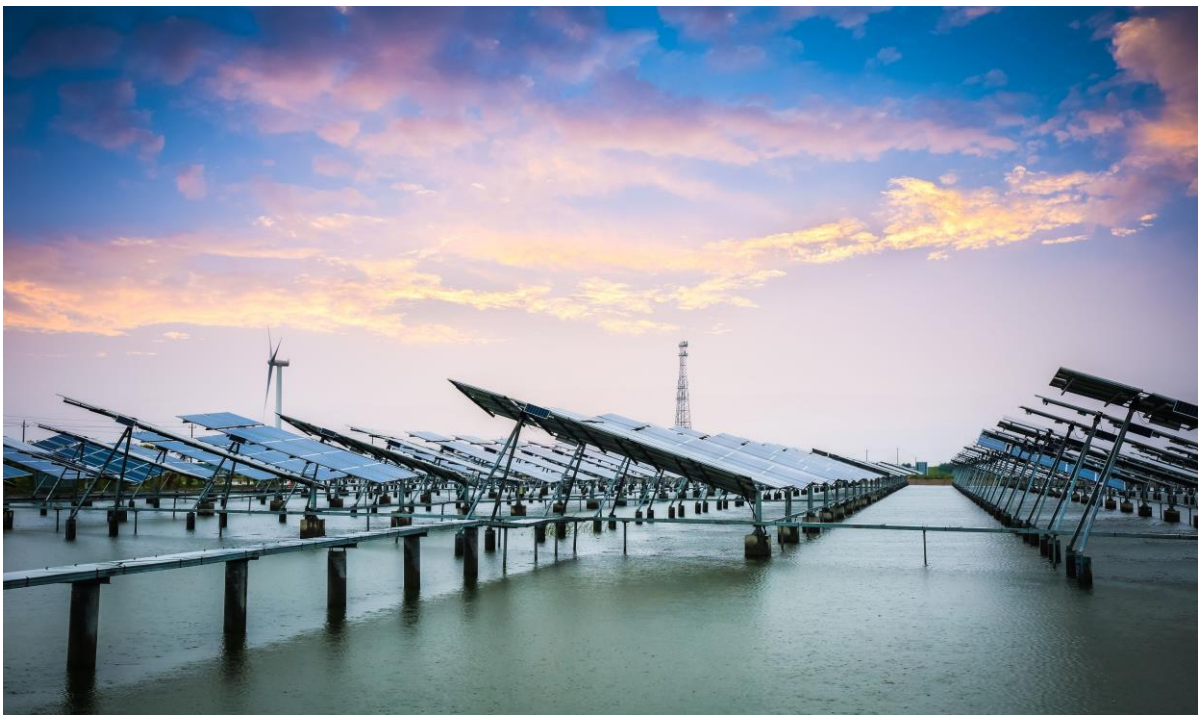
DEVELOPING SECTORAL MRV SYSTEMS IN MYANMAR FOR IPPU SECTOR

December 2020



LIST OF ACRONYMS

ADB	Asian Development Bank		MoA	Ministry of Agriculture and Irrigation
AEC	ASEAN Economic Community		MoALI	Ministry of Agriculture, Livestock and Irrigation
AFOLU	Agriculture, Forestry and Other		MoE	Ministry of Energy[1]
BUR	Biennial Update Report		MoECAF	Ministry of Environment, Conservation and Forestry[2]
CDC	City Development Committee		MoEE	Ministry of Electricity and Energy
CO_2 eq	Carbon dioxide equivalent		MoEP	Ministry of Electric Power[3]
DCA	Department of Civil Aviation		MoGE	Myanmar Oil and Gas Enterprise
DMA	Department of Marine		MoI	Ministry of Industry
DRD	Department of Rural Development		MoLFRD	Ministry of Livestock, Fisheries and Rural Development[4]
ECD	Environmental Conservation		MoM	Ministry of Mines[5]
EDC	Energy Development Committee		MoNREC	The Ministry of Natural Resources and Environmental Conservation
EE	Energy Efficiency		MoST	Ministry of Science and Technology
EECD	Energy Efficiency and Conservation Division		MoTC	Ministry of Transport and Communication
EE&C	Energy Efficiency and Conservation		MPA	Myanmar Port Authority
EIA	Environmental Impact		MPE	Myanmar Petrochemical Enterprise
EPGE	Electric Power Generation Enterprise		MPPE	Myanmar Petroleum Products Enterprise
EST	Environmentally Sound Technology		MR	Myanmar Railways
ETPA	Education, Training and Public Awareness		MSDP	Myanmar Sustainable Development Plan
FDI	Foreign Development Index		NC	National Communication
GGGI	The Global Green Growth Institute		NDC	Nationally Determined Contributions
GHG	Greenhouse gases		NEMC	National Energy Management
GMS	Greater Mekong Sub-region		NGHGI	National Greenhouse Gas Inventory
GPG	Good Practice Guidance		NGOs	Non-government Organizations
IEP	Integrated energy planning		NMVOC	Non-methane Volatile Organic Compound

[1] Ministry of Energy was merged into Ministry of Electricity and Energy in 2016

2 Ministry of Environment, Conservation and Forestry was merged into Ministry of Natural Resources and Environmental Conservation in 2016

[3] Ministry of Electric Power was merged into Ministry of Electricity and Energy in 2016

4 Ministry of Livestock, Fisheries and Rural Development was merged into Ministry of Agriculture, Livestock and Irrigation in 2016

5 Ministry of Mines was merged into Ministry of Natural Resources and Environmental Conservation in 2016

INC	Initially National Communication		NSDS	The National Strategy for Development of Statistics
INDC	Intended Nationally Determined Contribution		OGPD	Oil and Gas Planning Department
INGOs	International Non-Government		PIP	Project Implementation Plan
IPCC	Intergovernmental Panel on Climate Change		PMT	Project Management Team
IWT	Inland Water Transport		PRC	The People's Republic of China
ktoe	Kilo tonnes of oil equivalent		QA/QC	Quality Assurance and Quality Control
kton	Kilo tonnes		REAM	Renewable Energy Association Myanmar
LPG	Liquefied petroleum gas		RTAD	Road Transport Administration Department
LULUCF	Land use, land-use change, and forestry		RSO	Research and Systematic Observation
MCCSAP	Myanmar Climate Change Strategy and Action Plan		SDG	Sustainable Development Goal
MEP	Ministry of Electric Power		SME	Small and Medium Enterprise
MES	Myanmar Engineering Society		SNC	Second National Communication
MGS	Myanmar Geoscience Society		TFEC	Total Final Energy Consumption
MNA	Myanmar National Airline		TWG	Technical Working Group
Mtoe	Million tonnes of oil equivalent		UNFCCC	United Nations Framework Convention on Climate Change
MRV	Monitoring, Reporting and Verification		V&A	Vulnerability and Adaptation

ACKNOWLEDGEMENTS

GGGI is supporting the Republic of the Union of Myanmar in developing the country's MRV systems to support the country's reporting against the Article 13 enhanced transparency framework requirements of the Paris Agreement. GGGI would like to thank the staff of the several departments and ministries in Myanmar who participated in meetings. The report was prepared by Siddhartha Nauduri (GGGI) and benefits from inputs from U Kyaw San Naing (MONREC), Daw Su Su Lwin (MONREC), U Kyaw Moe Aung (UNEP-SNC), U Aung Thu Han (MONREC), U Min Myat Aung (MONREC), Aaron Russel (GGGI), Thiha Aung (GGGI) and Yoolim Jeon (GGGI).

EXECUTIVE SUMMARY

The enhanced transparency framework of the Paris Agreement requires countries to measure, report and verify their greenhouse gas emissions and removals, mitigation, and adaptation measures transparently, accurately and consistently. Myanmar has embarked on this journey by taking the lessons learnt from its reporting systems under the UNFCCC, and identifying the gaps and working internally and with development partners on improving internal systems and capacities. In this regard, GGGI is collaborating with the ECD in developing the MRV systems for future reporting. GGGI concluded a gap assessment in 2017, and in the following years has continued to work on Energy sector and on other capacity-building initiatives. Between 2019 and 2020, GGGI has worked on identifying the existing systems under UNFCCC that can be used *mutatis mutandis* to meet the ETF requirements under Paris Agreement.

This report is expected to be a living document to serve as a primary point for starting the data and information gathering exercises for preparing future GHG inventories as per the ETF requirements under the Paris Agreement. Therefore, this first covers the requirements arising out of the modalities, procedures and guidelines (MPG) of the ETF of the Paris Agreement as agreed at Katowice in 2018.

This report presents the existing MRV systems of Myanmar under the scope of industrial processes and product use (IPPU) sector in national GHG inventory and their transferability to meet the ETF requirements. GGGI conducted stakeholder analysis to study institutional arrangements, legal infrastructure, and internal processes for developing GHG inventory within the country.

IPPU Sector

The industrial processes and product use (IPPU) sector is not one of the main contributors to national GHG inventory. However, increased economic capacity of the country will increase the sector's contribution in the coming years, and hence it is being considered as an important element for building country's GHG inventory capacity. While existing data and information capturing systems are being utilized for the second national communication (SNC) under UNFCCC and the biennial update report, several systematic and capacity-gaps continue to exist within the country.

In the report the relevant sub-sectors and economic activities relevant to the IPPU sector in the country, as well as primary Departments and ministries who could be the source of information and data gathering have been identified.

Challenges and recommendations

Common cross-cutting issues between the IPPU sector being faced by the country are:

1. Lack of extensive stakeholder consultation systems for gathering information and data. While there are several industrial stakeholders within the country, the distributed nature of these economic activities, limited institutional and human capacity as well as private sector engagement are few of the principal challenges in improving the overall MRV system.
2. Clearly defined roles and responsibilities of the stakeholders are currently non-existent and those who are aware of them lack access to correct tools and technologies for data and information collection.
3. The country is working on improving access to primary sources of data from secondary sources, and thereby improving the overall quality of the GHG inventory that can be prepared.

4. Relevant ministries and departments have other priorities and limited human and financial capacities to redirect to climate change data and information gathering systems. The results are vastly improved when they do get these resources, but they are short-lived as there are no systems currently in place to institutionalize these lessons learnt. There are no dedicated staff or positions in all relevant Government departments planned and tasked with this responsibility. Activities, such as the SNC and BUR, are currently conducted on an ad-hoc basis, with funding from external agencies.
5. There are systems for collection of data and information, but to support the regular creation of national and sectoral GHG inventories, Myanmar needs to implement the existing legal instruments and data and information collection systems must be reviewed and revised.
6. A framework for data flow expertise and standards for reporting and data collection has to be created. The country needs to develop regulations or in the least, specific terms of reference for the various stakeholders for monitoring and reporting of data and information. These data and information collection systems can be further made robust with non-GHG related mechanisms as well
    a. A consolidated, and up-to-date stakeholder consultations map and registry needs to be created. This needs to be another living document to ensure that latest updates in economic activity in the country are readily reflected
    b. The stakeholders from not just other ministries, but also private sector and the universities have to be added. Further, the scope of this analysis should include sub-national systems as well.
    c. There should be renewed top-level commitment from the Government of Myanmar, in terms of legislation or steering committee or other such mechanism to indicate leadership and ownership of the GHG inventory process.
    d. The country can populate an experts roster which will serve as the starting point for GHG inventory creation.
    e. Furthermore, the country needs to identify its human resource gaps for conducting several kinds of analysis with the collected data and information: be it projections of different scenarios, or to assess the climate finance needed to achieve them, or to postulate the jobs that would be created, and people who need to be re-trained.
7. Laws and regulations for data collection and sharing have to be implemented in the country. There are two layers of laws and regulations required to support regular production of GHG inventory.
8. The country needs to develop a GHG database management system (DBMS).
9. A QA/QC system needs to be developed for the country. While there are existing QA/QC systems in place, the levels of uncertainty in the GHG inventory have to be improved.

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INTRODUCTION

1. The Global Green Growth Institute (GGGI) is an intergovernmental organization based in Seoul, founded to support and promote a model of economic growth known as "green growth", which targets key aspects of economic performance such a poverty reduction, job creation, social inclusion, and environmental sustainability. GGGI works with countries around the world, building their capacity and working collaboratively on green growth policies that can impact the lives of millions. The organization partners with countries, multilateral institutions, government bodies, and the private sector to help build economies that grow strongly and are more efficient and sustainable in the use of natural resources, less carbon intensive, and more resilient to climate change.

2. Republic of the Union of Myanmar has ratified the Paris Agreement (PA), and it came into effect on 19 October 2017. A robust measurement, reporting, and verification (MRV) system is essential to track and report its progress toward climate change mitigation under the enhanced transparency framework (ETF) of the PA. Myanmar is developing its institutional arrangements and systems to meet its reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC). The country is currently in the process of preparing its second national communications (SNC) and is also preparing its initial biennial update report (BUR) with support from the United Nations Environment Program (UNEP) which requires more accurate and reliable data sources.

3. While the country is making giant progress on building institutional capacities, Myanmar continues to face challenges in choosing the appropriate tools and methods used for calculating the GHG emissions, identifying nationally appropriate mitigation actions (NAMA) and their requisite MRV methods, and continues to have large gaps in vulnerability and adaptation assessment. Moreover, the reporting obligations under the ETF of PA add a layer of stringency and require expanded institutional and technical capacities across several government departments and at both national and sub-national levels. This means that the country needs additional technical and capacity-building support.

4. In this backdrop, Myanmar has been developing an integrated national MRV system with technical assistance from GGGI. In 2017, as part of the preliminary analysis, GGGI carried out a gap assessment of the MRV system in Myanmar and hosted an inception workshop with the Environmental Conservation Department (ECD) to share understanding of the MRV development of the government of Myanmar. In 2018, GGGI developed national MRV system baseline for the energy sub-sector in partnership with the ECD. The key institutions were identified, the policy frameworks within which data required for the preparation of a national GHG inventory were evaluated, and the stakeholders responsible for data assimilation and consolidation were identified. In 2019, GGGI initiated its support to Myanmar in accessing climate finance with capacity-building initiative for transparency (CBIT) funding from the Global Environment Facility (GEF), the key financing agency of the Paris Agreement as well, for setting up the national MRV systems in the country through partnership with UNEP. Through enhanced institutional and technical capacity, it is expected that the initiative will enable Myanmar to become better equipped to understand their baseline and track progress towards NDC targets.

5. Based on Myanmar's request for GGGI to support nationally determined contributions (NDC) implementation and financing, GGGI will support government in establishing an MRV system to facilitate data collection and report generation requisite for national and international review. To introduce MRV in Myanmar, GGGI conducted a detailed stakeholder and situation analysis to assess the current institutional capacity and data availability for such a system, to eventually

build on the existing mechanisms and institutional roles and responsibilities, strengthen capacity to collect and manage data, and support the aggregation of this information into reports and inventories. The MRV system will incorporate poverty reduction, gender and social inclusion metrics in its design in order to strengthen buy- in for mitigation action among policy makers and their constituencies, showcasing the social impact of mitigation.[6] This report is part of the wider GGGI support to the country, which includes evaluations on other sectors and a train the trainer program which was organized in collaboration with Australian Volunteers program.

Country context

6. Myanmar is an LDC in Southeast Asia, with a population of 51.4 million and a per capita income of $1,105. Since 2011, Myanmar has begun transition to a market economy, and from military rule to democracy. The opening up of the economy has accelerated growth, with a 6.5 percent growth average since 2011. Myanmar relies heavily on natural resources such as energy, minerals, forestry, and agriculture for its main exports and industries, which makes it essential that its growth pattern is environmentally sustainable. Myanmar's potential needs to be unlocked through careful analysis and by charting a sustainable development path that generates strong economic, environmental and social outcomes.

Initial National Communication

7. The first national communication was officially submitted to UNFCCC in 2012. The key information in INC are summarized as follow-
   a. Myanmar is a sink country with the net removal of ~67,000 Gg CO2 eq;
   b. Agriculture and Other Land Use Sectors are key categories for GHG emissions and removals.
   c. IPCC 2006 guideline was used at Tier 1 level;
8. Based upon the INC submission, Project Implementation Plan - PIP for second national communication report preparation was formulated to implement the following activities (preparation of NC report chapters);
   a. Introduction and Institutional Setup
   b. National Circumstance
   c. National Greenhouse Gas Inventory on
   d. Energy Sector
   e. Industrial Sector
   f. Agriculture Sector
   g. Land Use Change and Forestry Sector
   h. Waste Sector (Myanmar Energy Sector Assessment, Strategy and Roadmap, 2016) (Myanmar's Intended Nationally Determined Communication - INDC, 2015) (Myanmar's

[6] Seres, Stephen. 2017. The Status of Monitoring, Reporting and Verification of Nationally Determined Contributions to Climate Actions in Myanmar. GGGI/MONREC MRV Project Report No.1

Intended Nationally Determined Communication - INDC, 2015) (Myanmar's Intended Nationally Determined Communication - INDC, 2015)

i. Measures to facilitate vulnerability assessment and adaptation options

j. Measures to facilitate Climate Change Mitigation;

k. Other information on (Environmentally Sound Technology; Climatic Research and Systematic Observation; Education, Training and Public Awareness);

l. Constraints and Gaps in terms of Finance, Technology and Capacity Building.

9. The first national communication of Myanmar, prepared as per the IPCC 2006 guidelines, with the base year of 2000 covered the following sources:

10. A detailed list of activity and source structure in the Energy Sector according to 2006 IPCC Guidelines is provided in Appendix I. The following types of GHGs will be covered, as per the IPCC 2006 guidelines: CO_2, N_2O, CH_4.

11. The current inventory of GHG emissions from energy consumption took into account all emissions from fossil fuel combustion. Fuel combustion, one of the largest contributors to GHG emissions in Myanmar, can be broadly categorized into four groups for emission assessment, i.e. energy industries, manufacturing industries and construction, transport and other sectors having emissions from energy consumption. Myanmar's commercial energy resources depended almost fully on hydropower and fossil fuels. The emission sources in the sector of electric power and heat supply were defined to be the power generation and heat supply of Myanmar's thermal power utilities while the emissions from auxiliary power plants and other sources of heat supply were reported in the relevant sectors. Machineries and equipment for fossil fuel combustion composed of gas turbines and combined cycle power plants, power generating boilers, industrial boilers, industrial kilns, household cooking ovens, farm implements, power-generation internal-combustion engines, different kinds of aviation vehicles, road transport vehicles, railway transport vehicles, shipping transport vehicles, etc.

12. The national GHG inventory for the energy sector covered three major GHGs: CO_2, CH_4, N_2O. The main sources of GHG emissions examined are fossil fuel combustion, traditional biomass fuel combustion, fugitive emissions from coal mining activities, and oil & natural gas system. The total GHG emissions from energy sector of Myanmar were estimated to be 7,863.47 Gg CO_2e most of which come from fossil fuel combustion according to Myanmar INC 2012. CO_2 emissions accounted for 97 % of total emissions while CH4 and N2O emissions shared only 2% and 1% respectively.

13. Currently, Myanmar has been using different types of primary energy sources such as solid and liquid fuels. The main sources of GHG emissions in the energy sector are fossil fuel combustion, traditional biomass fuel combustion, fugitive emissions from coal mining activities, and oil and natural gas system. Three different gases are tracked which are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in national GHG inventory of energy sector[7].

Second National Communication

14. The country is in the process of preparing and submitting its second national communication. The project, which began in 2017 is still on-going. This further highlights the need for the country to

[7] Myanmar's Initial National Communication Under the United Nation Framework Convention on Climate Change (UNFCCC), 2012

enhance its human and technical capacities to meet the reporting obligations under the Paris Agreement.

Intended Nationally Determined Contribution

15. Myanmar has submitted its INDC in 2015 and its NDC released in 2017. Mitigation actions from INDC, and probable data to be measured include:

    a. Renewable energy – Hydroelectric power. Increase the share of hydroelectric generation within limits of technical hydroelectric potential and instead of the development of fossil fuel-based power generation. Indicative data and information to be collected and measured: installed capacity, planned capacity, emission factors for the grid, grid-connected or off-grid, water sources other non-carbon benefits; and at later stages, potential sources of methane emissions.

    b. Renewable energy – Rural electrification. To increase access to clean sources of electricity amongst communities and households currently without access to an electric power grid system. The Project will support the scale-up of low carbon energy through grid connections and renewable or hybrid energy for village-scale mini-grids and off-grid solar home systems to replace current fossil fuel sources of electricity and lighting including diesel and kerosene. Indicative data and information to be collected and measured: types of renewable energy available; potential of exploitable renewable energy available and utilized; emission factors for the renewable energy sources; grid-connectivity / off-grid access points; non-carbon benefits.

    c. Energy efficiency – industrial processes. To mitigate GHG emissions in the rapidly developing industrial production sector by reducing energy consumption by 20% by 2030 against the base year of 2012. Indicative data and information to be collected and measured: Existing baseline of select industrial processes for energy consumption, projections for demand in the next short to long-term, supply-side and demand-side energy-efficiency audits, baseline fuels, emission factors, grid-connectivity / off-grid access points; non-carbon benefits.

    d. Energy efficiency – cook stoves. To increase the number of energy efficient cook stoves distributed in order to reduce the amount of fuel wood used for cooking.8 Indicative data and information to be collected and measured: Baseline fuel consumption, categorization, renewable and non-renewable biomass categorization, cookstove usage, suppressed-demand estimation and calculation, any other methodology-related parameters.

16. Myanmar's Climate Change Strategy and Action plan's ultimate goal is to plot out climate resilient, low carbon and sustainable development pathway for the country. For the energy sector, this means choosing a development strategy that minimizes social and environmental impacts while expanding access to energy to the public and for economic development.

    a. Expand energy access to the public using renewable and low-impact technologies. The INDC targets 6 million people living in rural areas to gain access to electricity from micro-hydro, biomass, wind and solar mini-grid technologies.

    b. Increase the role of renewable energy throughout the energy sector.

    c. Promote technology transfer, capacity building, and funding to minimize the environmental impacts of energy sector development

[8] Myanmar's Intended Nationally Determined Communication- INDC, 2015

Updated NDC

17. The revised and updated NDC is under final stages of confirmation for submission to UNFCCC.
18. The NDC does not cover any targets under the IPPU sector. However, the baseline emissions for the sector are set to increase in the future with new industries coming-up.

Need for developing MRV system

19. The need for developing a robust MRV system for the country emanates from the requirements under the enhanced transparency framework (ETF) of the Paris Agreement, codified in its Thirteenth Article.
20. At Katowice in 2018, the modalities, procedures and guidelines (MPG) for the Article 13 were agreed upon by the Parties.
21. As previously indicated, the country has had experience in meeting its reporting obligations under the UNFCCC. However, the country has faced challenges and gaps in implementing the projects.
22. The FNC was communicated in 2012, the SNC is still in the workings, and the country has only now started its work on its first BUR.
23. In Myanmar, some MRV-related initiatives are already in place and therefore it makes sense to build on the existing structures. However, these structures are often disparate.
24. The country still faces systemic challenges of tackling its reporting obligations on a project-by-project basis and doesn't have institutional arrangements in place to implement them seamlessly.
25. The enhanced reporting obligations under the Paris Agreement require the country to quickly update its systems and capacities to enable the country to submit its first biennial transparency report (BTR) by 2024.
26. This report was undertaken with a focus on MRV systems for GHG inventory. The scope of evaluation was restricted to the IPPU sector, and sub-sectors relevant to the country.

The Enhanced Transparency Framework of the Paris Agreement

27. The knowledge and experience from the design and implementation of measurement, reporting and verification (MRV) systems under the UNFCCC were the basis for the enhanced

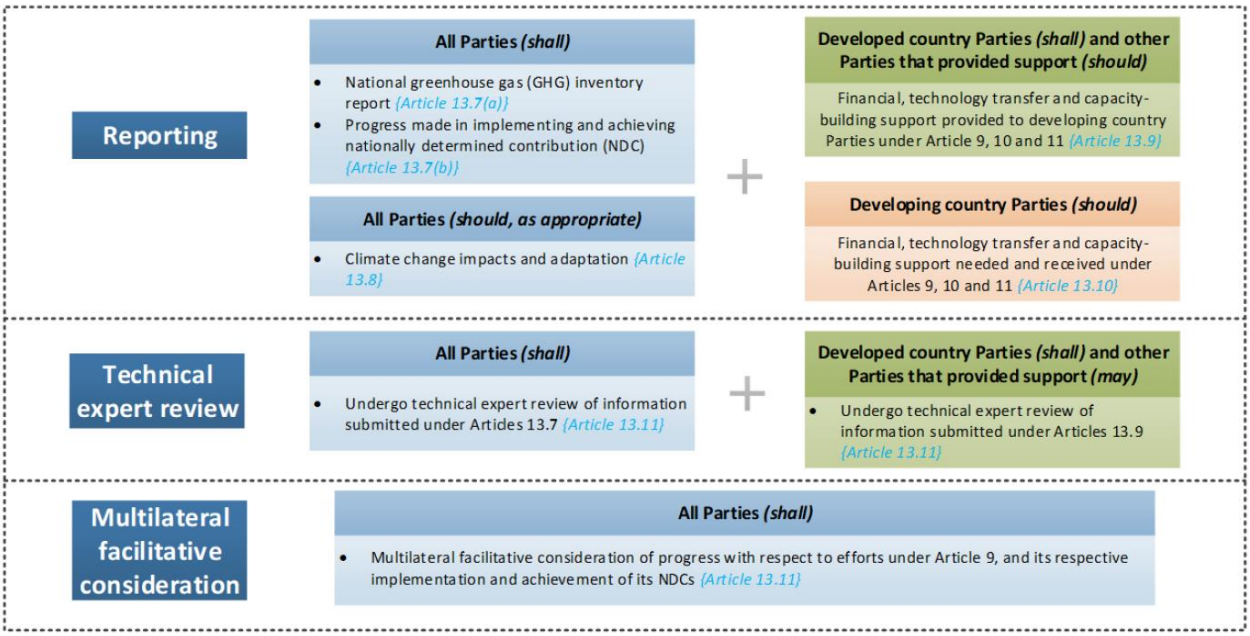


Figure 2: Article 13: The Enhanced Transparency Framework

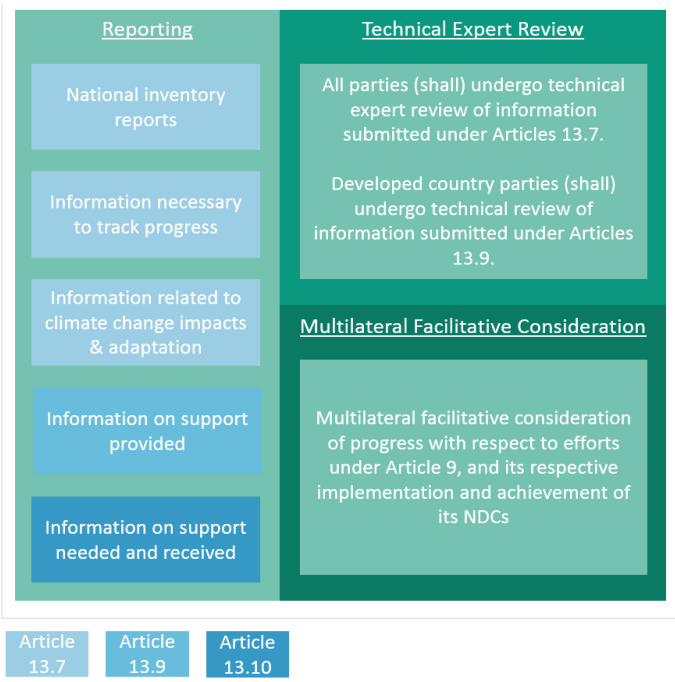


Figure 1: Verification under the ETF

transparency framework (ETF) of the Paris Agreement. The modalities, procedures and guidelines (MPG) of the Article 13 of the Paris Agreement were agreed at COP24 at Katowice in 2018. While they exhaustively cover the requirements for both developing and developed countries, a blurring of distinction fundamental to the Paris Agreement, they have in-built flexibilities for those developing countries that need it. These flexibilities are embedded both in the Paris Agreement itself as well as the MPGs. Few of the critical elements pertaining to developing countries are summarized below.

28. The ETF sets the following requirements for all Parties to the Paris Agreement, specifically focused on the developing country Parties. Underpinning the different rules and regulations and norms of the Paris Agreement is the requirement to assess the progress being made on a global scale to reduce GHG emissions; either predict or assess the short, medium and long-term impacts of climate change; adapt to these expected changes in climate and collectively assess the climate finance needed to carry out these activities.

Guiding principles

29. The guiding principles of the ETF are identified in the MPGs as follows:
    a. Building on and enhancing the transparency arrangements under the Convention
        i. recognizing the special circumstances of the least developed countries
        ii. facilitative, non-intrusive, non-punitive manner, respecting national sovereignty and avoiding placing undue burden on Parties
    b. Facilitate improved reporting and transparency over time;
    c. Provide flexibility to those developing country Parties that need it in the light of their capacities;
    d. Promote transparency, accuracy, completeness, consistency and comparability;
    e. Avoid duplication of work and undue burden on Parties and the secretariat;
    f. Ensure that Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention;
    g. Ensure that double counting is avoided;
    h. Ensure environmental integrity

Flexibility to those developing country Parties that need it in the light of their capacities

30. One of the principal considerations of the Paris Agreement and its MPGs is the flexibility afforded to countries that need it in line of their capacities. Embedded in the Paris Agreement itself, with clear mandate to have the principle embedded in the MPGs of its implementation, these flexibilities offer countries that need them in light of their limited capacities to opt for them during implementation. The MPGs:
    a. Provide flexibility in the implementation of the provisions of Article 13
    b. In the scope, frequency and level of detail of reporting, and in the scope of the review

c. Self-determined – *i.e., they are determined by the Party itself*

d. Flexibility description

   i. Clearly indicate the provision to which flexibility is applied

   ii. Concisely clarify capacity constraints, noting that some constraints may be relevant to several provisions, and

   iii. Provide self-determined estimated time frames for improvements in relation to those capacity constraints

e. The technical expert review teams **shall not review** the Party's determination to apply such flexibility or whether the Party possesses the capacity to implement that specific provision without flexibility

MPGs of Article 13

31. COP 24 (Katowice, 2018) agreed that common time frames shall be applied from NDCs to be implemented from 2031 onwards. As it is expected that NDCs shall be submitted five years before the start of their timeframes, this means that the common timeframes will be applied to the NDCs submitted in 2025. While the specific contents of the NDCs has not been decided, the following elements that have to be reported under the biennial transparency reports (BTR) mean that the information should be monitored by the country and be the basis for the revision of the NDC.

32. The ETF of the Paris Agreement[9] has set expanded the requirements for Parties to measure, report and verify their climate actions and information provided under their national GHG inventory.

33. While the ETF has converged all reporting requirements for both developing and developed countries, there are embedded flexibilities provided in the Paris Agreement for those countries that need them in light of their capacities, with special regard to LDCs and SIDs.

34. The Chapter II of the MPGs, contains provisions on the following for GHG inventories submitted by Parties:

    a. Definitions

    b. National circumstances and institutional arrangements

    c. Methods, including:

       i. Methodologies, parameters and data

       ii. Key category analysis

       iii. Time series consistency and recalculations

       iv. Uncertainty assessment

       v. Assessment of completeness

       vi. QA/QC;

[9] https://unfccc.int/sites/default/files/resource/ETF_technical%20handbook_First%20Edition.pdf

d. Metrics

e. Reporting guidance on information to be reported, including:

   i. Information on methods and cross-cutting elements

   ii. Sectors and gases

   iii. Time series

Evaluation methodology

35. A series of questions were discussed with the key coordinating agencies, and their feedback collected. The following analysis is based on the feedback received and further one-on-one discussions that were carried out in person and online.

36. The discussions centred around the following elements:

    a. First the above ETF framework was presented to facilitate the understanding of requirements, as well as providing the explanations on the flexibilities inherent to the ETF MPGs were discussed.

    b. Institutional arrangements: how the organization or department participated in previous GHG inventories, the information they provided and how they communicated these with the coordinating agency. Issues of their ability to collect primary data and their human, technical and financial capacities were also discussed.

    c. Activity data and information: The organization or department's ability to gather key data points against the IPCC 2006 Guidelines were discussed, including the frequency of collection, systems of collection and data verification. Issues of data quality checks and retention and retrieval were also discussed.

    d. Emission factors: whether the organization or department provided emission factors data, or if it had the ability to provide these data points were discussed.

    e. Laws and regulations: this was primarily to understand the existing laws and regulations that facilitated data and information sharing not just within the country, but across different ministries. Issues of data sensitivity, confidentiality and records were discussed.

IPPU SECTORAL SCOPE FOR MYANMAR

37. The IPCC 2006 Guidelines specify the data and information required to assess the GHG emissions from the industrial processes and product use (IPPU) sector. While the guidelines cover various activities, not all of them are relevant to Myanmar. Therefore, in the following pages, the results of the exercises carried out to identify the major sub-sectors and activities within the country are summarized.

38. Myanmar has used a mixture of both Tier 1 and Tier 2 systems for preparing the IPPU sector's GHG inventory in the SNC. To support the country to progress to Tier 2 systems in all relevant sub-sectors of the country, this document identifies the data and information required for the progression.

Mineral Industry

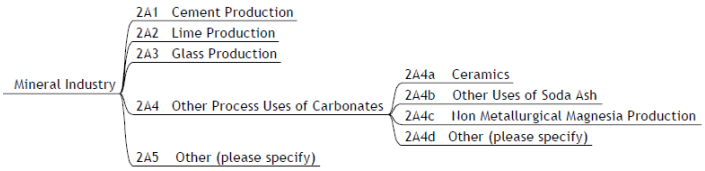
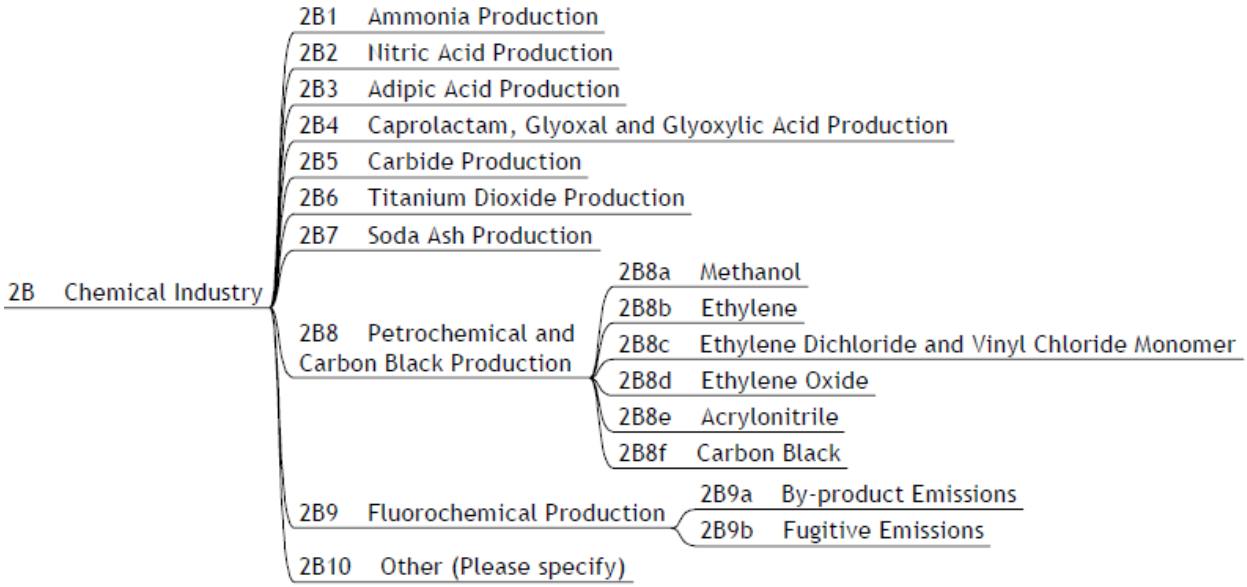


Table 1: Relevant IPCC 2006 Guidelines sectors in Myanmar under Mineral Industry

Sub-sector	Activity	Relevance to Myanmar	Relevant Ministry
2A1	Cement Production	Relevant industry	Ministry of Industry
2A2	Lime Production	Relevant industry	Ministry of Industry
2A3	Glass Production	Only one factory; it is not being operated at commercial conditions, but will hopefully start soon again; but this will not be a key category;	-
2A4	Other Process Uses of Carbonates	Further analysis presented below	-
2A4a	Ceramics	Ceramics are usually imported into the country, not a relevant sector	-
2A4b	Other Uses of Soda Ash	Soda Ash is imported, but this information is not being collected. However, it is not expected to be a key category.	-

2A4c	Non-Metallurgical Magnesia Production	A relevant category	-
2A5	Others	No other GHG emission sources were identified	-

Chemical Industry



Sub-sector	Activity	Relevance to Myanmar	Relevant Ministry
2B1	Ammonia Production	Ammonia is used in fertilizer production, is a Key Category	Ministry of Energy
2B2	Nitric acid Production	This is used for military purposes, but information is restricted; not considered a key category	Military
2B3	Adipic Acid Production	Not relevant	
2B4	Caprolactam, Glyoxal and Glyoxylic Acid Production	Not relevant	
2B5	Carbide Production	Carbide is used but not produced in the country; not relevant	

2B6	Titanium Dioxide Production	No factory in the country; not relevant	
2B7	Soda Ash Production	Currently no production in the country, new factories being proposed; not relevant now but could be in future	
2B8	Petrochemical and Carbon Black Production	Further analysis presented below	
2B8a	Methanol	Relevant category	Ministry of Electricity and Energy
2B8b	Ethylene	Relevant category	Ministry of Electricity and Energy
2B8c	Ethylene Dichloride and Vinyl Chloride Monomer	Not relevant category	
2B8d	Ethylene Oxide	Not relevant category	
2B8e	Acrylonitrile	Not relevant category	
2B8f	Carbon Black	Is used for bleaching purpose, is only imported, but is a relevant category	Ministry of Electricity and Energy
2B9	Fluorochemical Production	Not relevant	
2B10	Other	No other GHG emission sources were identified	

Metal industry

- 2C Metal Industry
  - 2C1 Iron and Steel Production
  - 2C2 Ferroalloys Production
  - 2C3 Aluminium Production
  - 2C4 Magnesium Production
  - 2C5 Lead Production
  - 2C6 Zinc Production
  - 2C7 Other (please specify)

Table 2: Relevant IPCC 2006 Guidelines sectors in Myanmar under Metal Industry

Sub-sector	Activity	Relevance to Myanmar	Relevant Ministry
2C1	Iron and Steel Production	Relevant industry	Ministry of Industry
2C2	Ferroalloys Production	Relevant industry, although information availability from small-scale industries is low;	Ministry of Industry
2C3	Aluminium Production	A relevant category	-
2C4	Magnesium Production	Not relevant category	
2C5	Lead Production	Not relevant category, but information to be obtained	Mining Enterprise
2C6	Zinc Production	Not relevant category, but information to be obtained	Mining Enterprise
2C7	Other: Copper, Tin, Gold	Not relevant category, but information to be obtained	Mining Enterprise

Non-energy products from fuels and solvent use

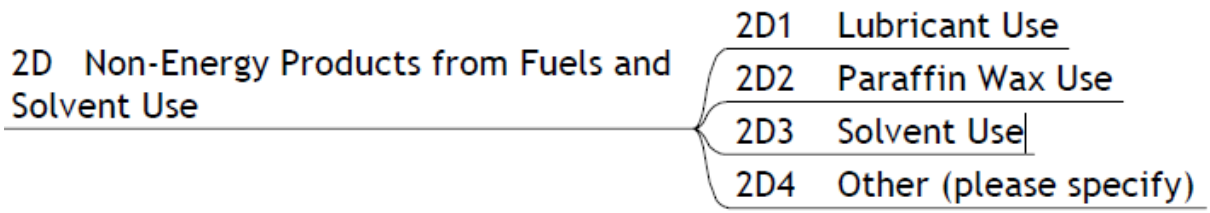


Table 3: Relevant IPCC 2006 Guidelines sectors in Myanmar under non-energy products from fuels and solvent use

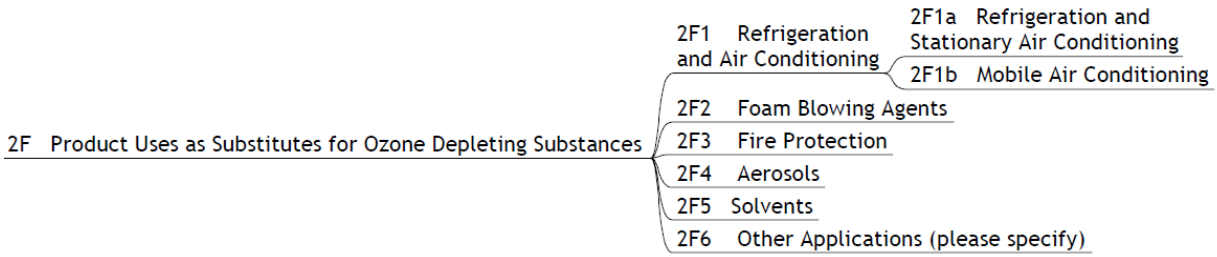
Sub-sector	Activity	Relevance to Myanmar	Relevant Ministry
2D1	Lubricant use	Relevant industry	
2D2	Paraffin wax use	Not relevant use	
2D3	Solvent use	Relevant category, but data is difficult to be obtained	-

2D4	Other	No other GHG emission sources were identified	

Electronics Industry

This is not a relevant sector for the country, as there are no electronics manufacturing units.

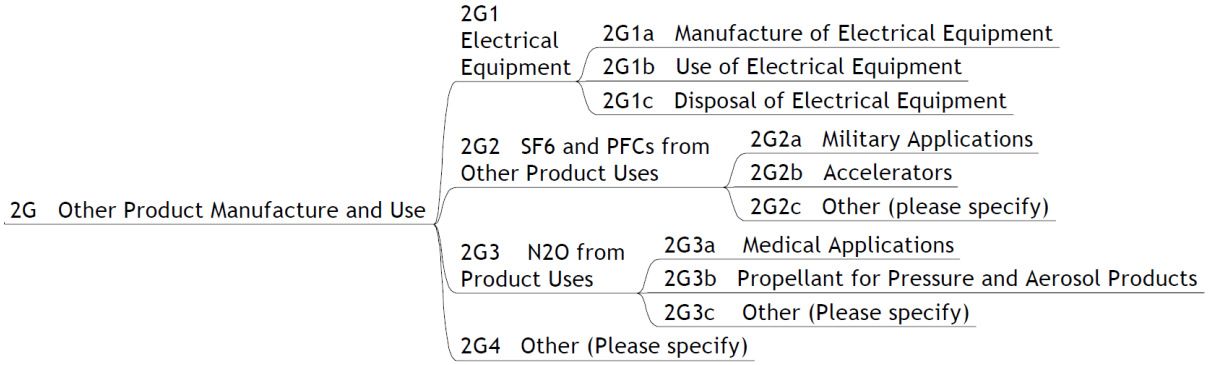
Product uses as substitutes for Ozone Depleting Substances



Sub-sector	Activity	Relevance to Myanmar	Relevant Ministry
2F1	Refrigeration and Air Conditioning		
2F1a	Refrigeration and stationary air conditioning	Relevant category, no manufacturing unit in Myanmar; all equipment are imported and utilized. Repair facilities are localized	Central Statistics Organization
2F1b	Mobile air conditioning	Relevant category	Central Statistics Organization
2F2	Foam blowing agents	Relevant category	
2F3	Fire protection	Relevant category, but information is difficult to be obtained	
2F4	Aerosols	Not relevant category	
2F5	Solvents	Relevant	

2F6	Other applications	No other GHG emission sources were identified	

Other product manufacture and use



Sub-sector	Activity	Relevance to Myanmar	Relevant Ministry
2G1	Electrical equipment	Relevant sub-categories, explained further below	
2G1a	Manufacture of electrical equipment	Relevant category	
2G1b	Use of electrical equipment	Relevant category	
2G1c	Disposal of electrical equipment	Relevant category	
2G2	SF6 and PFCs from Other Product Uses	Information is not collected; relevant category	
2G2a	Military applications	Information is not available	
2G2b	Accelerators	Information is not collected	
2G3	N2O from Product Uses	Not a relevant category	
2G4	Other		

Other

2H Other
- 2H1 Pulp and Paper Industry
- 2H2 Food and Beverages Industry
- 2H3 Other (please specify)

Sub-sector	Activity	Relevance to Myanmar	Relevant Ministry
2H1	Pulp and paper industry	Relevant sector	Central Statistics Organization
2F1a	Food and beverages industry	Relevant sector	Central Statistics Organization

CEMENT PRODUCTION

Data Sources and Methodologies

39. Both cement production (source category 2A1) and lime production (source category 2A2) constitute key categories in the country, which have a significant influence on the total inventory in terms of the absolute levels of emissions. In terms of process, cement production is an energy- and raw material-intensive process that results in the generation of CO_2 from both the energy consumed in making the cement and the chemical process itself. Whereas emissions from fuels consumed for energy purposes during the production of cement are accounted to the Energy Sector.

40. During the cement production process, calcium carbonate ($CaCO_3$) is heated in a cement kiln at a temperature of about 1,450 °C to form lime (i.e., calcium oxide or CaO) and CO_2 in a process known as **calcination or calcining**.

41. The quantity of CO_2 emitted during cement production is directly proportional to the CaO content of the clinker. An intermediate product created at high temperature in a kiln during the manufacture of cement. In the kiln, calcium carbonate is calcined to lime (CaO) and carbon dioxide (CO_2). The CaO then reacts with silicon dioxide (SiO_2) and other oxides to form hydraulically reactive minerals (primarily calcium silicates) within semi-vitrified nodules called clinker. The clinker is then finely ground (typically with a small quantity of gypsum) to form cement. The CO_2 (both from calcination and from the combustion of kiln fuels) from clinker manufacture is normally released to the atmosphere as a waste product and is a significant global source of CO_2 emissions (IPCC 2006, Glossary). During calcination, each mole of limestone (CaCO3) heated in the clinker kiln forms one mole of lime (CaO) and one mole of CO_2. The main chemical process in cement, lime and limestone industries is:

$$CaCO3 + heat \rightarrow CaO + CO2$$

42. CaO is combined with silica-containing materials to produce clinker (an intermediate product), with the earlier by-product CO_2 being released to the atmosphere. The clinker is then allowed to cool, mixed with a small amount of gypsum and potentially other materials (e.g., slag), and used to make Portland (typically for Myanmar) cement.

Tiered approach for GHG estimation from cement production

43. Tiers 1 and 2 are based on estimates of the amount of raw materials consumed or products manufactured, along with emission factors that represent the amount of CO_2 emitted per unit of mass (IPCC 2006). This method relies on the estimation of clinker production through use of cement production data. If cement may be made (ground) entirely from imported clinker, in which case the cement production facility may be considered to have zero process-related CO_2 emissions (IPCC 2006). CO_2 emissions from the manufacture of cement can be calculated in several ways depending on available data.

44. The Tier 1 approach used in Myanmar's GHG inventory is based on estimations of clinker production through the use of cement production data.

45. Calculation of CO_2 emissions is based directly from cement production in the absence of national clinker production data. Cement production data may be used to estimate clinker production by taking into account the amounts and types of cement produced and their clinker contents.
46. Information flow takes the following steps:
    a. Information comes from Ministry of Industry
    b. Reporting occurs
        i. Monthly: target against actual production
        ii. Quarterly: target against actual production
        iii. Yearly: target against actual production
    c. Fiscal year for reporting has now changed to calendar year and data is usually available by December of each year.
    d. Raw information and data from government and private industries are received by Planning Department before November (previously before March).
    e.
47. Information on the amount of limestone produced is being collected as of now, but the systems need to be improved in expand the coverage, and ensure the data and information is flowing consistently over time.
48. Double counting: emissions from the production of imported clinker should not be included in national emissions estimates as these emissions were produced and accounted for in another country
    a. Account the clinker imports.
    b. It is noted that the country imports high quantities of clinker but only in-country produced cement is used for inventory estimations.
    c. Cement may be made (ground) entirely from imported clinker, in which case the cement production facility may be considered to have zero process-related CO_2 emissions (IPCC 2006)

Emission Factor

49. Default emission factor EF_{clc} was used by the country
    a. Uses a default CaO content for clinker of 65 percent (assumed)
    b. 100% of CaO is from calcium carbonate ($CaCO_3$) material and 100% calcination is achieved (assumed)
    c. Includes a correction for cement kiln dust[10] (CKD)
    d. Leads to a default EF of 0.52 tonnes CO_2 / tonne of Clinker, which is the default used by Myanmar

[10] Non-calcined to fully calcined dust produced in the kiln or pyro-processing line. CKD may be partly or completely recycled to the kiln (IPCC 2006, Glossary)

Tier 1 Default Emission Factor

CaO percent in clinker	EF_{cl}	Range of CaO between 60-67%
65%	0.52 t CO_2/t-clinker	Tier I with CKD corrected

Tier 2 approach

50. This approach is based on the use of aggregated plant or national clinker production data, and data on the CaO content in clinker. Myanmar has used the Tier 1 estimation method and its GHG emissions have been estimated directly from the cement production, and not from inferred clinker production.

Activity data

51. Emissions are estimated directly from clinker production data.
    a. Collection of clinker production data directly from individual plants has not yet been put in place
    b. Any non-carbonate sources of CaO, such as steel slag or fly ash, should not be included in the CaO content of clinker used for calculating emissions.
52. As of now, CKD data for collection and recycling practices at individual plants has not yet been implemented.

Emission factor

53. Country-specific emission factor if sufficient country-specific CaO content of clinker and inputs of non-carbonate CaO is available.
54. Assumed that the CaO range is with 60-67 per cent and remain stable at the plant level to within 1-2 percent. This has to be corroborated with first-hand data.

Tier 2 Default Emission Factors

CaO percent in clinker	EF_{cl}	Range of CaO between 60-67%
60%	0.47 t CO_2/t-clinker	Not including a CKD correction
65%	0.52 t CO_2/t-clinker	Tier I with CKD corrected
67%	0.53 t CO_2/t-clinker	Tier 2 default

Emission Factor for cement kiln dust (CF_{ckd})

55. In absence of data, the default CKD correction factor (CFckd) is 1.02 (i.e., add 2 percent to the CO_2 calculated for clinker, same as Tier I above).

Tier 1 Emission Calculation

56. Myanmar has followed the Tier 1 emission method as follows.

$$CO_2\ emissions = \left(\sum_i (M_{ci} * C_{cli}) - I_m + E_x\right) * EF_{clc}$$

where:

CO_2 emissions	Emissions of CO_2 from cement production (tonnes)
M_{ci}	Weight (mass) of cement produced of type *i* (tonnes)
C_{cli}	Clinker fraction of cement of type *i* (fraction)
I_m	Imports for consumption of clinker (tonnes)
E_x	Exports of clinker (tonnes)
EF_{clc}	Default emission factor for clinker in the particular cement = 0.52 tonnes CO_2/tonne clinker (corrected for CKD)

Tier 2 activity data needs and emission calculation

57. Tier 2 makes use of the aggregated clinker production data and does not need as much disaggregated plant and/or disaggregated clinker production data as for Tier 3.

Data Needs: Tier 2

58. Collection of clinker production data: Use aggregated plant or national clinker production data
    a. Collection of CaO content of the clinker
    b. Collection of clinker fraction of this CaO content from carbonate
    c. Where data are available on CaO from non-carbonate sources (e.g., slags and fly ash), this CaO should not be included in the CaO content of clinker used for calculating emissions
    d. Collection of data related to CKD collection and recycling practices at facilities

Tier 2 Emission Calculation

$$CO_2\ emissions = M_{cl} * EF_{cl} * CF_{ckd}$$

CO_2 emissions	Emissions of CO_2 from cement production (tonnes)
M_{cl}	Weight (mass) of clinker produced (tonnes)
EF_{cl}	Emission factor for clinker (tonnes CO_2/tonne clinker)

	Note: clinker EF is not corrected for CKD (as done for Tier 1 above)
CF_{ckd}	Emissions correction factor for CKD (dimensionless) – see below equation

Current data and information collection systems

59. The country can currently get production capacity and can get detailed data. Production data and raw material data used can be obtained by the ECD directly from Ministry of Industry.
60. Data is monitored and shared on a monthly, quarterly and annual reports to the Ministry of Industry, Heavy Industry Enterprise. All the reports for annual production and distribution, raw material, etc. are submitted to HIE.
61. Data is collected on a January to December basis, shifting from fiscal to calendar year reporting.
62. The departments have their own formats of raw data, and these need to be reviewed and synced to include the formats that would provide the activity data for calculating GHG emissions.
63. Currently data and information requests are shared in an Excel format and submitted via email.
64. New projects must submit feasibility study to Myanmar Investment Commission, which then provides this information to Ministry of Industry. This enables new capacity addition projects to synchronize their data and information provision systems.
65. There is a regulation[11] enacted by Ministry of Industry, Industrial Policy this is applicable to all industries that both publicly and privately owned have to follow.
66. While data for the GHG inventories currently provided by different ministries had to be checked sector-by-sector by ECD. Accuracy checks on information on raw material had to be carried out with QA/QC carried out through third party checks with analyses of cash flow and production numbers. The third-party reports to the ministry were verified by the Auditor General. However, this was based on expert judgement of experts and systems haves to be built to ensure that these are based on verified methods.

[11] https://www.mlis.gov.mm/mLsView.do;jsessionid=E494AE48E941CCBD009094168CE0A51D?lawordSn=3794

LIME PRODUCTION

67. Lime can be produced from the calcination of high calcium limestone ($CaCO_3$), or dolomite or dolomitic limestones that contain high magnesium as follows:
    a. For high calcium limestones

$$CaCO_3\ (high\ purity\ limestone) + heat \rightarrow CaO\ (quicklime) + CO_2$$

    b. For dolomite or dolomitic limestones

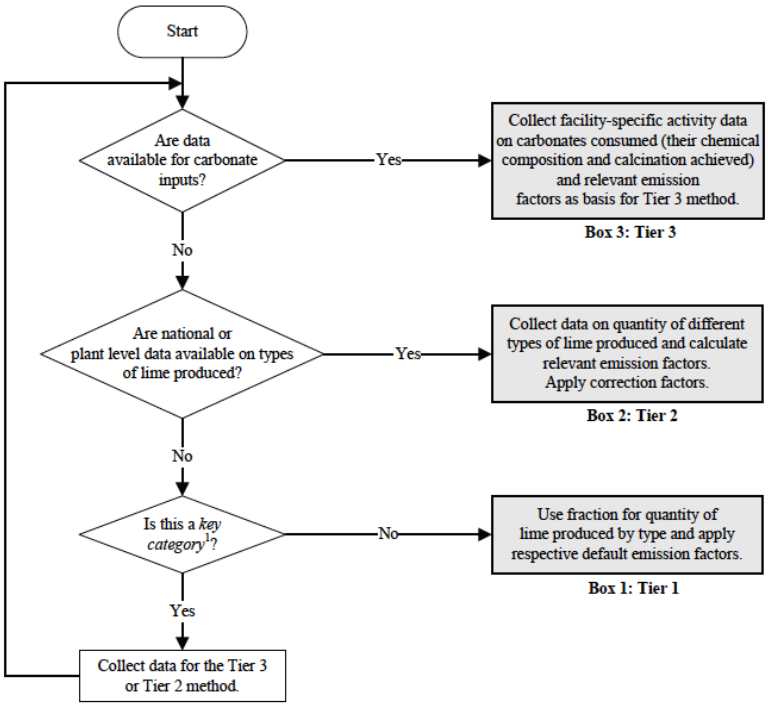
$$CaMg(CO_3)_2 + heat \rightarrow CaO \cdot MgO\ (dolomite\ lime) + 2CO_2$$

68. Limestone ($CaCO_3$) and dolomite ($CaCO_3.MgCO_3$) are basic raw materials commercially used in a number of industries including metallurgy (e.g. iron and steel) and glass manufacture. These are also used in construction and environmental pollution control. Lime produced therefore depends on the product requirements where it would be used.

GHG emissions from lime formation

69. Similar to the case for cement production there are three basic methodologies available for estimating the emissions from lime production. Figure 2A2-1 below (adopted from IPCC 2006) provides a snapshot of the various approaches in the estimation of CO_2 emissions that can be achieved.

Decision tree for estimation of CO_2 emissions from lime production



Source: IPCC 2006, volume 3

Tiered approach for GHG estimation from lime production

70. Tier 1 is an output-based approach that uses default values and is the easiest of the tiered approaches in terms of data and information needs.

Tier 1 approach

Emissions = Activity data (total amount of lime produced) * default EF

Activity Data

71. Activity data required are:
    a. Determine the aggregated national level lime production data
    b. If national level lime production data is not available, then country-production on the types of lime produced in the country may be used
    c. Does not require to account for the loss of lime Kiln dust (LKD) generated in lime production

Emission factor

72. Emission factor for lime production reflects the stoichiometric ratios between CO_2 and CaO and/or CaO·MgO, and an adjustment to account for the CaO or the CaO·MgO content of the lime. The default CO_2 emission factor for lime production is described below.
73. For high calcium lime
    a. 1 tonne of CaO requires calcination of 1.785 tonnes of $CaCO_3$ (high calcium lime), which releases 0.785 tonne of CO_2 per tonne of CaO produced
    b. Default content for CaO = 0.95 (fraction)
    c. Therefore, default CO_2 emission factor ($CaCO_3$) is
        i. 0.785 t- CO_2/t-CaO * 0.95
        ii. 0.75 t- CO_2/t-lime (high calcium)
74. For dolomitic lime:
    a. Value of tonne of CO_2 produced per tonne of MgO = 0.913
    b. Default content for CaO·MgO = 0.95 or 0.85 (fraction)
    c. Therefore, default CO_2 emission factor (dolomite) is 0.86 or 0.77 t- CO_2/t-lime (dolomitic lime)
75. Assuming lime consists an 85 percent production of high calcium lime; and 15 percent production of dolomitic lime, we have as follows

Default CO_2 emission factor = **0.75 tonnes of** CO_2 **per tonne of lime produced**

Typical lime types and default emission factors

Lime type	Stoichiometric ratio (tonnes CO_2 per tonne CaO or CaO·MgO)	Default value for CaO or CaO·MgO Content (fraction)	Default EF (tonnes CO_2 per tonne lime)
	A	B	C = A * B
High-calcium lime	0.785	0.95	0.75
Dolomitic lime	0.913	0.95 or 0.85	0.86 or 0.77
Hydraulic lime	0.785	0.75	0.59

Source: IPCC 2006, volume 3

Tier 2 approach

Activity data

76. Requires national level data on the types of lime produced

Emission Factor

77. Needs to account for the country specific CaO or CaO·MgO content
    a. Type 1: High-calcium lime

$$EF_{high-calcium\ lime} = stoichoimetric\ ratio_{CaO} * CaO\ content_{country-specific}$$

    b. Type 2: Dolomitic lime

$$EF_{dolomitic\ lime} = stoichoimetric\ ratio_{CaO \cdot MgO} * CaO \cdot MgO\ content_{country-specific}$$

    c. Type 3: Hydraulic lime

$$EF_{hydraulic\ lime} = stoichoimetric\ ratio_{CaO} * CaO\ content_{country-specific}$$

Data and information needs and equations for GHG emissions estimation

Tier 1 activity data needs and emission calculation

Data Needs: Tier 1

78. Option 1: No disaggregated data of lime production i.e., it is assumed that there is no production breakdown by lime types
79. Option 2: Disaggregated data on lime production is assumed i.e., an assumption is made that 85% is high-lime calcium and 15% is dolomitic lime
80. In both options, proportion of hydraulic lime is assumed to be zero

Tier 1 Emission Calculation

81. Emissions based on aggregated national lime production data

$$CO_2\ emissions = M_{lime} * EF_{lime}$$

Where:

CO_2 emissions	Emissions of CO_2 from lime production (tonnes)
M_{lime}	Weight (mass) of lime produced (tonnes)
EF_{lime}	Default emission factor = 0.75 (tonnes of CO_2 per tonne of lime produced)

Tier 2 activity data needs and emission calculation

Data Needs: Tier 2

82. Collection of disaggregated data by lime type (three main types of Table 2A2-1 above), since each have a different emission factor that would impact the emission estimates
    a. For sake of simplification, IPCC Tier 2 is simplified here by discounting correction factor for hydrated lime
    b. Collection of non-carbonate sources of CaO (*if applicable*)
    c. Collection of data related to lime kiln dust (LKD)
    d. Assume a correction addition of 2 percent if LKD data is not available (i.e., multiply emissions by 1.02)
    e. If vertical shaft kilns (VSKs) are used for production of lime, then LKD can be ignored

Tier 2 Emission Calculation

83. Emissions based on national lime production data by type (simplified)[12]

$$CO_2\ emissions = \sum_i \left(M_{lime,i} * CF_{lkd} * EF_{lime,i}\right)$$

CO_2 emissions	Emissions of CO_2 from lime production (tonnes)
$M_{lime,\,i}$	Mass of lime produced by type *i* (tonnes)
CF_{lkd}	Correction factor for LKD for lime of type *i* (dimensionless)
$EF_{lime,\,i}$	Emission factor for lime of type *i* (tonnes CO_2/tonne lime)

[12] Discounting the correction factor for hydrated lime of the type *i* of lime.

Existing institutional arrangements

Key data sought

Type of Lime produced in the Country	A	B	C	D
	Mass of lime produced	EF for lime production	CO_2 emissions	CO_2 emissions
	(tonne)	t- CO_2/t-lime	(tonne CO_2)	(Gg CO_2)
			C = A * B	D = C/10^3
Type 1				
Type 2				
Type 3				

Source: IPCC 2006, volume 3 worksheets

Data needs

Data Parameter	Indicator
Mass of lime produced	Aggregated weight as per type of lime produced in Myanmar
Mass of lime produced by type *i*	Aggregated weight per type of lime *i* produced in Myanmar

Current data and information collection systems

84. The reporting systems for lime production are not as sophisticated as they are for cement industry. Data on approved production numbers, based on which the current GHG inventories are being prepared, has been based on Mining Enterprise values.
85. Data on lime used for road construction, building, housing, etc. was obtained from the Ministry of Industry.
86. As the country has plans for expanding the sector, this becomes an important sector to focus on for future reporting.

METAL INDUSTRY

Scope	• All Iron and Steel plants in Myanmar • Data includes only pig iron production from metallurgical coke, and steel production, which is relevant to Myanmar
GHG	• CO_2

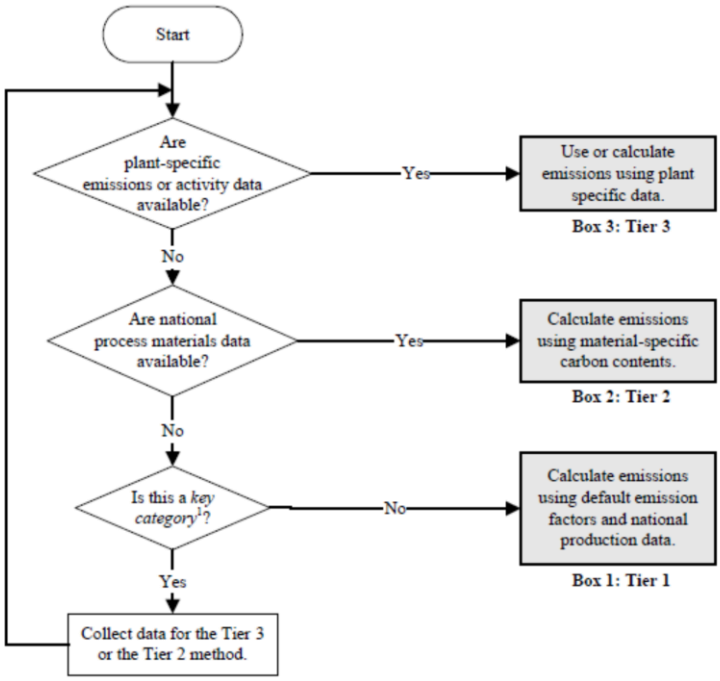
87. The industrial manufacturing of metals is an energy intensive process, requiring both heat and electricity, depending on the manufacturing process. Due to the nature of the underlying processes, usually only CO_2 is being accounted for, which is also the case with the IPCC Tier 1 methodology used in Myanmar.

Metal and steel manufacturing and estimation methods

Iron and steel production

88. Iron is produced in Myanmar using metallurgical coke. Steel production in Myanmar uses only electric arc furnaces (EAF) technology. The inventory calculation under this source category therefore include only pig iron production from metallurgical coke and steel production in EAF.

Decision tree for estimation of CO_2 emissions for the metal industry



Source: IPCC 2006, volume 3, chapter 4, figure 4.7

Tiered approach for GHG estimation from Metal production

Tier 1 approach

89. Tier 1 method uses IPCC defaults for the iron and steel production and default emission factors. Tier 1 does not consider plant-specific data or local raw material properties. Under this Manual no methane (CH_4) emissions were considered.

Activity Data

90. Data required for Tier 1 calculations are:
    a. Amount of iron/steel manufactured i.e., national production data
    b. Amount of pig iron produced and not processed into steel

Emission factor

91. Default IPCC emission factor for EAF
92. Default IPCC emission factor for pig iron production

Tier 1 Default Emission Factors

Parameter / emission factor		Value	Unit
Emission factor for pig iron not manufactured into steel	EF_{EAF}	1.35	tCO_2/tonne pig iron produced
Emission factor of steelmaking by EAF	EF_{IP}	0.08	tCO_2/tonne steel produced

Source: IPCC 2006, volume 3, chapter 3, table 4.1

Disaggregated data – higher Tier approach

93. The relevant Tier 2 method from IPCC requires considerably more data compared the Tier 1 method presented above. Not only is a disaggregation by facilities required, but also the amount of the various process (input) materials is required, in addition to the amount of product.

Methodological steps – Tier 2

Activity data

94. Activity data to be collected for Tier 2 MRV systems are:
    a. Access to national data on the use of process materials for iron and steel production
    b. Detailed activity data for the process materials and off-site transfers is needed for each manufacturing site

Emission Factor

95. Based on the carbon contents as seen in Table below.

Default Emission Factors

Parameter / emission factor (kg C/kg)		Value
Carbon content of coke consumed	C_{PC}	0.83
Carbon content of onsite coke-oven by-products consumed in blast furnace	C_a	monitored
Carbon content of coal directly injected into blast furnace	C_{CI}	0.67
Carbon content of limestone consumed in iron and steel production	C_L	0.12
Carbon content of dolomite consumed in iron and steel production	C_D	0.13
Carbon content of carbon electrodes consumed in EAFs	C_{CE}	0.82
Carbon content of other carbonaceous and process materials, consumed in iron and steel production, such as sinter or waste plastic	C_b	monitored
Carbon content of coke oven gas consumed in blast furnace in iron and steel production	C_{COG}	0.47
Carbon content of steel produced	C_s	0.01
Carbon content of iron production not converted to steel	C_{IP}	0.04
Carbon content of blast furnace gas transferred offsite	C_{BG}	0.17

Source: IPCC 2006, volume 3, chapter 3, table 4.3

96. Site-specific emission factors have to be monitored, namely
    a. Carbon content of onsite coke-oven by-products consumed in blast furnace; and
    b. Carbon content of other carbonaceous and process materials, consumed in iron and steel production, such as sinter or waste plastic.

Data and information needs, emission estimation and corresponding Institutional support

Tier 1 activity data needs and emission calculation

Data Needs

97. Data needs for Tier 1 Systems are:
    a. The amount of pig iron produced and not processed into steel
    b. The amount of steel produced in electric arc furnaces

Tier 1 Emission Calculation

98. The emission calculated simply multiplies the amount of product with its corresponding emission factor.

    a. CO_2 emissions from iron and steel production

$$E_{CO2,non-energy} = \mathrm{EAF} \cdot \mathrm{EF_{EAF}}$$

where:

$E_{CO2,\ non\text{-}energy}$	Emissions of CO_2 (tonnes)
EAF	Quantity of EAF crude steel produced (tonnes)
EF_{EAF}	Emission factor for EAF manufacturing (tonnes CO_2/tonne product)

    b. CO_2 emissions from production of pig iron not processed into steel

$$E_{CO2,non-energy} = \mathrm{IP} \cdot \mathrm{EF_{IP}}$$

where:

$E_{CO2,non\text{-}energy}$	Emissions of CO_2 (tonnes)
IP	Quantity of pig iron production not converted to steel (tonnes)
EF_{IP}	Emission factor for pig iron manufacturing (tonnes CO_2/tonne product)

Tier 2 activity data needs and emission calculation

99. The relevant Tier 2 method from IPCC requires considerably more data compared the Tier 1 method presented above. Not only is a disaggregation by facilities required, but also the amount of the various process (input) materials is required, in addition to the amount of product.

Data Needs: Tier 2

100. Data needs for a Tier 2 MRV system are:

    a. Quantity of coke consumption
    b. Quantity of onsite coke-oven by-products consumed in blast furnace
    c. Quantity of coal directly injected into blast furnace
    d. Quantity of limestone consumed in iron and steel production
    e. Quantity of dolomite consumed in iron and steel production
    f. Quantity of carbon electrodes consumed in EAFs
    g. Quantity of other carbonaceous and process material b, consumed in iron and steel production, such as sinter or waste plastic

h. Quantity of coke oven gas consumed in blast furnace in iron and steel production
i. Quantity of steel produced
j. Quantity of iron production not converted to steel
k. Quantity of blast furnace gas transferred offsite
l. Carbon content of material input or output

Tier 2 Emission Calculation

101. CO_2 emissions from iron and steel production (Tier 2)

$$E_{CO2,non-energy} = \left[PC * C_{PC} + \sum_a (COB_a * C_a) + CI * C_{CI} + L * C_L + D * C_D + CE * C_{CE} + \sum_b (O_b * C_b) + COG * C_{COG} - S * S_C - IP * S_{IP} - BG * S_{BG} \right] * \frac{44}{12}$$

Where

$E_{CO2,non-energy}$	Emissions of CO_2 (tonnes)
PC	Quantity of coke consumption
COB_a	Quantity of onsite coke-oven by-products consumed in blast furnace
CI	Quantity of coal directly injected into blast furnace
L	Quantity of limestone consumed in iron and steel production
D	Quantity of dolomite consumed in iron and steel production
CE	Quantity of carbon electrodes consumed in EAFs
O_b	Quantity of other carbonaceous and process material b, consumed in iron and steel production, such as sinter or waste plastic
COG	Quantity of coke oven gas consumed in blast furnace in iron and steel production
S	Quantity of steel produced
IP	Quantity of iron production not converted to steel
BG	Quantity of blast furnace gas transferred offsite

C_x	Carbon content of material input or output

Data and information and corresponding Institutional Arrangements

102. Data Needs – Tier 1: Existing Data Collection System

Parameter / emission factor		**Institutional Arrangement**
The amount of pig iron produced and not processed into steel	IP	National statistics office of Myanmar (NSO)
The amount of steel produced in electric arc furnaces.	EAF	National statistics office of Myanmar (NSO)

103. Tier 2 Data Needs

Parameter / emission factor	**Institutional Arrangement**
Access to national data on the use of process materials for iron and steel production	AD: Will need to be ascertained if the country decides to move to a higher tier EF: Site specific information is needed
Site-specific emission factors	

104. Data Needs (aggregated)

A	**A**	**B**	**C**
Metal production	**Amount of Steel or Iron Production**	**Emission Factor**	**CO_2 Emissions**
	(tonne crude steel produced, pig iron, DRI, sinter or pellet)	**(tonne CO_2/tonne production)**	**(tonne CO_2)**
			C = A * B
Electric Arc Furnace			
Pig Iron Production (not converted into steel)			
Total	A	B	C

Source: IPCC 2006, volume 3 Worksheets

NON-ENERGY PRODUCTS FROM FUEL AND SOLVENT USE

Scope	• Lubricant use in industrial and transport applications • All lubricants are imported with no local lubricants manufactured
GHG	• CO_2

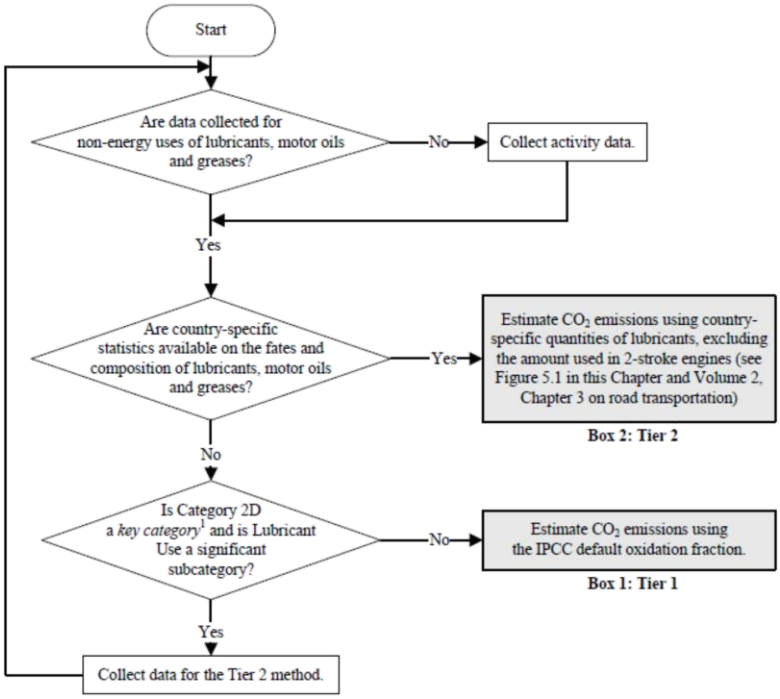
105. Currently the Myanmar GHG inventory includes GHG emissions from lubricant use in industrial and transport applications. This source category is responsible for a minute fraction of the IPPU related emissions (see Table 2-1 above) and is therefore not considered a key category.

106. In this estimation, it is assumed that all the lost lubricant is converted to CO_2, in accordance with IPCC guidelines. Also, it is assumed that all the imported lubricants are consumed at the year of import. There is no local lubricants manufacturing.

107. The section assumes that all imported lubricants are completely utilized at the year of purchase, and there is no national production of lubricants. Also assumed that all lubricants belong to source category 2D and all other uses are considered appropriately under those relevant source category(ies).

Solvent use and estimation methods

108. Decision tree for estimation of CO_2 emissions for the non-energy products industry



Source: IPCC 2006, volume 3, chapter 5, figure 5.2

Tiered approach for GHG estimation from Fuel and Solvent use

Tier 1 approach

109. The Tier 1 method uses IPCC defaults, combined with the amount of lubricant consumption nation-wide.

Activity Data

110. For Tier 1 systems, the data needs are quite basic:

a. Amount of lubricants used

Emission factor

111. For Tier 1 systems, the default IPCC emission factor for lubricants, as given in table below are used

Tier 1 Default Emission Factors for lubricants

Parameter / emission factor		Value	Unit	Source
Carbon content in lubricant	$CC_{Lubricant}$	20.0	%	IPCC 2006, volume 2, chapter 1, table 1.3
ODU factor	$ODU_{Lubricant}$	0.2	-	IPCC 2006, volume 3, chapter 5, table 5.2

Tier 2 approach

112. The relevant Tier 2 method from IPCC is similar to the Tier 1 method, with additional disaggregation to the various types of lubricants consumed. IPCC default emission factors may still be used, if local and/or type specific values are unavailable.

Activity data

113. For Tier 2 systems, the data needs are

a. Consumption of each type of lubricant

Emission Factor

114. The emission factors under Tier 2 systems could be expanded to include country-specific factors. However, this needs further prioritization based on resource availability.

a. Default IPCC emission factor for lubricant

b. Emission factor for each type of lubricant

Data and information needs and equations for GHG emissions estimation

Activity data needs and emission calculation

Data Needs: Tier 1

115. The amount of lubricant imported and used (national production/national statistic) is sufficient to calculate the GHG emissions from a Tier 1 MRV system.

Tier 1 Emission Calculation

116. Lubricants – Tier 1 method

$$CO_2\text{emissions} = \text{LC} \cdot \text{CC}_{\text{Lubricant}} \cdot \text{ODU}_{\text{Lubricant}} \cdot 44/12$$

where:

CO_2 emissions	Emissions of CO_2 (tonnes)
LC	Total lubricant consumption (TJ)
$CC_{Lubricant}$	Carbon content of the lubricant (kg C / GJ)
$ODU_{Lubricant}$	ODU factor for the lubricant

Tier 2 activity data needs and emission calculation

Data Needs: Tier 2

117. Tier 2 systems need the consumption of each type of lubricant.

Tier 2 Emission Calculation

118. Lubricants – Tier 2 method

$$CO_2\text{emissions} = \sum_i (\text{LC}_\text{i} \cdot \text{CC}_\text{i} \cdot \text{ODU}_\text{i}) \cdot 44/12$$

where:

CO_2 emissions	Emissions of CO_2 (tonnes)
LC_i	Consumption of lubricant type *i* (TJ)
CC_i	Carbon content of lubricant type *i* (kg C / GJ)
ODU_i	ODU factor for lubricant type *i*

Existing institutional arrangements

Data Needs – Tier 1: Existing Data Collection System

Parameter / emission factor		Source
Total lubricant consumption	LC	National statistics office of Myanmar (NSO)

Tier 2: Data needs

Parameter / emission factor		Source
Total lubricant consumption	LC	National statistics office of Myanmar (NSO)

Data needs (aggregated)

A	B	C	D
Amount of Lubricant Consumed	**Lubricant Carbon Content**	**Fraction Oxidized During Use (ODU factor)**	**CO_2 Emissions**
(TJ)	**(tonne-C/TJ)**	**(fraction)**	**(tonne CO_2)**
			D = A * B * C * 44/12

Source: IPCC 2006, volume 3 Worksheets

PRODUCT USES AS SUBSTITUTES FOR ODS

Fluorinated substitutes for ozone depleting substances (ODS)

Scope	• In Myanmar, the main application areas using substitutes for ODS that result in to Hydrofluorocarbon (HFC) emissions are from the following applications:
	  • Refrigeration (stationary, mobile) and air conditioning (stationary, mobile);
	  • Fire suppression and explosion protection; and
	  • Foam blowing agents
	• All ODS substitutes are imported

GHG	• HFCs

119. All the substitutes for ODS are imported, there is no local production of these chemicals, and it is also assumed that there are no exports from Myanmar for these ODS and no chemicals are recovered or destroyed at the equipment end-of-life[13]. Furthermore, there is a trend for growing use of substitutes for ODS in Myanmar. The consumption of ODS alternatives – chiefly HFCs – in commercial refrigeration and air-conditioning sector in Myanmar has grown rapidly over the past decade due to robust development of the construction industry and the commercial and servicing sectors.

Tiered approach for GHG estimation from ODS

Tier 1 approach

120. The Tier 1 method uses IPCC default emission factors, and aggregated activity data values of consumption of substitute for ODS carried out at the application level rather than for individual products or equipment types. The Tier 1 under this source category is conducted as described in Table. Data needs and different approaches within Tier 1.

Tier 1	Approach A: Tier 1a	Approach B: Tier 1b
Emission estimates based at an aggregated level	• Emission factor approach	• Mass balance approach
Activity data:	• Data on annual chemical sales at the level of application • Level of sub-application i.e., at the equipment or product type not required	• Data on new chemical sales by application • Data on historic and current equipment sales adjusted for import/export by application

[13] In discussion with the Inventory Team it is revealed that there are no facilities in Myanmar that are capable to either recover, recycle or destroy chemicals. The recovery is usually only for equipment parts that find value in the market.

Tier 1	Approach A: Tier 1a	Approach B: Tier 1b
	• Country-specific or globally/regionally derived	• Country-specific or globally/regionally derived
Emission factor:	• Composite EF at the application level • Country-specific or (composite) default	• Not relevant

Source: IPCC 2006. Volume 3, Chapter 7

Tier 1A: Emission factor approach at the application level

Activity Data

121. Annual chemical consumption data in each application that exhibit delayed emissions

Emission factor

122. Composite emission factor for substitutes for ODS at the application level

Tier 1B: Mass Balance Approach at the Application Level

Activity Data

123. Measured consumption (i.e., sales) of each chemical in the country or facility being considered

Emission factor

124. No reliance on emission factor estimation under this approach

Data and information needs and equations for GHG emissions estimation

Tier 1 activity data needs and emission calculation

125. Activity data for the estimation of GHG emissions from product uses as substitutes for ODS were available only from year 2012 to 2015 and for the period in which the activity data was unavailable (2007-2011), which was back-calculated as needed for Tier 1 emission method.

Data Needs – Tier 1A

126. Data needs for a Tier 1 MRV system
    a. Production of substitutes for ODS (new chemical production and not reprocessing of recovered fluids)
    b. Imports of substitutes for ODS
    c. Exports of substitutes for ODS

d. Destruction of substitutes for ODS

e. Banks of substitutes for ODS

Emission Calculation – Tier 1A

127. The emissions are calculated using the following IPCC equations. Note, the equations are generic, and should be repeated for each chemical substitute for ODS and for each area of application. Calculation of net consumption of a chemical in a specific application

$$Net\ Consumption = \text{Production} + \text{Imports} - \text{Exports} - \text{Destruction}$$

where:

Net consumption	Net consumption of substitutes for ODS for the application (tonnes)
Production	Production of substitutes for ODS for the application (tonnes)
Imports	Production of substitutes for ODS for the application (tonnes)
Exports	Imports of substitutes for ODS for the application (tonnes)
Destruction	Destruction of substitutes for ODS for the application (tonnes)

128. Calculation of emissions of a chemical from a specific application

$$Annual\ \text{emissions} = \text{Net consumption} * Composite\ EF$$

Annual emissions	Emissions of CO_2 ($tCO_{2equivalent}$)
Net consumption	Net consumption for the application (tonnes)
Composite EF[14]	Composite emission factor for the application

Data Needs – Tier 1B

129. Data on annual sales of new chemical (for current equipment stock), which is the annual chemical consumption

130. In absence of net consumption data, regional and international databases and models that allocate regional chemical sales for different end uses (sub-applications) can be used.

[14] Composite emission factor refers to an emissions rate that summarises the emissions rates of different types of equipment, product or, more generally, sub-applications within an ODS application area. Composite emission factors should account for assembly, operation and, where relevant in the time-series, disposal emissions (IPCC 2006)

Emission Calculation – Tier 1B

131. General mass balance equation

$$\begin{aligned} Net\ Consumption \\ &= \text{Annual sales of New Chemical} \\ &- (Total\ charge\ of\ New\ equipment \\ &- Original\ total\ charge\ of\ Retiring\ equipment) \end{aligned}$$

Data and information and corresponding Institutional Arrangements

132. Myanmar country specific information is as follows.

Application area	HFC Gases	Period data is available from	Estimation method applied (period)
Mobile air conditioning	• HFC-134a	Introduced in year 2007	• IPCC 2006 Tier 1 and default EFs • GWPs for HFCs were taken from 1995 IPCC Second Assessment Report
Other applications	• HFC-23 • HFC-32 • HFC-134a • HFC-152a	Introduced in year 2010	• IPCC 2006 Tier 1 and default EFs • GWPs for HFCs were taken from 1995 IPCC Second Assessment Report

Substitutes for ODS used in Myanmar

Source Category	HFC Gases in Myanmar	Inventory sources
2F. Fluorinated substitutes for ODS	• HFC-23 • HFC-32 • HFC-125 • HFC-134a • HFC-143a • HFC-152a	

Key data sought

Non-ODS substance, grouped by application	A	B	C	D	
	Domestic production	Imports	Exports	Banks	EF
	Production	Imports	Exports		
	(tonne)	(tonne)	(tonne)	(tonne)	(CO_{2e}/tonne)

133. Assumptions and expert judgment exercised

a. No national generation of chemicals serving as substitute for ODS

b. No exports of substitutes for ODS

c. No destruction of substitutes for ODS

CHALLENGES AND RECOMMENDATIONS

Challenges

134. Building national and sectoral MRV systems requires the development of the following elements:
    a. Organisation – clear mandates, roles and responsibilities that bring people and data together to fulfil objectives to support decision makers.
    b. Data flows – the regular movement of data from specific data collection services into useful analysis and reports.
    c. Expertise – teams of individuals that understand the data and can use it to provide clear messages and indicators.
    d. Tools – the systems, templates, workplans, models and services available to ensure data flows, experts can work efficiently, and the system can inform decision makers.
    e. Stakeholder Engagement – the valued input of any stakeholders that provide data, tools, services, expertise and use the data and outputs of the MRV system.
135. ECD has the data requesting authority from each ministry. However, the response is often delayed due to capacity challenges in understanding the requirements.
136. Furthermore, there is room to improve on data collection, recording and management.
137. To calculate GHG emissions from the IPPU sector, activity data collection process is beyond the regular data collection activities carried out by responsible entities, which in themselves face delays due to human, technical and financial challenges and require constant follow-up.
138. The process of data request and collection is also procedural. To initiate the data process each time, ECD sends official letters to each ministry, which in turn send their own letters to their respective companies and other entities requesting data.
139. From the first national communication, data was eventually acquired to produce a basic GHG inventory but it was very laborious and costly to collect. Often, several personal visits to the source of the data (ministry, association or private company) over several months had to be carried out in order to acquire the data.
140. In few instances, proxy data had to be pieced together to reconstruct missing data.[15]
141. There are ad-hoc arrangements for regular collection of certain data points and each ministry has responsibility for its own data collection. However, these data collection frequency and methods vary from ministry to ministry.
142. The country does not have a GHG database management system that can consistently collect the data and information required from the key stakeholders.

[15] Seres, Stephen. 2017. The Status of Monitoring, Reporting and Verification of Nationally Determined Contributions to Climate Actions in Myanmar. GGGI/MoNREC MRV Project Report No.1

Recommendations

143. There are systems for collection of data and information, but to support the regular creation of national and sectoral GHG inventories, Myanmar needs to implement the following systems:
    a. Existing legal instruments and data and information collection systems must be reviewed and revised
    b. A framework for data flow expertise and standards for reporting and data collection has to be created
    c. The country needs to develop regulations or in the least, specific terms of reference for the various stakeholders for monitoring and reporting of data and information
    d. These data and information collection systems can be further made robust with non-GHG related mechanisms as well
144. The ECD is building its capacity to deal with GHG related data and information collection. Building on existing systems of ad-hoc data collection for the SNC, ECD is seeking funds from the GEF through the CBIT project to further consolidate these arrangements into regular reporting lines. However, the following elements can be further improved:
    a. The country can create an organogram for systematic and regular data and information collection.
    b. A consolidated, and up-to-date stakeholder consultations map and registry needs to be created. This needs to be another living document to ensure that latest updates in economic activity in the country are readily reflected
    c. The stakeholders from not just other ministries, but also private sector and the universities have to be added. Further, the scope of this analysis should include sub-national systems as well.
    d. There should be renewed top-level commitment from the Government of Myanmar, in terms of legislation or steering committee or other such mechanism to indicate leadership and ownership of the GHG inventory process.
    e. The country can populate an experts roster which will serve as the starting point for GHG inventory creation.
    f. Furthermore, the country needs to identify its human resource gaps for conducting several kinds of analysis with the collected data and information: be it projections of different scenarios, or to assess the climate finance needed to achieve them, or to postulate the jobs that would be created, and people who need to be re-trained.
145. On the allocation of resources for the regular collection of data and information needed for the GHG inventory, the country needs to prepare and implement robust planning.
    a. Currently only ad-hoc arrangements are in place to support this type of GHG inventory preparation. These have been supported financially by the GEF (National communications and biennial update reports) or other agencies.
    b. Longer-term solutions are the allocation of internal resource streams, and embedding regular data collection and sharing between ministries, departments as well as other public and private sector bodies.

c. The resource allocation should also include requirements for public dissemination and general awareness raising.

146. Laws and regulations for data collection and sharing have to be implemented in the country. There are two layers of laws and regulations required to support regular production of GHG inventory.

a. The first one involves the review and update of existing environmental laws and regulations to include data and information required from the various economic activities currently being undertaken in the country. This includes public and private institutions, industries, societies and other sources. Where data points are not being collected, these can be either added on to existing systems, or new laws and regulations have to be created. This could be the case where either the economic activities are newly introduced into the country, or there are existing thresholds which have been exceeded.

b. The second looks at systems for sharing of collected data and information between various ministries and departments and ECD. This can be achieved by either creating new regulation or be formalizing existing ad-hoc arrangements into formal ones.

c. These arrangements could either look at specific data flows, by establishing specific data points that need to be shared at specified intervals. Or they could look at over-arching umbrella agreements between responsible stakeholders so that fresh arrangements are not required each time a new data point is added to the list.

d. Analysis has to be done on the congruence of data and information collection systems with those serving other purposes, such as SDGs.

147. The country needs to develop a GHG database management system (DBMS) with the following features:

a. There must be effective regulatory framework available to enable the establishment and operation of an effective GHG database management system.

b. It should be able to clearly identify existing institutions and place systems to add and remove institutions, designating key contact personnel and providing them access to the DBMS

c. It should have clearly defined roles and responsibilities for

i. A statutory regulator

ii. A program administrator

iii. An IT developer

iv. A system developer

v. An end-user

d. The system should also be able to act as a primary point of QA/QC, ensuring that incorrect data (such as a number beyond a range, or text instead of number) is not entered

148. A QA/QC system needs to be developed for the country. While there are existing QA/QC systems in place, the levels of uncertainty in the GHG inventory have to be improved.

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