that Malaysia can meet its climate commitments while navigating complex frameworks like Article 6 on carbon trading and cooperative approaches.

Moreover, capacity building is required in areas such as data management, emissions tracking, and reporting, as well as developing institutional frameworks for climate finance and technology transfer. Training and upskilling initiatives are essential to enable effective stakeholder engagement and decision-making processes, ensuring that Malaysia can fully leverage international cooperation and support for climate action.

Table SIII.6 Support Needed for Capacity Building

Sector	Type of Support	Activity	Lead Agencies	Status/ Duration	Capacity-building
Cross-cutting	Cross-cutting	Regulatory and Policy Development.	NRES	5 years	Assessment and best practices among developed countries to aid in government strategic way forward
Cross-cutting	Cross-cutting	MRV Tools Utilisation.	NRES	5 years	Best practices and application of knowledge including CCUS and related emerging technology.
Cross-cutting	Cross-cutting	Capacity building programmes targeted at various stakeholders involved in the development of carbon market, including potential buyers and suppliers of carbon credits.	NRES	3 years	Training on carbon project development and corporate offsetting.
Cross-cutting	Cross-cutting	Development of digitalised ESG reporting platform for internal use include GHG accounting for Scope 1,2 and 3.	Financial Sector	2 years	Training on climate-related upskilling including certifications, GHG accounting for investments, product innovation and development on specific carbon offsetting projects, ESG fund valuation.

Sector	Type of Support	Activity	Lead Agencies	Status/ Duration	Capacity-building
Cross-cutting	Mitigation	Identify and develop technological tools required to operationalise National Carbon Registry.	Bursa Malaysia	3 years	Capacity building programmes on developing effective National Carbon Registry that serves domestic and international voluntary and compliance markets.
Cross-cutting	Mitigation	Development of Domestic ETS (DETS)	Bursa Malaysia	3 years	Training on developing Domestic ETS (DETS) including: i) How to design a domestic ETS with features that ensures the effectiveness of the mechanism, declining e.g., cost containment mechanism, declining baseline, allocation of free allowances, allowable offsets; ii) Approach for stakeholder engagements and awareness campaigns on entities impacted by DETS; and iii) Sharing of expertise to draft legal and regulatory frameworks on DETS
Transportation	Cross-cutting	Enabling Mobility Electrification for Green Economy	MOSTI	5 years	1. Enhance capacity in the Development and Implementation of Autonomous Buses in University Campus. 2. Enhance capacity in the Deployment of Renewable Energy Charging Station to Electric Vehicles
Transportation	Cross-cutting	Training on port sustainable management	MOT	7 years	Capacity building programmes for all federal ports in Malaysia on port sustainable management (maritime sector)
Transportation	Cross-cutting	Development of an integrated system of all 3 sectors (land, maritime and aviation) in term of GHG calculation and tracking.	MOT	7 years	Capacity building programmes on dynamic carbon tracking and calculation for transport sector (land, maritime and aviation sector)
Energy	Adaptation	Development of National Policy on Malaysian Agrivoltaic Model with emphasis on 500MWp Agrivoltaic Quota on LSS program.	UPM	2 years	Policy development and LSS quota on Agrivoltaic projects with multiple agriculture activities i.e poultry, sheep, crops, mushroom, etc
Energy	Mitigation	Adoption Renewable Energy (RE) in Healthcare Facilities.	MOH	5 years	Enhancing workforce through advanced training in carbon accounting, energy efficiency, and continuous improvement to achieve MOH goal of carbon neutrality for healthcare facilities as early as 2045. This comprehensive training initiative will empower MOH staff to drive sustainable practices, optimize energy use, and implement innovative solutions that contribute to a healthier planet and a resilient healthcare system.
Agriculture	Cross-cutting	Capacity building in GHG inventories and technical reviewing processes	MARDI	2 years	Training on GHG inventories for newer staff
Agriculture	Cross-cutting	Capacity building in IPCC Software management and GHG calculation	MARDI	2 years	Hands on Training for compilers

Sector	Type of Support	Activity	Lead Agencies	Status/ Duration	Capacity-building
Agriculture	Mitigation	Training on voluntary carbon market project development	KPK	2 years	Capacity building programmes targeted at various stakeholders in rubber industry (upstream, midstream, downstream) in the development of a voluntary carbon market, including potential buyers and suppliers of carbon credits
Agriculture	Cross-cutting	Development of Climate Ready Rice for sustaining Rice Food Security (Climate Ready (CR)	UPM	5 years	Adaptation of drone technology for rice management system under climate uncertain.
Agriculture	Adaptation	Development of Climate Ready Rice for sustaining Rice Food Security (Climate Ready (CR)	UPM	5 years	Strengthening the basic concept of Plant Physiology for understanding, mitigation and adaptation of climate change strategies.
Waste	Mitigation	Supply of Anaerobic Digester (AD) Machine including infrastructure with 2.5tonne/day capacity.	SWCorp	3 years	› Treats food waste that are generated by premises within specified area. › The outcomes product is liquid fertiliser that can be used to nourish growth of plant. › Aims to reduced wastes that are being sent to landfill and extends landfill life span. Towards low carbon emission and circular economy.
Waste	Mitigation	Development of material recovery facility (MRF) with 160 TPD capacity	SWCorp	5 years	› Waste sorting and segregation facility that allows recyclables to be sorted and baled before being sent for recycling. › Reduced wastes that are being sent to landfill and extends landfill life span.
Water	Adaptation	Development the most effective renewable energy for selected hydromechanical infrastructure	JPS	5 years	› To reduce the energy consumption for hydromechanical infrastructures
Water	Cross-cutting	Technology transfer on flood mitigation, water resource management and climate change adaptation	JPS	5 years	› Flood mitigation - advanced in flood control system/ nature-based solution/ early warning system/ climate change adaptation › Water resource management – such as smart irrigation system/water balance/Water monitoring system Climate change adaptation – climate modelling tools or software /integration of renewable energy
Water	Cross-cutting	Water Management Curricula	JPS	5 years	› Develop educational programs on water conservation and climate adaptation for tropical regions
Water	Cross-cutting	Ecohydrology Guidelines in Tropical Region	JPS	5 years	Experts in Ecohydrology field
Water	Cross-cutting	Research on climate change impacts, nature-based solutions, and water security in humid tropics	JPS	5 years	Reference for Continuing water education

Sector	Type of Support	Activity	Lead Agencies	Status/ Duration	Capacity-building
Water	Cross-cutting	Acquisition of integrated databases for water resources, climate data, and biodiversity.	JPS	5 years	Improved decision-making.
Water	Adaptation	Capacity building on climate changes factors that will be contributed to the designing flood mitigation and irrigation infrastructures.	JPS	5 years	Flood mitigation and irrigation infrastructures are designed in the best engineering practices and succeed after considering the correct climate change factors.
Water	Cross-cutting	Capacity building to educate stakeholder on best practise in water management and climate adaptation involving program with local community.	JPS	5 years	Provide various types of support, the programme can effectively facilitate the transfer and implementation of advanced technologies for flood mitigation, water resource management and climate adaptation lead to more resilient and sustainable.
Water	Cross-cutting	Advanced hydrological monitoring and climate resilience tools.	JPS	5 years	Leverage modern technologies to forecast water needs, flooding, and climate impacts.
Water	Cross-cutting	Co-organise international training programs on humid tropics water challenges	JPS	5 years	Partnership on capacity building.
Water	Cross-cutting	Train staff on participatory approaches to involve communities in water and sanitation solutions.	JPS	5 years	Partnership on capacity building.
Water	Cross-cutting	Capacity building on adoption and adaptation of Blue-green infrastructures with grey environment.	JPS	5 years	Capacity building support.

3.7 Information on capacity building support received by developing country Parties under Article 11 of the Paris Agreement

Malaysia has also benefited from capacity-building support through a wide range of training programmes conducted between 2020 and 2021 (Table SIII.8). Most workshops were organised virtually due to travel restrictions from the COVID-19 pandemic. During this period, Malaysia participated in numerous virtual workshops and webinars, covering topics such as climate finance in ASEAN, adaptation finance, and the GEF-8 replenishment. The capacity-building sessions also addressed areas such as GHG inventory, mitigation (including measurement, reporting, and verifying emissions data), enhanced transparency framework, BTR preparation, adaptation planning, and the implementation and enhancement of NDCs, as well as climate negotiations. These trainings were provided by the UNFCCC, various multilateral organisations, the Institute for Global Environmental Strategies (IGES), UNEP Copenhagen Climate Centre, and Annex I Parties.

Table SIII.7 **Capacity Building Support Received for All Sectors**

Sector	Title	Programme, project description	Time Frame	Recipient Entity	Implementing Entity	Type of Supports	Status of Activity
Cross-cutting	Capacity building support for financial sector (via Joint Committee on Climate Change) under the ASEAN Low Carbon Energy Programme	Capacity-building Technical;	2020-2021	JC3	British High Commission	Cross-cutting	Completed
Cross-cutting	Achieving 2030 Agenda for Sustainable Development – 2.3_Business and Human Rights	Capacity-building; Reporting	2020-2024	UNDP	UNDP	Adaptation	Ongoing
Cross-cutting	Environment – Project sustainable consumption and production (Scaling SCP) with GIZ	Capacity building	2022-2024	Ministry of Economy	GIZ	Mitigation	Completed
Cross-cutting	Qualitative Climate Risk Assessment (QCRA) and Climate Action on Adaptation of the Kuala Lumpur City Council Climate Action Plan	Capacity Building; Workshop / Stakeholder Engagement; and Reporting	2020-2021	DBKL	GIZ	Adaptation	Completed
Water Management	Policy Dialogue and Network Building of Multi-Stakeholders on Integrated Decentralized Domestic Wastewater Management in ASEAN Countries (PODIWM) Project	Capacity Building	2020	JPS	NIES, JAPAN	Mitigation	Completed

Sector	Title	Programme, project description	Time Frame	Recipient Entity	Implementing Entity	Type of Supports	Status of Activity
Water Management	The Eleventh Governing Body Meeting (11th GBM) of the Inter-Islamic Network on Water Resources Development and Management (INWRDAM)	Capacity Building	2020	JPS	INWRDAM	Mitigation	Completed
Water Management	Technical Visit dan Knowledge Sharing with JICA	Capacity Building	2020	JPS	JICA, JAPAN	Mitigation	Completed
Water Management	Workshop & Collaboration HTC KL with UNESCO Water Centre & Chairs	Capacity Building	2021	JPS	UNESCO	Mitigation	Completed

3.7.1 Other Capacity Building Assistance

Malaysia is actively exploring opportunities to access the Green Climate Fund and has received readiness support to identify national projects focused on adaptation and mitigation in the agriculture sector. In this regard, Malaysia is currently developing the Malaysia National Adaptation Plan (MyNAP), with the support of EUR 2.8 million recently allocated from GCF, approved in 2024. The details will be reported in the next BTR.

Malaysia has received capacity-building support through a wide range of training programmes conducted between 2020 and 2021. Most workshops were organised virtually due to travel restrictions from the COVID-19 pandemic.

During this period, Malaysia participated in various virtual workshops and webinars, including sessions focused on climate finance in ASEAN, adaptation finance, and the GEF-8 replenishment. The capacity-building training also covered areas such as GHG inventory, mitigation (measurement, reporting, and verifying emissions data), enhanced transparency framework, BTR preparation, and adaptation planning, as well as implementing and enhancing NDCs and climate negotiations. These trainings were provided by the UNFCCC, various multilateral organisations, IGES, UNEP Copenhagen Climate Centre and Annex I Parties.

Both technical and commercial feasibility also present significant challenges to Malaysia's energy transition. A shortage of expertise, particularly in green technologies, coupled with high capital expenditures and limited resources, further impedes progress toward net-zero emissions. For instance, in hydrogen production, the availability of electrolysers—crucial for water splitting—is constrained in the global market, making large-scale production difficult. Additionally, the development of carbon capture, utilisation, and storage (CCUS) technologies in Malaysia has yet to reach commercial scale. This is due to the nascent nature of the technology and the substantial costs associated with its implementation.

Malaysia's needs for external financial, technical, and capacity-building support are summarised in Table SIII.4. These needs have been identified by proponent agencies, nationally agreed upon through workshops, and endorsed by the NSCCC.

Table SIII.6 outlines Malaysia's technology requirements necessary to support its efforts in GHG inventory management, mitigation, and adaptation. The country faces significant technological gaps in areas such as renewable energy, energy efficiency, carbon capture, utilisation and storage (CCUS), and monitoring systems for emissions. These technologies are essential for meeting Malaysia's climate targets, but access to advanced, cost-effective solutions remains a major barrier. Additionally, the development and scaling of green technologies, such as electrolysers for hydrogen production and sustainable agricultural practices, are key areas where Malaysia requires further investment and international cooperation.

The table also highlights the importance of adopting digital tools for real-time monitoring and reporting of emissions data, particularly for land use, forestry, and agriculture sectors. Technologies to support climate-resilient infrastructure, such as early warning systems and water management solutions, are also crucial. Meeting these technological needs will significantly enhance Malaysia's ability to achieve its net-zero aspirations and implement effective mitigation and adaptation strategies.

IV

SECTION

INFORMATION ON FLEXIBILITY

In this section, the information on flexibility for the Section I and Section II of the BTR1 is provided each in Table SIV.1 and Table SIV.2.

Table SIV.1 **Information on the flexibility applied for Section I**

Reference	Provision in The MPGS	Flexibility Provision for Those Developing Country Parties That Need It in The Light of Their Capacities	Capacity Constraints in Relation to the Application of Flexibility	Self Determined Estimated Time Frames for Improvements in Relation to Those Capacity Constraints
Paragraph 58 Reporting year	The latest reporting year shall be no more than three years prior to the submission of the national inventory report.	The latest reporting year shall be no more than three years prior to the submission of the national inventory report.	In this BTR1, Malaysia reports the inventory year for the 1990-2021 period. To make available AD biennially with two years lack period. Most of the inventory data compiled are based on stakeholders' goodwill and voluntary cooperation. Malaysia is in the process of developing its climate change act bill. The climate change act bill would facilitate the need of reporting year to be no more than two years prior to the submission of the national inventory report.	The improvement on the latest reporting year shall be no more than two years prior to the submission of the national inventory report is estimated to be made as early as during the BTR4.

Table SIV.2 **Information on the flexibility applied for Section II**

Reference	Provision in The MPGS	Flexibility Provision for Those Developing Country Parties That Need It in The Light of Their Capacities	Capacity Constraints in Relation to the Application of Flexibility	Self Determined Estimated Time Frames for Improvements in Relation to Those Capacity Constraints
Projections extension **Projections methodology or coverage**	Projections shall begin from the most recent year in the Party's national inventory report and extend at least 15 years beyond the next year ending in zero or five.	May extend their projections at least to the end point of their NDC. May report using a less detailed methodology or coverage.	In this BTR1, the projection extensions are to the end point of Malaysia's NDC year i.e. 2030. Malaysia will require capacity building in order to quantify the projected mitigation policies in the periods or years after 2030.	The extension of the projection to be least 15 years beyond the next year ending in zero or five is estimated to be made as early as during the BTR3.
	As paragraphs 93 through 101 of the annex to decision 18/CMA.1		In this BTR1, the projections may be delivered in relatively less detailed methodology or coverage. Malaysia will require capacity building in order to quantify the projected mitigation policies in the periods or years after 2030.	It is estimated that the improvement on this theme is estimated to be made in the next BTR i.e. BTR2.

V

SECTION

IMPROVEMENTS IN REPORTING

In this section, the improvements in reporting pertaining to the Section II and Section III of the BTR1 are written in accordance with the 5/CMA.3 document.

For the Section II, the improvements are intended to be undertaken mainly on the key categories. Description on the improvements for the key categories is provided in the Chapter 8 of Section I. Improvement for all key categories may require relatively extensive capacity and resources. Hence, certain key categories are given priority to be improved while for other key categories, Malaysia may require additional capacity and funding. Practically, the improvements prioritised would require time for development and subsequent implementation. Any applicable improvements would be reported in the next BTRs.

For the Section III, the improvements are given priority mainly on the sectoral projection and the quantification of the PAMs. Malaysia may require capacity building to develop the capacity needed for both areas mentioned.

Malaysia through NRES has initiated technical collaboration with the Japan International Cooperation Agency (JICA) to enhance its capacity under the ETF. Besides, Malaysia also receives support through the Capacity-building Initiative for Transparency (CBIT) for the same purpose mentioned.

VI

SECTION

GENDER PARTICIPATION

In accordance with the Enhanced Lima Work Programme on Gender (LPWG) and its gender action plan[46] which advocates for the full, equal, and meaningful participation of women in the international climate process, the Committee facilitated 56 engagements as part of the First Biennial Transparency Report (BTR1) process. These included meetings, workshops, training sessions, and consultations sessions that involved a total of 1,267 participants, where women covering 681 participants or 53.7%. Meanwhile, men comprised 586 participants or 46.3% from the total number of participants.

Additionally, the percentage of women who held technical positions was still relatively lower than men. Women elected as chairperson and members at the level of the national climate change technical committees and working groups were 35.3% (Table SV.1). This includes the involvement at the Technical Committee on Climate Change, Technical Working Groups on GHG Inventory, Mitigation and Finance, Technology and Needs and respective Sub-Working Groups levels, as illustrated in Figure SIC1.2 in Chapter 1 on National Circumstances, Institutional Arrangements and Cross-Cutting Information.

Table SV.1 **Women's Engagement and Participation in the BTR1 Preparation Process in 2024**

Indicator	Female	Male
1. Women and men participating in consultations and engagement workshops by NRES	681 (53.7%)	586 (46.3%)
2. Number of women in technical positions in National Climate Change Committees	36 (35.3%)	66 (64.7%)

6.1 Gaps and Opportunities

The gender profile of Malaysia, along with main climate change trends, policies, and programs, offers a data set for each sector; however, there is relatively minimal integration between them. Academically, there were studies that highlight the negative impacts of climate change on gender[47], which also reveal a limited understanding of the connection between environmental sustainability and gender equality that is also a subject to the cultural and social norms. The sectors addressing climate change have not

[46] United Nations Framework Convention on Climate Change, 2023).
[47] (UNICEF, Universiti Kebangsaan Malaysia, & Universiti Malaysia Sabah, 2021), (Universiti Kebangsaan Malaysia, 2015), (Goh & Bisan, 2015).

yet incorporated the specific needs, experiences, and knowledge of both women and men to develop a gender-responsive approach to climate issues.

A description regarding gender participation was first incorporated in the Malaysia's NC4. As a continuation, in this BTR1, Malaysia has updated the specific indicators for each Priority Area to guide its focus on developing a comprehensive gender-responsive approach as the following:

Priority Area A: Capacity-building, knowledge management and communication

- **Objective:** To enhance the systematic integration of gender considerations into climate policy and action and the application of understanding and expertise to the actions called for under the Lima work programme on gender and its gender action plan, and facilitate outreach, knowledge-sharing and the communication of activities undertaken to enhance gender-responsive climate action and its impacts in advancing women's leadership, achieving gender equality and ensuring effective climate action.

Priority Area B: Gender balance, participation and women's leadership

- **Objective:** To achieve and sustain the full, equal and meaningful participation of women in the UNFCCC process.

Priority Area C: Coherence

- **Objective:** To strengthen the integration of gender considerations within the work of UNFCCC constituted bodies, the secretariat and other United Nations entities and stakeholders towards the consistent implementation of gender-related mandates and activities.

Priority Area D: Gender-responsive implementation and means of implementation

- **Objective:** To ensure the respect, promotion and consideration of gender equality and the empowerment of women in the implementation of the Convention and the Paris Agreement.

Priority Area E: Monitoring and reporting

- **Objective:** To improve tracking of the implementation of and reporting on gender-related mandates under the Lima work programme on gender and its gender action plan.

WAY FORWARD

Malaysia is committed to progress in the climate actions as part of its contribution to global endeavours. Hence, NRES is now in the process of developing the Climate Change Act Bill dan National Carbon Market Policy to support the growing climate change ecosystems in Malaysia. Besides, the exercise to develop the Malaysia National Adaptation Plan (MyNAP) is also currently in development to strengthen Malaysia's capability to address the vulnerability and adaptation challenges. NRES also intends to submit its Long-Term Low Emissions Development Strategy (LT-LEDS) to the UNFCCC shortly in order to signify its aspiration to achieve net-zero emissions in 2050.

In 2026, Malaysia will submit the Second BTR (BTR2) which will report the information on the national GHG inventory, NDC Tracking, climate change impacts and adaptation as well as financial, technology development and transfer and capacity building support needed and received sections each.

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ANNEX 1: **COMMON REPORTING TABLES FOR THE ELECTRONIC REPORTING OF THE NATIONAL INVENTORY REPORT OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GREENHOUSE GASSES**

The Common Reporting Table (CRT) on the Malaysia's GHG inventory for 1990-2021 is provided in the ETF Tools according to the requirement by UNFCCC.

The Common Tabular Format (CTF) on the information to track Malaysia's NDC is provided in the ETF Tools according to the requirement by UNFCCC.

For the preparation of CRT, Malaysia utilizes the IPCC Software to generate the json file. Next, the json file was exported to the ETF Tools. The CRT in excel format for each year (1990 – 2021) was then generated via the platform/tools.

As such, certain values generated through the ETF Tools may be placed or written in different cells/parts in the generated CRTs. As mentioned in the NID, Malaysia would like to improve its understanding of the latest version of the IPCC Software in order to improve the relative quality of the CRTs generated. This could be in line with the spirit of the BTR reporting i.e. continuous improvement.

ANNEX 2: **COMMON TABULAR FORMATS FOR THE ELECTRONIC REPORTING OF INFORMATION NECESSARY TO TRACK PROGRESS IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT**

The Common Tabular Format (CTF) on the information to track Malaysia's NDC is provided in the ETF Tools according to the requirement by UNFCCC.

ANNEX 3: **INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT**

The Common Tabular Format (CTF) for the information on financial, technology development and transfer and capacity-building support needed and received Under Articles 9–11 of The Paris Agreement is not provided in this report.

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