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

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Disclaimer: Training material has been prepared based on the CGE training materials on the national GHG inventories.
LESSON 11

IPPU MRV SYSTEM REQUIREMENTS
Lesson 11: Training on IPPU MRV system requirements

Objectives
- Introduce requirements for the ideal GHG Inventory
- Understand the data flow arrangements
- This is for FUTURE REPORTING
- We are not here to qualify the data quality
- We are here to support IMPROVING the data quality
- Link these activities to CBIT activities

GHG emissions from IPPU sector

1. Industrial Processes that chemically or physically transform materials releasing GHG
   - Chemically: \( \text{NH}_3 + \text{O}_2 = 0.5 \text{ N}_2 + 1.5 \text{ H}_2 \text{O} \) (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
   - 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 product's life and either recycled or destroyed.

IPCC 2006 Guidelines – IPPU

- GHG emissions occurring from industrial processes, from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon
- Link these activities to CBIT activities
- Understand the data flow arrangements
- This is for future reporting

Sectors relevant to Myanmar

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Activity</th>
<th>Sub-sector</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZA1</td>
<td>Cement Production</td>
<td>ZD1</td>
<td>Lubricant use</td>
</tr>
<tr>
<td>ZA2</td>
<td>Lime Production</td>
<td>ZD2</td>
<td>Solvent use</td>
</tr>
<tr>
<td>ZA3</td>
<td>Glass Production</td>
<td>ZF1a</td>
<td>Refrigeration and stationary air conditioning</td>
</tr>
<tr>
<td>ZA4</td>
<td>Other Uses of Soda Ash</td>
<td>ZF1b</td>
<td>Mobile air conditioning</td>
</tr>
<tr>
<td>ZA4c</td>
<td>Non-Metallurgical Magnesia</td>
<td>ZF2</td>
<td>Foam blowing agents</td>
</tr>
<tr>
<td>ZB1</td>
<td>Ammonia Production</td>
<td>ZF3</td>
<td>Fire protection</td>
</tr>
<tr>
<td>ZB2</td>
<td>Nitric Acid Production</td>
<td>ZF9</td>
<td>Soot</td>
</tr>
<tr>
<td>ZB3</td>
<td>Soda Ash Production</td>
<td>ZG1a</td>
<td>Manufacture of electrical equipment</td>
</tr>
<tr>
<td>ZB4</td>
<td>Methanol</td>
<td>ZG1b</td>
<td>Use of electrical equipment</td>
</tr>
<tr>
<td>ZB6b</td>
<td>Ethylene</td>
<td>ZG1c</td>
<td>Disposal of electrical equipment</td>
</tr>
<tr>
<td>ZB8T</td>
<td>Carbon Black</td>
<td>ZG2b</td>
<td>Antifreeze</td>
</tr>
<tr>
<td>ZC1</td>
<td>Lead Production</td>
<td>ZH1</td>
<td>Pulp and paper industry</td>
</tr>
<tr>
<td>ZC4</td>
<td>Zinc Production</td>
<td>ZH1a</td>
<td>Food and beverages industry</td>
</tr>
<tr>
<td>ZC7</td>
<td>Other: Copper, Tin, Gold</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IPPU sector - Gases

- A wide variety of gases
  - \( \text{CO}_2, \text{CH}_4, \text{N}_2\text{O} \)
  - \( \text{HFCs, PFCs, SF}_6 \)
  - Other halogenated gases
  - Ozone/aerosol precursors (e.g., \( \text{NMVOCs} \))

Under the UNFCCC, non-Annex I Parties:
- Should report \( \text{CO}_2, \text{CH}_4 \) and \( \text{N}_2\text{O} \)
- Are encouraged to report \( \text{HFCs, PFCs, SF}_6 \) and precursors
2A: Mineral Industry

- Transformation of carbonate-contained compounds – limestone, dolomite, etc. (CaCO₃, MgCO₃, Na₂CO₃)
- CO₂ Emissions

<table>
<thead>
<tr>
<th>Code</th>
<th>Category</th>
<th>Default EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A1</td>
<td>Cement Production</td>
<td>0.51 t CO₂/t clinker</td>
</tr>
<tr>
<td>2A2</td>
<td>Lime Production</td>
<td>0.75 t CO₂/t lime</td>
</tr>
<tr>
<td>2A3</td>
<td>Glass Production</td>
<td>0.20 t CO₂/t glass</td>
</tr>
<tr>
<td>2A4</td>
<td>Other Process Uses of Carbonates</td>
<td>0.41 t CO₂/t soda ash</td>
</tr>
<tr>
<td>2A4b</td>
<td>Other Uses of Soda Ash</td>
<td></td>
</tr>
<tr>
<td>2A4c</td>
<td>Non-Metallurgical Magnesia Production</td>
<td></td>
</tr>
<tr>
<td>2A4d</td>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>2A5</td>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

CO₂ from Cement Production (Tier 1)

- \( M_{Cl} \) - mass of cement produced of type \( i \), tonnes
- \( C_{Cl} \) - clinker fraction of cement type \( i \), fraction
- \( I_{m} \) - imports for consumption of clinker, tonnes
- \( E_{x} \) - exports of clinker, tonnes
- \( EF_{Cl} \) - emission factor for clinker, tonnes CO₂/tonne clinker

\[
\text{CO}_2 \text{ Emissions} = AD \text{ clinker production} \times EF \text{ clinker}
\]

Default \( EF_{Cl} \) = 0.52 tonnes CO₂/tonne clinker (corrected for cement kiln dust (CKD))

CO₂ from Cement Production (Tier 1)

- National-level data should be collected on:
  - Cement production by type (Portland, masonry, etc.)
  - Clinker fraction by cement type
- If detailed information on cement type is not available, multiply total cement production by:
  - Default CF = 0.75 (if blended/masonry) is much
  - Default CF = 0.95 (if all is essentially Portland)
- Data should be obtained on the amount of clinker imported and exported

CO₂ from Cement Production (Tier 2)

- 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:
- \( C_{FCKD} \) - emissions correction factor for CKD, dimensionless
- \( Md \) - weight of CKD not recycled to the kiln, tonnes
- \( Md \) - weight of clinker produced, tonnes
- \( C_d \) - fraction of original carbonate in the CKD (i.e., before calcination) fraction
- \( F_d \) - fraction calcination of the original carbonate in the CKD, fraction
- \( EF_c \) - emission factor for the carbonate, tonnes CO₂/tonne carbonate
- \( EF_d \) - emission factor for clinker uncorrected for CKD, tonnes CO₂/tonne clinker (i.e., 0.51)

\[
\text{CO}_2 \text{ Emissions} = Md \times EF_d \times C_{FCKD}
\]

2B: Chemical Industry

Ammonia Production
The Tier 2 method requires plant-level data on ammonia production classified by fuel type and production process. In addition, plant-level data on CO₂ recovered for downstream use or other application are required.

Nitric Acid Production
The Tier 2 method requires plant-level production data disaggregated by technology type and abatement system type. It is good practice to gather activity production data at a level of detail consistent with that of any generation and destruction data. Typical plant-level production data is assumed to have an uncertainty of ±2% due to the economic value of having accurate information.

Soda Ash Production
Activity data should be collected at the plant-level to use the Tier 2 method. The most important data are the amount of Tonna used for soda ash production and the amount of natural soda ash produced at each plant. Although soda ash production is not used in the calculation if emissions are derived from Tonna input, it is good practise to collect and report these data to enable comparisons of inputs per unit of outputs over time and provide a sound basis for ensuring time series consistency.

2B: Chemical Industry

Methodology
Emissions of CO₂ from methanol production may be calculated from specific feedstock (e.g., natural gas) consumption and product (methanol) production activity data and carbon mass balance calculations.

Ethylene production
Emissions of CO₂ from ethylene production may be calculated from specific feedstock consumption and product production activity data and carbon mass balance calculations. In order to create a complete mass balance for the ethylene production process and implement the Tier 2 methodology for ethylene production, all feedstocks and the production and disposition of all primary and secondary products of the process should be identified using activity data.

Carbon black production
Emissions of CO₂ from carbon black production may be calculated from specific feedstock (e.g., carbon black feedstock) and secondary feedstock (e.g., natural gas) consumption and product (carbon black) production activity data and carbon mass balance calculations.
2B1: Ammonia Production

- CO₂ associated with urea production & use:
  - 1996 GL: all these emissions were implicitly included in CO₂ from Ammonia Production
  - 2006 GL: CO₂ recovered in the ammonia production process for urea production should be deducted from CO₂ emissions from 2B1 Ammonia Production
- CO₂ emissions from urea use/incineration should be reported in the category where they occur, e.g.:  
  - Use of urea-based catalysts (Energy – Road Transport)
  - Urea application to agricultural soils (AFOU)
- Incineration of urea-based products (Waste)
- Thus, now, proper account can be taken for urea produced in ammonia plants

2C: Metal Industry

<table>
<thead>
<tr>
<th>Code</th>
<th>Category</th>
<th>CO₂</th>
<th>Cl₂</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2C1</td>
<td>Iron and Steel Production</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2C2</td>
<td>Ferroalloys Production</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C3</td>
<td>Aluminium Production</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2C4</td>
<td>Lead Production</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C5</td>
<td>Zinc Production</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C7</td>
<td>Other: Copper, Ti, Gold</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2C1: CO₂ from Iron and Steel Production (Tier 1)

\[
\text{CO}_2 \text{ emissions from Iron & Steel production:}
\]

\[
\text{CO}_2 \text{ Emissions} = \left( \text{EF} \times \text{AO}_2 \right) \cdot \text{EF}^i
\]

\[
\text{EF}, \text{ emission factor for production of material } i, \text{ tonnes CO}_2/\text{tonne material } i \text{ produced}
\]

2C3: Aluminium production – PFCs Emissions

<table>
<thead>
<tr>
<th>Tier 1 uses technology-based default EFs for 4 main production technologies: Centre-Worked Precast (CWBP), Side-Wrought Precast (SWBP), Horizontal Slab Sanderberg (HSS) and Vertical Slab Sanderberg (VSS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 2 based on direct measurements of PFCs for 4 technologies and 2 different methods: Slope and Overlapping relationship between anode effect and performance</td>
</tr>
</tbody>
</table>

2D: Non-Energy Products from Fuels and Solvent Use

- GHG emissions from use of non-energy products (lubricants, waxes, greases, solvents) other than:
  - Combustion for energy purposes
  - Use as feedstock or reducing agent
  - Incineration of waste oil/grease with/without energy recovery (Energy/Waste Sector)
- A small proportion of non-energy products oxidised during use
- Focus on direct CO₂ emissions and substantial NMVOC/CO emissions which eventually oxidise to CO₂ in the atmosphere

<table>
<thead>
<tr>
<th>Code</th>
<th>Category</th>
<th>CO₂</th>
<th>NMVOC, CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D1</td>
<td>Lubricant Use</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2D3</td>
<td>Solvent Use</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
2F: Fluorinated Substitutes for ODS

<table>
<thead>
<tr>
<th>Code</th>
<th>Category</th>
<th>HFCs</th>
<th>PFCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2F1</td>
<td>Refrigeration and Air Conditioning</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2F1a</td>
<td>Refrigeration and Stationary Air Conditioning</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2F1b</td>
<td>Mobile Air Conditioning</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2F2</td>
<td>Foam Blowing Agents</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2F3</td>
<td>Fire Protection</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2F5</td>
<td>Solvents</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2F6</td>
<td>Other Applications</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

2F: Fluorinated Substitutes for ODS

- **Applications or Sub-applications** - major groupings of current and expected usage of the ODS substitutes
- **Actual emissions vs. Potential emissions** (2006 vs. 1996)
- **Prompt emissions** (within 2 years) and **Delayed emissions**
- **Bank** - total amount of substances contained in existing equipment, chemical stockpiles, foams, other products not yet released to the atmosphere (+Exnet)
- **Approaches:**
  - Emission Factor (a) and Mass-balance (b)
  - Tier 1 and Tier 2

Actual emissions vs. Potential emissions

- The 2006 IPCC Guidelines provide methods for estimating actual emissions of ODS substitutes in contrast to potential emission approach (1996 IPCC Guidelines) taking into account the time lag between consumption of ODS substitutes and emissions.
- **Potential emissions approach** assumes that all emissions from an activity occur in the current year (manufacture + import - export - destruction), ignoring the fact they will occur over many years, thus estimates may become very inaccurate

**Example:** A household refrigerator emits little or no refrigerant through leakage during its lifetime and most of its charge is not released until its disposal, many years after production. Even then, disposal may not entail significant emissions if the refrigerant and the blowing agent in the refrigerator are both captured for recycling or destruction

- Use of **actual emissions** allows to:
  - Accurately estimate emissions of ODS substitutes
  - Properly address emission reductions of abatement techniques

Bank

- Where delays in emission occur, the cumulative difference between the chemical that has been consumed in an application and that which has already been released is known as a **bank** (refrigeration and air conditioning, fire protection, closed-cell foams).
- **Example**: Blowing agent still present in foamed products which may have already been land-filled is still part of the bank, since it is chemical which has been consumed and still remains to be released.
- Estimating the size of a bank in an application is typically carried out by evaluating the historic consumption of a chemical and applying appropriate emission factors. It is also sometimes possible to estimate the size of bank from a detailed knowledge of the current stock of equipment or products.
- **Example**: In mobile air conditioning - the automobile statistics may be available providing information on car populations by type, age and even the presence of air conditioning. With knowledge of average charges, an estimate of the bank can be derived without a detailed knowledge of the historic chemical consumption, although this is still usually useful as a cross-check.

Product Data for Application

- Chemical Consumption, Bank, or Emissions
- Product Data for Application
- Sub-application 1
- Sub-application 2
- Etc.

- Domestic or Impor
- Exports
- Domestic Production
- Imports
- Exports

Chemical 1

Chemical 1

Chemical 2

Chemical 3

Board A

Board B

Etc.
2F: Sub-applications

2F: Chemicals and blends

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Refrigeration and Air Conditioning</th>
<th>Fire Suppression and Explosion Prevention</th>
<th>Arrack</th>
<th>Solvent</th>
<th>Foam Blowing</th>
<th>Other Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFC-134a</td>
<td>X</td>
<td>X</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>HFC-134b</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFC-227ea</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFC-227ea</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>HCFC-22</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCFC-142b</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HCFC-143b</td>
<td>X</td>
<td>X</td>
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<td></td>
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<tr>
<td>HCFC-124</td>
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<td>X</td>
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</table>

2F: Blends

2F: Tiers / Approaches and Data

<table>
<thead>
<tr>
<th>Tier 2</th>
<th>Tier 1</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Tier 2</th>
<th>Tier 1</th>
</tr>
</thead>
</table>

2F2: Foams Blowing Agents

Open foams: GHG immediate release

GHG Emissions = M_i

Closed foams: GHG delayed release

GHG Emissions = M_i * EF_{PBC} \times Bank_t * EF_{Fm} + DL + RD

2F5: Solvents

For prompt emissions (solvents, aerosols):

GHG Emissions = S_i \times EF_{1-t} \times EF_{1-t} - D_{1-t}

EF_{1-t} = 1 for two years (100%), default EF = 0.5/0.5

D_{1-t} = Quantity of solvents destroyed in year t-1, tonnes

HFC/PFC solvent uses occur in four main areas as follows:

- Precision Cleaning
- Electronics Cleaning
- Metal Cleaning
- Deposition applications
2F2: Closed Foams: Emission Factors

2F1: Refrigeration / Air Conditioning

- Tier 2b (Mass-Balance)

Emissions = Annual Sales of New Refrigerant – Total Charge of New Equipment – Original Total Charge of Retiring Equipment – Amount of Intentional Destruction

In estimating Annual Sales of New Refrigerant, Total Charge of New Equipment, and Original Total Charge of Retiring Equipment, inventory compilers should account for imports and exports of both chemicals and equipment.

Tier 2a (Emission factor)

Emissions = E\text{emissions} = \frac{M\text{mass} \times \text{Tier 2a emission factor}}{100}

\text{Tier 2a emission factor} = \frac{M\text{mass}}{100}

2F1: Refrigeration/AC: Emission Factors

IPPUG Activity Data: Cross-Checks

2G: Other Product Manufacture and Use

- GPGs and PFGs: electrical equipment, gas insulated substations, gas circuit breakers (GCB), gas insulated power transformers (GPT), gas insulated window systems (GIW)
- Military equipment: ground and airborne radars, avionics, missile guidance systems, ECM (Electronic Counter Measures), airborne early warning air, autonomous surveillance vehicles, stealth aircraft, FPGs for cooling electric motors, etc.
- Cosmetic and medical applications, research particle accelerators.
- H2O Medical applications, Auto-racing, Propellant in aerosol products

IPPUG Activity Data: Cross-checks / QC

- The CO2 completeness check
- Feedstock balance check
- Potential emissions approach for estimating HFCs, PFCs, or SF6
IPPU Activity Data: Data Collection – RAC

Where to get
- Regulation for phase-out of CFCs and HCFCs
- Government Statistics
- Refrigerant Manufacturers and Distributors
- Disposal Companies
- Import/Export Companies
- Manufacturer Association
- Marketing Studies

What to get
- Schedule of phase out for charging of brand new equipment and for servicing
- Number of equipment disposed of for each type of application
- Virgin refrigerants sold for charging new equipment and for servicing in the different sectors
- Equipment produced on a national level using HFC refrigerants (for all sub-applications)
- Number of equipment using HFCs (imported and exported)
- HFC refrigerants recovered for re-processing or for destruction
- Average equipment lifetime
- Initial charge of systems

IPPU Activity Data: Confidentiality

- Data providers might restrict access to information because it is confidential, unpublished, or not yet finalized
- Find solutions to overcome their concerns by:
  - Explaining the intended use of the data
  - Agreeing, in writing, to the level at which it will be made public
  - Identifying the increased accuracy that can be gained through its use in inventories
  - Offering cooperation to derive a mutually acceptable data set
  - And/or giving credit/acknowledgement in the inventory to the data provided

Conclusion
- Diversity of sources and gases in the IPPU Sector
  - Difficult to exhaustively include all sources & gases
  - At least major sources & gases (key categories) must be included
- Care to Activity Data:
  - Difficult to collect activity data (Input/output data, plant-specific data)
  - Data allocation and Double-counting
  - Confidential data from private companies
- Various opportunities for GHG abatement
  - Capture and abatement at plants (i.e., destruction at nitric acid production plants)
  - Recovery at the end of product’s life and subject to either recycled or destroyed (HFCs in refrigerators)

Group activity
- Data and parameters that are already monitored
- For information that is already being collected, what is the data flow pattern
  - Who collects this data
  - What is the frequency of collection
  - How is that information transferred to the concerned department

Myanmar INC GHG Emissions

[Graph showing GHG Emissions by sector (Gg) and Sector-wise GHG %ages]
**LESSON 11: IPPU MRV SYSTEM REQUIREMENTS (41 SLIDES)**

**Slide 3**: It is important to understand the distinction between GHG emissions from “industrial processes” and “product use”.

**Slide 4**: As can be seen from the First national GHG inventory, the contribution of IPPU sector is quite low. The industrial processes and product use (IPPU) sector is important for all countries because although it may not be an important source of activities for GHG emissions now, improving economic activity and development activities will increase these emissions in the future. It will be important for countries to be prepared to monitor these emissions in the future.

**Slide 5**: The IPCC 2006 Guidelines for IPPU sector. Similar to all other sectors, not all are relevant to the country, and the choices have to be made.

**Slide 6**: A preliminary analysis, based on SNC and interviews, has indicated that these are the relevant sectors for the country, as of now.

**Slide 7**: Inclusion of F-gases is important because of their high global warming potential (GWP), substantial use in industrial processes and in households, significant opportunities for GHG abatement. If these have been included either in one of the inventories, or any NDC activities, then it becomes important to continue to monitor these.

**Slide 8**: Here emissions are associated with the production of the mineral, and not its use.

**Slide 9**: Since the number of cement manufacturers in Myanmar isn’t expected to be too high, it would be good to liaise early with the units. Issues of confidentiality will be major barriers to overcome.

**Slide 10**: The import and export data of cement will be important because Myanmar is embarking on largescale infrastructure projects.

**Slide 11**: Cement kiln dust data is needed for Tier 2 MRV systems, and needs to be provided by all factories.

**Slide 12**: For Ammonia production, Compare the results with emissions data calculated for the same facility in previous years. A calculation error is probable if differences between current data and data from previous years cannot be explained by changes in activity levels, or fuel switching. Also, if the calculation process involved conversion of fuel use data and emission factors, you might want to go back and double check whether no conversion mistakes occurred.

If facility-specific production data are missing for one year, an average value using the production data from the year prior and the year after the missing year may be calculated.

**Slide 13**: Methanol and ethylene and carbon black are relevant data points for the country that have to be developed to Tier 2, and needs increasing private sector participation.

**Slide 14**:For Industrial ammonia production emits more CO2 than any other chemical-making reaction. To make urea, fertilizer producers combine ammonia with carbon dioxide (CO2), but when farmers apply that urea to the soil, an equal amount of CO2 is emitted to the atmosphere. No CO2 is permanently stored or sequestered through the production of urea.

**Slide 15**: Process CO2 emissions are generated from the processing of metal ore with carbonaceous materials and fluxes, production of coke, consumption of carbon-containing electrodes, and the use of fluorinated cover gases.

IEA states that the direct CO2 intensity of crude steel has been relatively constant (within a 20% range) during the past two decades. Energy efficiency improvements spurred much of the reduction in recent years, returning CO2 intensity to previous levels, but opportunities for further efficiency improvements will likely soon be exhausted. Thus, innovation in the upcoming decade will be crucial to commercialise new low-emissions process routes, including those integrating CCUS and hydrogen, to realise the long-term transformational change required.

**Slide 16**: Tier 1 systems are based on national averages, rather than actual measuredreported values of production data.

**Slide 17**: There are several technologies used to produce iron and steel, and these default emission factors are used for Tier 1 systems. Tier 2 systems are appropriate when there is access to national data on the use of process materials for iron and steel production, sinter production, pellet production, and direct reduced iron production.

**Slide 18**: The primary aluminium production process has been identified as the largest anthropogenic source of emissions of two perfluorocarbons (PFCs): tetrafluoroethane (CF4) and hexafluoroethane (C2F6). Prima- ry aluminium is produced using the Hall-Héroult electrolytic process, where the smelting pot itself acts as the electrolysis cell during the reduction process. When the alumina ore content of the electrolytic bath falls below critical levels required for electrolysis, rapid voltage increases occur, termed “anode effects”. Anode effects cause carbon from the anode and fluorine from the dissociated molten cryolite bath to combine, producing CF4 and C2F6. The frequency and duration of anode effects depend primarily on the pot technology and operating procedures. Emissions of CF4 and C2F6, therefore, vary significantly from one aluminium smelter to the next, depending on these parameters.

**Slide 19**: The products covered here comprise lubricants, paraffin waxes, bitumen asphalts, and solvents. Emis- sions from further uses or disposal of the products after first use (i.e., the combustion of waste oils such as used lubricants) are to be estimated and reported in the Waste Sector when incinerated or in the Energy Sector when energy recovery takes place.

**Slide 20**: Hydrofluorocarbons (HFCs) and, to a very limited extent, perfluorocarbons (PFCs), are serving as alternatives to ozone-depleting substances (ODS) being phased out under the Montreal Protocol. Current and expected application areas of HFCs and PFCs include (IPCC/TEAP, 2005):

- refrigeration and air conditioning;
- fire suppression and explosion protection;
- aerosols;
- solvent cleaning;
- foam blowing; and
- other applications

**Slide 21**: Tier-2 systems require data on applications and sub-applications. When selecting a method for estimating emissions, it is good practice to consider the number and relevance of sub-applications, the data availability, and the emission patterns. Applications with a high number of sub-applications (refrigeration has six major sub-applications; foam has even more) will generally benefit from a higher level of disaggregation in their data sets, owing to the differences between the sub-applications.

**Slide 22**: The approach to use depends on the type of data available, level of disaggregation and the quality and uncertainty of the data points.

**Slide 23**: Solvent use is a major contributor to NMVOC emissions. Most solvents are part of a final product, e.g., paint, and will sooner or later evaporate. Estimating emissions from solvent use can be done in two ways: either by estimating the amount of (pure) solvents consumed or by estimating the amount of solvent containing prod-
This type of equipment generally contains between 5 and several hundred kg per functional unit. Transmission equipment normally falls into this category. Both categories of equipment have lifetimes of more than 30 to 40 years. In Asia, significant quantities of SF6 are used in gas-insulated power transformers (GIT).

Slide 31: The division of foams into open-cell or closed-cell relates to the way in which blowing agent is lost from the products. For open-cell foam, emissions of HFCs used as blowing agents are likely to occur during the manufacturing process and shortly thereafter. In closed-cell foam, only a minority of emissions occur during the manufacturing phase. Emissions therefore extend into the in-use phase, with often the majority of emission not occurring until end-of-life (de-commissioning losses). Accordingly, emissions from closed cell foams can occur over a period of 50 years or even longer from the date of manufacture.

Open-celled foams are used for applications such as household furniture cushioning, mattresses, automotive seating and for moulded products such as car steering wheels and office furniture. Closed-cell foams, on the other hand, are primarily used for insulating applications where the gaseous thermal conductivity of the chosen blowing agent (lower than air) is used to contribute to the insulating performance of the product throughout its lifetime.

Several types of foams are used in building/construction applications: extruded polystyrene (XPS) boards and polyurethane (PU) rigid continuous panels, discontinuous panels, spray, boardstock, block, and pipe-in-pipe. A variety of climate-friendly blowing agents have been or are being developed for use in building/construction foam applications to replace CFCs, HCFCs, and HFCs.

Slide 33: Refrigeration and air-conditioning (RAC) systems may be classified in up to six sub-application domains or categories:
- Domestic (i.e., household) refrigeration,
- Commercial refrigeration including different types of equipment, from vending machines to centralised refrigeration systems in supermarkets,
- Industrial processes including chillers, cold storage, and industrial heat pumps used in the food, petrochemical and other industries,
- Transport refrigeration including equipment and systems used in refrigerated trucks, containers, reefers, and wagons,
- Stationary air conditioning including air-to-air systems, heat pumps, and chillers for building and residential applications,
- Mobile air-conditioning systems used in passenger cars, truck cabins, buses, and trains

Tier 2 systems require information on annual sales of new refrigerant, total charge of new equipment, original total charge of retiring equipment and amount of intentional destruction. Where there is no production of equipment in the country, data on total imports, types of equipment and any controlled destruction activities within the country become important data points.

Slide 35: Sulphur hexafluoride (SF6) is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity. Emissions occur at each phase of the equipment life cycle, including manufacturing, installation, use, servicing, and disposal. Most of the SF6 used in electrical equipment is used in gas insulated switchgear and substations (GIS) and in gas circuit breakers (GCB), though some SF6 is used in high voltage gas-insulated lines (GIL), outdoor gas-insulated instrument transformers and other equipment. The aforementioned applications may be divided into two categories of containment. The first category is ‘Sealed Pressure Systems’ or ‘Sealed-for-life Equipment’, which is defined as equipment that does not require any refilling (topping up) with gas during its lifetime and which generally contains less than 5 kg of gas per functional unit.1 Distribution equipment normally falls into this category. The second category is ‘Closed Pressure Systems’, which is defined to include equipment that requires refilling (topping up) with gas during its lifetime.
စာရေး 11

ဖျင်ရာပေါင်းစက်ရုံများမှ ထုတ်လုံးသည်များပြားလွန်းပြင်းမရှိဟု ယူေထားသပြင့် ယူနစ်များနှင့် အကယ်၍ သတ်မှတ်ဝန်ပောင်မှုပြးပြင်းေိုင်ရာအြျက်အလက်များသည် တစ်နှစ်စာပြျာက်ေုံးပနြါက ပြျာက်ပန တွင်ပလာင်စာသုံးစွဲမှုအြျက်အလက်နှင့် ပလာင်စာသုံးစွဲမှုပလာင်စာပြာင်းလဲပြင်းတို့ြါဝင်ြါက ပပြာင်းလဲပြင်းအမှားအယွင်းမပြစ်ပစများက အြျက်အလက်များအသကားကွာဟြျက်များအားလုြ်ငန်းပောင်ရွက်မှုအေင့် (သို့မဟုတ်) ပလာင်စာပလာင်စာပြာင်းလဲသုံးစွဲမှုပသာ ထုတ်လွှတ်မှုအြျက်အလက်များနှင့် ရလြ်များကို နှိုင်းယှဉ်သကည့်ြါ။

စာရင်း သို့မဟုတ် NDC ၏လုြ်ပောင်မှုများတွင် ထည့်သွင်းထားြါက F-gas ကို ေက်လက်၍ပစာင့်သကည့်ရန်အပါရးကကီးသည်။

မှုစစ်တမ်းပကာက်ယူပရးတွင် ထည့်သွင်းရန်အပါရးကကီးသည်။

အကယ်၍ ပရရှည်ပြုပြင်ပပြာင်းလဲပရးပြစ်ပပမာက်ပအာင်အဆိုးပါးအပြစ် သတ်မှတ်နိုင်

စက်ရုံမှအမိုးနီးယားထုတ်လုြ်မှုများသည် အပြားဓာတုထုတ်လုြ်မှုဓာတုပြုပြင်းများထက် ကာဗွန်ြိုင်ပအာက်ေိုက်

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NMVOCs များကို အုပ်စိုးအုပ်စိုးသင်္ချေးကြားသော အခြေအနေများကို လေ့လာနေကြသည်။ သို့သော် ပြင်းထန်သည်ကို အကောင်အထည်ဖော်ပြခြင်းဖြစ်သည်။

Slide 20: Hydrofluorocarbons (HFCs) နှင့် (အပေါ်များအတွက်အမြဲပြုလုပ်သူများ) perfluorocarbons (PFCs) သုံး၍ ပြိုင်ပွဲဆောင်ရွက်ဆောင်ရွက်သော သို့သော် အခြေအနေများကို လေ့လာနေကြသည်။ (ODS) ကို လုံးဝပ်ပြုပြီး HFCs နှင့် PFCs သို့မဟုတ် ချွန်စိုးမှန်းစိုးချွန်စိုးသည် ပြိုင်ပွဲဆောင်ရွက်သော အချိန် (IPCC/TEAP, 2005) -

Slide 21: Tier-2 စနစ်သည် အသုံးပြုမှုအမျိုးမျိုးများနှင့် ပြျာ်ရည်သန့်စင်ပြင်း၊ ၂ ချောက်လားရေးဖြစ်ပြီး Tier-2 စနစ်သည် အသုံးပြုမှုအမျိုးမျိုးပြါးပြီး အားလုံးများကို လိုအောင်ပါသည်။

Slide 22: အစောပိုင်းအလိုအပျော်၍ အမှုန်/ပရပမှုြ်များမှုတ်ထုတ်ပြင်းနှင့်ပြျာ်ရည်သန့်စင်ပြင်း၊ အထူးသဖြင့် အဓိကအသုံးပြုသည်။

Slide 23: အျက်များနှင့်ပြျာ်ရည်အသုံးပြုပြင်းသည် NMVOC ထုတ်လွှတ်မှုများကို အဓိကပြစ်ပါကမ်းပစ်သည်

Slide 24: Sulphur hexafluoride ကို gas-insulated switchgear and substation (GIS) နှင့် gas circuit breakers (GCB) ပေါင်းသုံး၍ ချွန်စိုးမှန်းမှုးကောင်းသည်။

Slide 25: Polystyrene ထုတ်လွှတ်မှုများကို gas-insulated switchgear and substation (GIS) နှင့် gas circuit breakers (GCB) ပေါင်းသုံး၍ ချွန်စိုးမှန်းမှုးကောင်းသည်။

Slide 26: NaN အတွက် သို့မဟုတ် သို့သော် များစွာပြင်းသည် Open-cell အပမှုြ်များကို ပိတ်ပြန်ပြါးလာနိုင်သများစွာပြင်းသည်-
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