Training Manual on Climate Change Monitoring/
Measuring, Reporting and Verification

A 13-module course (26 hours) held between Dec. 23, 2019 - Nov. 13, 2020
at the Environmental Conservation Department, Nay Pyi Taw

Jointly Prepared by

Environmental Conservation Department,
Australian Volunteers Program, and
Global Green Growth Institute

February 2021

Disclaimer: Training material has been prepared based on the CGE training materials on the national GHG inventories.
LESSON 9

INTRODUCTION TO SUB-SECTOR MRV

(A) ENERGY/TRANSPORT, (B) IPPU
GGGI MRV Support for Myanmar Climate Change and Sustainable Development

Lesson 9 sub-sector MRV:
(a) Energy/Transport,
(b) IPPU (Industrial Processes and Product Use)

March 2020

What We’ve Learnt So Far...

Lesson 2 - What is the greenhouse effect, GHGs, global warming and climate change. Why a global approach to climate change is appropriate.
Lesson 3 - The aims and provisions under the UNFCCC, Kyoto and Paris Agreement. Reporting requirements under the Paris Agreement ETF
Lesson 4 - Myanmar climate change impacts (current and projected). International climate change framework and relations to Myanmar policies/bodies.
Lesson 5 - MRV – why is it necessary, status in Myanmar current and future.
Lesson 6 - SDGs, the Paris Agreement, NDCs and MRV – social, economic and environmental risks and risk assessment.
Lesson 7 - Updates - Paris Agreement, SDGs and Risk.
Lesson 8 - Myanmar’s Climate Actions, UNDP Screening tool.

Learning Outcomes

By the end of this lesson you will be able to:
1. Recognise what is included in the Energy and Transport sub-sectors;
2. Identify some the complexities for MRV in the Energy and Transport sub-sectors;
3. Recognise what is included in the IPPU sub-sector; and
4. Identify some the complexities for MRV in the IPPU sub-sector.

Recap - What is MRV?

The Monitoring, Reporting and Verification (MRV) framework is based around 5 principles:

Measuring/Monitoring
- GHG inventory
- Information on climate action impacts (both mitigation and adaptation)
- Financial arrangements, funds either given or received
- Technology advances and altered uses
- Other support that is either given or received

Reporting
- National Inventory Report (NIR) every year
- GHG Inventory (annually from 2020 - flexible for LDCs)
- Biennial Transparency Reports (BTR) (previously BUR) every two years, includes REDD+
- National Communications (NC) every four years

Verification
- Internal domestic data checks
- International consultation and analysis (ICA) of BUR
- Technical Expert Review (TER) - under Paris Agreement
- Facilitative multilateral consideration of progress (FMCP) - under Paris Agreement

Fuel Combustion Activities

Importance for Non-Annex I Parties

In Myanmar the IPPU sector is less significant compared to Energy and AFOLU

IPPU emissions estimation is important to find opportunitie s for GHG abatement

 Myanmar's GHG Emissions for Year 2000

Situation varies from country to country

IPPU sources may become significant in the future as developing countries' economies and industries grow

Including F-gases estimates can significantly add to IPPU emissions and influence total GHG estimates – also more abatement?
**IPPU Sector**

**IPPU – GHG emissions**

1. **Industrial Processes**
2. **Product Use**

1. **Industrial Processes** that chemically or physically transform materials releasing GHG:
   - chemically: \( \text{NH}_2 + \text{O}_2 = 0.5 \text{ N}_2 \text{O}_1 + 1.5 \text{ H}_2 \text{O} \) (nitric acid production)
   - physically: \( \text{CaCO}_3 + \text{(Heat)} = \text{CaO} + \text{CO}_2 \)

2. **Product Use**: GHGs are used in products such as refrigerators, foams or aerosol cans

**Note**: significant time can elapse between the manufacture of the product and the release of GHG. The delay can vary from a few weeks (e.g. for aerosol cans) to several decades (e.g. rigid foams). In refrigeration a fraction of GHG used in the products can be recovered at the end of a product’s life and either recycled or destroyed.

**IPPU Sector – in everyday life**

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**Cement**

- In 2016 produced 8% of global CO₂ emissions
- Annually over 10 bn tonnes of concrete used
- In next 40 yrs, global building floor area will double
- Cement production 25% increased by 2030

**Calcination**: \( \text{CaCO}_3 + \text{(Heat)} = \text{CaO} + \text{CO}_2 \) (IPPU)

**Combustion**: \( \text{Coal/Gas} + \text{O}_2 = \text{CO}_2 + \text{(Heat)} \) (Energy)

**CO₂ from Cement Production**

**Tier 1**

- \( \text{CO}_2 \) Emissions = AD clinker production \( \times \) EF clinker
- \( \text{CO}_2 \) Emissions = \( [M_{\text{cl}} \times C_{\text{cl}}] - \text{Im} \times \text{Ex} \) \( \times \) EF clinker
  - \( M_{\text{cl}} \): mass of cement produced of type i, tonnes
  - \( C_{\text{cl}} \): clinker fraction of cement type i, fraction
  - \( \text{Im} \): imports for consumption of clinker, tonnes
  - \( \text{Ex} \): exports of clinker, tonnes
  - \( \text{EF}_\text{clinker} \): emission factor for clinker, tonnes \text{CO}_2/\text{tonne clinker}

**Default EF_clinker = 0.02 tonnes CO₂/tonne clinker**

**Tier 2**

- Includes a correction addition for emissions associated with Cement Kiln Dust (CKD) not recycled to the kiln which is considered to be 'lost' and associated emissions are not accounted for by the clinker:

\[ \text{CO}_2 \text{ Emissions} = M_{\text{ckd}} \times \text{EF}_{\text{ckd}} \times \text{CF}_{\text{ckd}} \]

**Tier 3**

- Emissions based on carbonate raw material inputs

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**Energy Sector**

**1. Fuel Combustion**

- the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus

- Fugitive emissions: accidental (e.g. leaks) or intentional releases of gas (e.g. venting) from pressurized equipment contributing to air pollution

Not Energy Sector:
- 1. waste incineration without energy recovery = Waste
- 2. use of fossil fuels as a feedstock in the Industrial Sector (e.g. coke in Iron and Steel) = IPPU
- 3. biomass fires/open burning = AFOU

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**IPCC Fuels and Energy Units**

<table>
<thead>
<tr>
<th>CO₂ emissions (not included in total energy emissions)</th>
<th>NCV, TJJg</th>
<th>Carbon Content, kg/GJ</th>
<th>Default CO₂ EF, kg/TJ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass (Wood)</strong></td>
<td>15.6</td>
<td>30.5</td>
<td>112,000</td>
</tr>
<tr>
<td><strong>Peat</strong></td>
<td>9.76</td>
<td>28.9</td>
<td>106,000</td>
</tr>
<tr>
<td><strong>Lignite</strong></td>
<td>8.9</td>
<td>27.6</td>
<td>101,000</td>
</tr>
<tr>
<td><strong>Anthracite</strong></td>
<td>26.7</td>
<td>26.8</td>
<td>98,300</td>
</tr>
<tr>
<td><strong>Coking Coal</strong></td>
<td>28.2</td>
<td>25.8</td>
<td>94,600</td>
</tr>
<tr>
<td><strong>Residual Fuel Oil</strong></td>
<td>40.4</td>
<td>21.1</td>
<td>77,400</td>
</tr>
<tr>
<td><strong>Diesel Oil</strong></td>
<td>43</td>
<td>20.2</td>
<td>74,100</td>
</tr>
<tr>
<td><strong>Motor Gasoline</strong></td>
<td>44.3</td>
<td>18.9</td>
<td>69,300</td>
</tr>
<tr>
<td><strong>Natural Gas</strong></td>
<td>48</td>
<td>15.3</td>
<td>56,100</td>
</tr>
<tr>
<td><strong>Fossil fuels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Non-biomass municipal &amp; industrial wastes, waste oils</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fuel emission estimates (MRV)**

- There are two methods for estimating emissions, and their use depends on available data: the Reference Approach (RA) and Sectoral Approach (SA).
- The RA is based on few fossil fuel supply data, it is a top-down approach, using a country’s energy supply data to calculate the emissions of CO₂ from fuel combustion. It indicates an upper range to the Sectoral Approach because some of the carbon in the fuel is not combusted but will be emitted as fugitive emissions.
- The SA collects and applies detailed information on how the individual fuels are used in each sector.
- For MRV, need details of how emissions are calculated for the Energy sector.

**How to calculate CO₂ emissions?**

1. Diesel burnt by:
   - Stationary source – a diesel-generator
   - Mobile source – a car
2. Amount of diesel burnt: 1 Giga-gram (or 1 201 923 litres, or 317 561 gallons)*
3. Assuming complete combustion

\[
\text{CO}_2 \text{ emissions} = \text{Amount of Fuel} \times \text{NCV} \times \text{EF}
\]

\[
\text{NCV} = \text{Net caloric value}
\]

\[
\text{EF} = \text{Emission factor}
\]

* Density of diesel 0.832 kg/litre or 6.943 lbs/US gallon

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**Road Transport**

- All fuel sold in a country is included in national estimates even if a vehicle crosses a border or fuel exported in fuel tanks of vehicles.
- Bio-fuels - carbon removed from total and reported separately.
- Carbon is also emitted from urea-based catalysts and included here (not strictly combustion).
- CH₄ and N₂O strongly technology related. At higher tiers need to know technologies in fleet (especially type and proportion of catalysts).
- Caution with “fuel sold” data:
  - overlaps with off-road and potentially other sectors (e.g., agriculture)
  - blended fuels (e.g., bioethanol) and lubricants
  - smuggling

**Summary**

- Energy Sector = Fuel combustion (mobile and stationary) + Fugitive emissions + CCS (carbon capture and storage).
- Energy emissions are usually the most important.
  - CO₂ from fuel combustion is major source.
  - CH₄ mainly comes from fugitive emissions.
- CO₂ emission factor depends on carbon content of fuel, non-CO₂ on the technology used.
- Methodological issues (biomass, international bunker, excluded carbon/fuels in other sectors).
- Reference Approach (RA) is used for checking figures (CO₂).

**Recommendations**

To improve the existing MRV system for the energy sector and to prepare for the enhanced transparency framework of the Paris Agreement, the following activities should be carried out:

1. Develop detailed tools, guidelines and data and information collection templates for the sub-sectors of energy as per IPCC 2006 guidelines.
2. Develop capacity-building and awareness creation plans and activities.
3. Capacity building of individual researchers in energy sector for MRV system should be promoted.
4. Develop guidelines and standards for data and information management and build capacity accordingly. This facilitates transfer and data sharing between institutions.
5. Engage one or more persons to set up and manage the data management system as it pertains to MRV under the Paris Agreement with a clear mandate and timelines to follow through.
6. Engage one or more persons responsible for the capacity building program with a clear mandate and timelines to follow through with training.
SLIDE 2 What we’ve learned so far

Lesson 2 - What is the greenhouse effect, GHGs, global warming and climate change. Why a global approach to climate change is appropriate.

Lesson 3 - The aims and provisions under the UNFCCC, Kyoto and Paris Agreement. Reporting requirements under the Paris Agreement ETF

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Lesson 8 - Myanmar’s Climate Actions, UNDP Screening tool.

Any questions? Is a quick recap necessary?

SLIDE 3 Learning outcomes

By the end of this lesson you will be able to:

1. Recognise what is included in the Energy and Transport sub-sectors;
2. Identify MRV needed for Energy and Transport sub-sectors;
3. Recognise what is included in the IPPU sub-sector; and
4. Identify MRV needed for IPPU sub-sectors.

SLIDE 4 Recap - What is MRV?

Read/review from slide

SLIDE 5 Fuel Combustion Activities

Energy, CLICK Transport CLICK and IPPU CLICK (Industrial Processes and Product Use) can be considered as different sub-sectors under the fuel combustion category within climate change. In this way of organising emissions categories, the diagram shows the sub-sectors as being different, but from a broad climate change perspective there are strong inter-relationships between them. The sub-sectors are often separated by the emissions they generate.

Within Energy, 3 activities are identified, the main activity is Electricity and Heat Production, next is Petroleum Refining, and finally manufacture of solid fuels and other Energy Industries.

Transport is separated into 5 categories: aviation; road transport, railways, water–related transport, and a category of other.

IPPU has many categories associated with mining and quarrying, production (e.g. iron and steel, paper, timber products, food products, leather, chemicals etc.) construction, transport and machinery.

So let’s separate these into 2 groups: Energy/Transport; and IPPU and look at them in more depth.

SLIDE 6 Importance for Non-Annex 1 Parties
CLICK The situation differs from country to country. CLICK In Myanmar the IPPU sector is less significant compared to Energy and AFOLU CLICK (diagram) the diagram shows that in 2000, Industry contributed 0.62% of GHG emissions, compared with 10.57% for Energy, 30.7% for Agriculture and 54.31% for Forestry. CLICK Notice that Transport as a separate sector is not even mentioned (it is included in Energy). But these figures are from 20 years ago, so it would be expected that the IPPU contribution has increased and likely will continue to increase CLICK F-gases (or Fluorinated gases) are a man-made source of GHGs, which can stay in the atmosphere for centuries and contribute significantly to the IPPU emissions and influence total estimates. Non-annex 1 parties are not required to report on these gases. There are four types of F-gases: HFCs, hydrofluorocarbons; PFCs, perfluorocarbons; SF₆, sulphur hexafluoride; and NF₃, nitrogen trifluoride. CLICK An estimation of IPPU emissions is important to find opportunities for GHG abatement currently and for future developments.

SLIDE 8 IPPU Sector in everyday life
Industrial processing reaches into many aspects of daily lives - read some of the examples. GHG emissions for each of these are well documented, as shown for some industries on the next slide, so MRV starts with monitoring the levels of gases that are produced. This can be a significant task and requires specific equipment and knowledge.

After looking at some of the gases from those industries, one process that we will look at more closely CLICK is cement production.

SLIDE 10 Cement
Cement in the form of concrete is all around us - in 2016 cement production was the source of 2.2 billion tonnes or 8% of global CO₂ emissions – if it were a country it would be the third highest emitter after China and USA. Over 10 billion tonnes of concrete are used each year, the floor area of the world’s buildings is projected to double in the next 40 years. This means cement production is set to grow to around 5bn tonnes by 2030, a 25% increase from today, reaching over four times 1990 levels.

CLICK Cement production is illustrated in the diagram go through process – it starts by quarrying limestone which is crushed, has clay and sand added, is then heated, with pulverized coal added to produce clinker with gypsum added to produce cement.

The GHG CO₂ is produced in two of the stages of the process. The first is in the calcination CLICK, or burning of the raw materials to produce clinker (which produces 50% of the emissions and is considered as an IPPU source of GHG) and the second CLICK is in combustion of the fuel such as coal or gas to produce heat (which produces 40% of the emissions and is considered as an ENERGY source of GHG). The final 10% is in the mining and transportation of the raw materials.

SLIDE 11 CO₂ from Cement Production

This slide indicates there are 3 tiers of CO₂ inputs from cement production. It also shows a couple equations CLICK used for calculating the inputs and the information needed in those calculations. The details are important for determining GHG emissions, this was to show how complex the monitoring part of MRV can be.

Quality assurance and quality control activities should be implemented at several stages in the emission estimation process. At the plant level, key activities include internal quality control on production data and emission factors, as well as documenting data and methods for reviewers. The inventory agency must ensure the accuracy of plant submissions as well as the compiled inventory. It is also responsible for providing documentation and sufficient information to the United Nations Framework Convention on Climate Change (UNFCCC). One or more types of external review may also be appropriate.

SLIDE 12 Energy Sector
Within the Energy Sector there are 3 categories, 1. Fuel combustion CLICK read, 2. Fugitive emissions CLICK read, and 3. Carbon capture and storage (which we will not look at). Breaking down emissions into different sectors has the potential for confusion and overlap, so definitions are needed for clarity. Within fuel combustion there are 5 classes 1. Energy industries (generation of electricity, 2 Manufacturing industries, 3. Transport, and 4 and 5 Commercial/Residential/Other). But manufacturing industries are part of IPPU so why is it here CLICK read these are 3 emission fields which are not included in Energy, but in the categories indicated.

I want to now focus on fuels.

SLIDE 13 IPCC Fuels and Energy Units
The table shows the IPCC classification of available fuels and their energy units, carbon content and default CO₂. They divided fuels into Biomass, which includes wood, charcoal and biofuels, Peat which is treated as a fossil fuel, Solid fuels which include coal and coke (and the gases they emit), Liquid fuels which includes petrol, aviation fuel, diesel and LPG, Natural gas and finally, fossil fuels CLICK is an additional class. Of interest in determining total emissions is that CLICK CO₂ emissions from biomass burning are not included in total Energy emissions.

The table shows the NCV or Net Calorific Value CLICK, which is the energy released as heat when a substance undergoes complete combustion. The low value in the table is 8.9 for Lignite and 48 for Natural gas. The other columns, Carbon Content CLICK and Default CO₂,EF (Carbon dioxide emission factor) CLICK display similar trends, with the fuels at the top of the table having greater carbon content and hence default CO₂,EF value, and the fuels at the bottom of the table with around half the amounts for those at the top. From both an energy and emissions perspective, the fuels at the bottom of the table are superior.

SLIDE 14 Fuel emissions estimates (MRV)
Read slide

SLIDE 15 How to calculate CO₂ emissions?
As an example, to calculate emissions, the equation below is used. Factors such NCV (Net calorific value) and EF (Emission factor need to be included) and will be provided as a generic figure or calculated from local data. Calculations are separate for each different type of fuel. Read slide

SLIDE 16 Road Transport
To estimate GHG emissions from road transport the following conditions apply. Read slide

Estimates for GHG emissions from Rail are similar, however, for aviation and shipping an additional factor is included, International bunker or bunker fuels (see next slide)
SLIDE 17 Summary

Read slide. GHG emission estimates for Energy and Transport are much simpler than for IPPU.

SLIDE 18 Recommendations

Read slide.

SLIDE 21 Helpful Sources of Information

1. UNFCCC Handbook on MRV for Developing Countries
2. World Resources Institute: MRV 101
3. CDKN Quick-Start Guide to MRV
4. GGGI 2019 Developing sectoral MRV systems in Myanmar for IPPU & AFOLU sectors
Click ဖန်လုံအိမ်ဓါတ်ငွေ့များကို အသုံးပြုပြီး Click ဖန်လုံအိမ်ဓါတ်ငွေ့အတွက် IPCC, UNFCCC ကိုဖတ်ကြည့်ပါ။

Slide ၆- IPCC CO2 from cement production

ကြိုးနံပါးပြည့်နှုန်း (Quality assurance and Quality control) အတွက် အခွံင့်ပြည့်စုံမှုများထုတ်လုပ်ပါသည်။

Slide ၇- IPCC Fuels and Energy Units

IPAPU ကဏ္ဍတွင် industrial processes နှင့် Product Use ပါဝင်ပါသည်။ IPPIU ကဏ္ဍတွင် သို့မဟုတ် Bill of lading ၏ အရှင်းအမြစ်များကို ခေါ်ဆောင်ရွက်ပါသည်။

Slide ၈- IPCC Sector in everyday life

Industrial processing မှာ အခြားသော်လည်း IPCC ကိုဖတ်ကြည့်ပါ။

Slide ၉- IPCC CO2 from cement production

ကြိုးနံပါးပြည့်စုံမှုများထုတ်လုပ်ပါသည်။

Slide ၁၀- IPCC Fuels and Energy Units

IPAPU ကဏ္ဍတွင် industrial processes နှင့် Product Use ပါဝင်ပါသည်။ IPPIU ကဏ္ဍတွင် သို့မဟုတ် Bill of lading ၏ အရှင်းအမြစ်များကို ခေါ်ဆောင်ရွက်ပါသည်။

Slide ၁၁- IPCC CO2 from cement production

ကြိုးနံပါးပြည့်နှုန်း (Quality assurance and Quality control) အတွက် အခွံင့်ပြည့်စုံမှုများထုတ်လုပ်ပါသည်။

Slide ၁၂- IPCC Sector in everyday life

Industrial processing မှာ အခြားသော်လည်း IPCC ကိုဖတ်ကြည့်ပါ။

Slide ၁၃- IPCC Fuels and Energy Units

IPAPU ကဏ္ဍတွင် industrial processes နှင့် Product Use ပါဝင်ပါသည်။ IPPIU ကဏ္ဍတွင် သို့မဟုတ် Bill of lading ၏ အရှင်းအမြစ်များကို ခေါ်ဆောင်ရွက်ပါသည်။
Training Evaluation & Quizzes

Name

Workshop/training title  Climate Change MRV lesson 9

Date

Location  NayPyiTaw, Myanmar

Workshop delivery partners  ECD, GGGI

Gender  ☐ Male  ☐ Female

Tick Designation as Appropriate  ☐ Government Officials  ☐ CSO  ☐ GGGI Staff  ☐ Others  (specify)

Instructions: Please tick your level of agreement with the statements below

<table>
<thead>
<tr>
<th>Strongly Agree (5)</th>
<th>Agree (4)</th>
<th>Neutral (3)</th>
<th>Disagree (2)</th>
<th>Strongly Disagree (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I understood the objectives of the workshop/training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The objectives of the workshop/training were met</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>The methodologies used were appropriate</td>
<td></td>
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<tr>
<td>The materials used were useful and relevant</td>
<td></td>
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<td></td>
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<tr>
<td>The content was organized and easy to follow</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>The workshop/training was relevant to improving the knowledge/skills I need to accomplish my job</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Overall, I am satisfied with the workshop/training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Content questions: Please provide a correct answer for each question.

1. What is an F gas?

2. For the IPPU sector, emissions come from 2 possible sources. Please name them.

3. Please name three manufacturing industries that may produce GHG emission.

4. What is the most significant GHG produced by the Metal Industry?

5. What are the 2 products from the calcination process in cement production?

6. What is a fugitive emission?

7. Of the liquid fuel group, from a climate change perspective, what are the best and the worst fuels, and why?

8. Please provide the formula for calculating CO2 emissions from fuel.

9. Does the Energy sector include both stationery and mobile fuel combustion?

10. If relevant data is available, which calculation method provides the most accurate estimate of emissions?

Thank you for completing this evaluation form. Feedback received will be used to provide improvements to future lessons/training.

Evaluation forms should be handed to the trainer/coordinator at the end of the lesson.
LESSON 9: ANSWER KEY

1. Slide 20: Fluorinated gas
2. Slide 7: 1. Industrial Processes, 2. Product Use
3. Slide 5: Iron and Steel…+13……….to Non-specified Industry
4. Slide 9: CO2
5. Slide 11: CaO+CO2
6. Slide 12: accidental (e.g. leaks) or intentional releases of gas (e.g. venting) from pressurized equipment contributing to air pollution
8. Slide 15: CO2 emissions = Amount of Fuel*NCV*EF
9. Slide 17: yes
10. Slide 14: SA – Sectoral Approach