

Greenhouse Gas (GHG) Emissions Measurement and Reporting Guidelines

PART II: MONITORING PLAN

VERSION 29 DEC 2017

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1. Introduction to the Guidelines

1.1 Purpose

This document is aligned with and supports the Greenhouse Gas Measurement and Reporting Regulations 2017 (i.e. GHG M&R Regulations gazetted on 22 Dec 2017) under the Energy Conservation Act (ECA).

This document is part of a series of Measurement and Reporting (M&R) Guidelines and template provided by the National Environment Agency (NEA):

i) Part I: Introduction to the GHG Measurement and Reporting Requirements

ii) Part II: Monitoring Plan

iii) Part III: Emissions Report

This series of Guidelines aims to provide guidance on:

- i) the implementation of the Measurement and Reporting (M&R) requirements;
- ii) compliance requirements relating to the measurement and reporting of greenhouse gas (GHG) emissions; and
- iii) the preparation of the Monitoring Plan and the Emissions Report.

2. Monitoring Plan Requirements

This section details the overarching requirements for the Monitoring Plan.

2.1 Monitoring Plan submission

The Corporation is required to prepare, submit and maintain a Monitoring Plan for each facility that exceeds the threshold.

The Monitoring Plan identifies and describes the facility's GHG emission sources and emission streams, emissions quantification methods, alternative methods, quality management procedures and uncertainty. The Monitoring Plan submission will assist the Corporation to:

- i) comply with the M&R requirements and GHG M&R Regulations; and
- ii) prepare its annual Emissions Report.

The Monitoring Plan Template ('MP Template') and supporting documents, will form the facility's Monitoring Plan submission. The MP Template should be supported by the relevant supporting documents (refer to Section 2.1.2) in order for NEA to validate and approve the Monitoring Plan. The Corporation is required to demonstrate that the information and data provided in the Monitoring Plan submission are accurate, robust and complete.

The Monitoring Plan submission must be endorsed by the Corporation's Chief Executive or equivalent, then validated and approved by NEA prior to the start of the facility's first reporting period. The approved Monitoring Plan submission will apply for all future reporting periods unless there is a change to the Monitoring Plan submission requiring a resubmission (refer to Section 2.3).

2.1.1 Monitoring Plan Template ('MP Template')

The Corporation shall use the Monitoring Plan Template ('MP Template') provided by NEA to prepare its Monitoring Plan submission. The MP Template has been designed in Microsoft Excel to allow it to be prepared offline and electronically. All facilities subject to the M&R requirements shall use this MP Template for consistency and its use will facilitate the approval of the facility's Monitoring Plan submission.

Further guidance on how to complete the MP Template is available in Section 5. NEA will inform Corporations via email whenever the default MP Template has been revised. Corporations shall download and use the updated MP Template for future Monitoring Plan submissions.

2.1.2 Supporting documents

The Monitoring Plan submission shall comprise a completed copy of the MP Template and a set of supporting documents containing:

- i) An outline of the facility's **Quality Management Framework** (refer to Section 4). The document name or reference must be specified in MP Template.
- ii) **Emission source diagram** showing the location of the facility's processes and activities resulting in GHG emissions, with the emission source(s) and stream(s) labelled using the same emission stream identifier as specified in the MP Template. This is to facilitate validation of the Monitoring Plan submission and third-party verification of the Emissions Report. Details

should include the physical locations of the equipment and systems representing the emission sources and emission points.

iii) **Emission stream diagram(s)** i.e. a series of diagrams covering each emission stream, linking the following components:

- a. major equipment item(s) or system(s) representing the emission source and emission point(s);
- b. fuel, feedstock or product flows; and
- c. measurement instrument(s), measurement and sampling point(s).

Each of the above should be labelled using the identifier (internal identifier/name) as specified in the MP Template. This is a more detailed diagram than the emission source diagram in (ii). NEA requests each facility to provide one emission stream diagram per emission source. Where there is more than one emission stream for an emission source (e.g. multiple feedstocks), all the emission streams can be clearly identified in one emission stream diagram.

iv) A detailed description of the **emissions quantification approach** for each emission stream.

v) Supporting documents (name(s) specified in the MP Template) that provide the detailed information and justification as required for:

- a. Description of the **alternative approach**¹ for each measurement instrument and analysis process (for activity data and conversion factor) to be used (refer to Section 3.2.3).
- b. Explanation and justification for any **engineering estimates** used for activity data, detailing the basis of the assumption and calculation (refer to Section 3.2.1).
- c. Justification for the selection of **activity data Tier 4**, detailing the measurement approach and the standard applied for the maintenance and calibration of the measurement instrument (refer to Section 3.2.1).
- d. For **conversion factors Tier 4**, the assumptions and justifications to substantiate that the samples are representative must be submitted to NEA in the Monitoring Plan submission (refer to Section 3.2.2).
- e. For **conversion factors Tiers 2, 3 and 4**, explanation for the selected sampling and analysis frequency and description of the metering and analysis process (including conversion factor formulation) to be used to derive the conversion factors (e.g. carbon content of fuels or material streams) (refer to Section 5.9.4).
- f. Details of **test methods/standards** used by the laboratories and accreditation details of laboratories used (if relevant). This could include any general laboratory accreditations for data quality management and specific accreditation for the tests to be conducted (refer to Section 5.9.4).

¹ Referred to as 'alternative method, step or procedure' in the GHG M&R Regulations.

- g. Supporting information on how each **site-specific uncertainty value** recorded in the MP Template was derived (refer to Section 5.9.4).
- h. Justification for the use of each **Tier 1 site-specific conversion factor** proposed. The site-specific value, together with a document name and/or reference must be specified in the MP Template (refer to Section 3.2.2).

The MP Template's Tab **L. Submission Checklist** incorporates a series of tables that list the names of each document and each item required to be included in the submission documents. The Corporation must confirm the inclusion of each item required by selection of a confirmation cell (refer to Section 5.9 for more details).

2.2 Approval of the Monitoring Plan

The Monitoring Plan submission must be endorsed by the Corporation's Chief Executive or equivalent, and approved by NEA prior to the start of the facility's first reporting period.

The Monitoring Plan submission shall be submitted to NEA for approval via the online Emissions Data Monitoring and Analysis (EDMA) system.

The criteria to be used by NEA for approval of the Monitoring Plan submission includes:

- i) Administrative elements:
 - a. Completeness of the Monitoring Plan submission – The submission adequately describes the measurement and reporting process proposed by the facility.
 - b. Completeness of supporting documents – All detailed descriptions, justifications and supporting information identified as required on Tab **L. Submission Checklist** have been provided and meet the requirements as detailed in Section 2.1.2.
 - c. Acknowledgement by the GHG manager(s) that the Monitoring Plan submission is complete, accurate, and free from false or misleading information and errors or omissions.
 - d. Endorsement of the submitted Monitoring Plan submission by the Corporation's Chief Executive or equivalent and declaration that the Monitoring Plan submission does not contain any intentional and/or fraudulent misrepresentation of the facility.
- ii) Technical elements:
 - a. Completeness of emission sources and emission streams – All relevant emission sources have been reported in the MP Template. For each emission stream identified within the MP Template, the applicable emission stream form has been completed and it describes the sources of all activity data and conversion factors that are to be used for emissions computation.
 - b. Appropriateness of emissions quantification methods – All emissions quantification methods and tiers used for computing the emissions represent the facility's processes and operations, lead to the accurate computation of emissions, and are based on technical or scientific considerations.

- c. Appropriateness of site-specific conversion factors and supporting documents – Justification(s) of the choice of all site-specific conversion factors are provided, including an explanation of how the site-specific conversion factors are more relevant and accurate, for example compared to the default conversion factors provided by NEA.
- d. Consistency between the MP Template and supporting documents – The Monitoring Plan submission comprises both the MP Template and the set of supporting documents to substantiate the methods, steps and procedures identified in the MP Template. Supporting documents should be aligned with the MP Template, including the necessary references on how they relate to each other.
- e. Appropriateness of the Quality Management Framework – The scope of the Quality Management Framework (QMF) to manage the facility's measurement and reporting process covers the QMF elements described in Section 4.3. The document reference has been specified in the MP Template and the outline is attached to the Monitoring Plan submission.

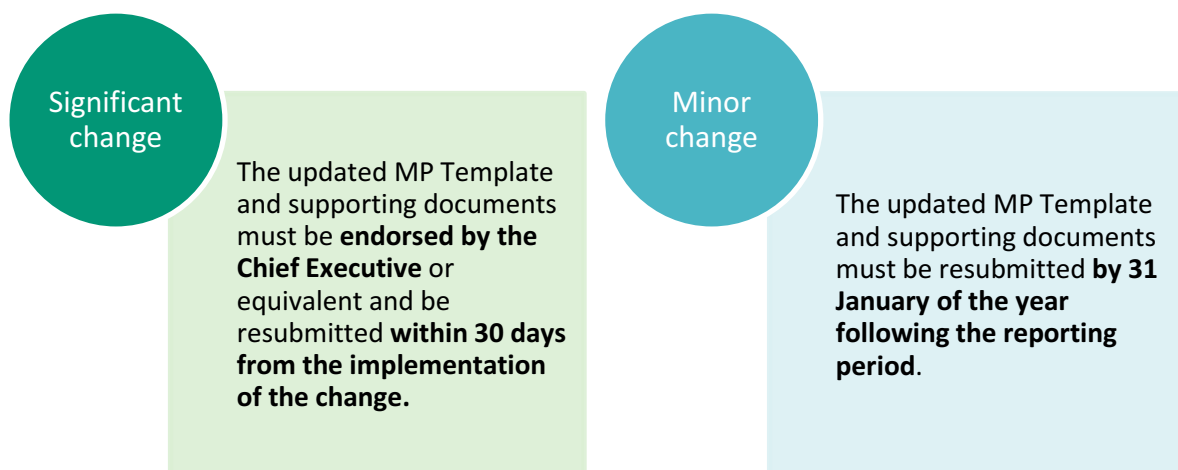
The approved Monitoring Plan submission will apply to all future reporting periods unless there is a change to the Monitoring Plan submission. Any changes to the Monitoring Plan submission would require the facility to resubmit the MP Template and updated supporting documents to NEA for approval.

2.3 Resubmission of the Monitoring Plan

The facility is required to update and resubmit the MP Template with the updated supporting documents to NEA for approval whenever there is any change to the (i) emission sources/emission streams or (ii) measurement and reporting processes.

There are two types of changes as shown in Figure 1 below. The resubmission deadline of the Monitoring Plan submission depends on the type of changes. Should the Corporation require more time for the resubmission of the Monitoring Plan, the Corporation will need to write to NEA to request for an extension, subject to NEA's approval.

Figure 1: Resubmission deadlines of the Monitoring Plan submission for significant change and minor change



A significant change occurring in the facility refers to any of the following:

- i) **Addition of an emission stream.** The introduction of a new fuel combustion or Industrial Processes and Product Use (IPPU) emission source, given that a new emission stream would need to be created in the MP Template. This includes any change in the facility's processes which results in new GHG(s) being emitted. A change to an existing emission stream, e.g. change in the process type, feedstock, or fuel type would require the creation of an additional emission stream, because the preceding emission stream (before the change) might still be relevant to the earlier part of the reporting period.
- ii) **Change of emissions quantification method and alternative approach.** Change of the primary or alternative emissions quantification method to measure and quantify emissions during the reporting period is a significant change. If the change of method applies to a part of the reporting period, a new emission stream should be added to the MP Template to account for the change in method. This includes any changes to the measurement method for the activity data, e.g. change of activity data tiers or type of measurement instrument. Do note that a change within activity data Tier 1: Engineering estimate which involves changes to the computation formula or methodology, sources of metered data, or the industry standard that is used as a reference, would also be considered a significant change. Exceptions to this case are changes that are within the operating assumptions as described in the engineering estimate.

A change in the primary or alternative emissions quantification method during a reporting period would require a new emission stream to be added, as the preceding emission stream should not be removed from the MP Template until the next reporting period. The relevant period for which the change apply/do not apply or when the preceding emission stream will cease to exist should be indicated.

- iii) **Change in the conversion factor tier.** A change in conversion factor tier is a significant change when:
 - a. There are any changes to the Tier 1 site-specific conversion factors approved by NEA in the MP Template. Each site-specific conversion factor used requires approval by NEA. The introduction of a new site-specific conversion factor during a reporting period constitutes a significant change.
 - b. Change from conversion factor Tier 1 to either Tier 2, 3 or 4 (i.e. changing from default factors to metering).
 - c. Any back-tracking on the conversion factor tiers, including changing from metering to default factors (e.g. from Tier 4 to Tier 2 or from Tier 2 to Tier 1).

The updated MP Template and all updated supporting documents should be endorsed by the Chief Executive or equivalent, and resubmitted to NEA via the EDMA system within 30 days from the implementation of the change.

All changes that are not included in the list of significant changes above would still require an update to the Monitoring Plan submission. However, the updated Monitoring Plan submission would only need to be resubmitted by 31 January of the year following the reporting period (i.e. facility is allowed to consolidate all minor changes to the MP Template and resubmit by 31 January of the year following the reporting period), along with any relevant supporting documents. The updated Monitoring Plan

submission for minor changes need not be endorsed by the Chief Executive or equivalent. Examples of minor change are detailed below:

- i) **Removal of an emission stream.** As the emission stream might still be relevant to parts of the reporting period, it should not be removed from the MP Template. For subsequent reporting periods where the emission stream becomes obsolete/irrelevant, the facility will update the MP Template to remove the emission stream.
- ii) **Introduction of new procedures or change in existing procedures related to sampling, analysis or calibration.** If a facility implements new procedures or changes its existing procedures that have a direct impact on the accuracy of the measurement and reporting process, the MP Template should be updated to reference the procedures and record their impact on the conversion factors.
- iii) **Increase in the accuracy of on-site metering and analysis for conversion factors** (i.e. going up the conversion factor tiers from Tier 2 to Tier 3 or Tier 4, hence increasing the metering frequency and accuracy). Note that changing from conversion factor Tier 1 to either Tier 2, 3 or 4 is however a significant change.
- iv) **Change in GHG Manager.** If a new GHG Manager is appointed, the supporting documents to demonstrate the necessary qualifications/experience should be submitted within 30 days after his appointment. In the event where the only GHG Manager is no longer appointed as a GHG Manager, the Corporation is required to appoint a replacement GHG Manager within three (3) months.

3. Key Concepts, Measurement and Methods

This section provides an overview of the key concepts, measurement and methods that underpin the M&R requirements.

3.1 Methods for quantifying GHG emissions

Generally, there are three methods available for the quantification of GHG emissions. These methods are consistent with international GHG emissions quantification methods:

Figure 2: Emissions quantification methods

Method 1: Calculation Approach

- Calculation of emissions from activity data (e.g. amount of fuel or process input) and appropriate conversion factors (e.g. emission factors and net calorific value).

Method 2: Material Balance

- Determination of CO₂ emissions based on the balance of the carbon content entering the process through feedstock and the amount exiting the process through products.
- Generally applicable to IPPU emission sources, where carbon is contained in the inputs and outputs of the process. The amount of carbon in the applicable inputs and outputs must be measured to quantify the carbon unaccounted for that is assumed to be oxidised.

Method 3: Direct Measurement

- Measurement of GHG emissions directly at the point of release, e.g. a Continuous Emissions Monitoring System (CEMS) that measures the exhaust gas flow rate and the concentration of the GHG emissions at an exhaust stack.

The facility is given the flexibility to choose and use the most appropriate emissions quantification method for the accurate computation of its emissions. More information on each of the emissions quantification method are detailed below. The Appendix details the available methods for each of the common emission sources i.e. process types.

In some cases, a combination of emissions quantification methods could be used to quantify different types of GHG emissions from a single emission source. When developing the MP Template, NEA has taken into account the different types of GHGs that could be quantified by different emissions quantification method for a particular emission source. For example, for fuel combustion, the Corporation may use Method 3: Direct Measurement for CO₂ and the MP Template will automatically create a Method 1: Calculation Approach emission stream form for CH₄ and N₂O (as Direct Measurement of CH₄ and N₂O are typically not conducted by CEMs). The Monitoring Plan and Emissions Report will require the Corporation to identify all GHG emissions that must be reported for

each process type. An example is provided in the Appendix for fuel combustion (refer to Section 5.4.4 and Section 5.4.5).

3.1.1 Method 1: Calculation Approach

Method 1: Calculation Approach calculates emissions based on activity data and conversion factors. It is the simplest and most common emissions quantification method.

Conversion factors can either be (i) default conversion factors based on the 2006 IPCC Guidelines, or (ii) site-specific conversion factors determined and substantiated by the facility.

- i) Default conversion factors based on the 2006 IPCC Guidelines. Where available, NEA will cater for the selection of these conversion factors in the MP Template for both IPPU (e.g. CO₂ emissions per tonne of ethylene produced) and fuel combustion (e.g. energy conversion factors (net calorific values (NCV)) and emission factors (CO₂, CH₄ and N₂O)) emission sources/streams.
- ii) The facility can use site-specific conversion factors if the facility can demonstrate that the site-specific conversion factor is appropriate and leads to a more accurate and representative quantification of its emissions. Such site-specific factors must be justified by supporting documents/data and will be subject to NEA's approval. These conversion factors can be derived from:
 - a. Reputable literature, industry guidelines or headquarters' guidelines and reports;
 - b. Historical measurement and analysis; or
 - c. Actual measurement and analysis performed during a reporting period. The derived conversion factors are to be reported in the Emissions Report. The facility will in the MP Template specify the measurement approach and analysis technique to be used. Conversion factors can be calculated from the analysis of materials or process performance during the reporting period (refer to Section 3.2.2).

3.1.2 Method 2: Material Balance

Method 2: Material Balance allows the facility to quantify carbon dioxide (CO₂) emissions from a process based on the difference in the quantity of carbon measured entering and exiting a process. The facility will then report the estimated carbon dioxide emissions together with the quantity of main product. The facility will also need to report emissions of other applicable GHGs using Method 1: Calculation Approach.

Method 2: Material Balance is for determining only carbon dioxide (CO₂) emissions and is only applicable to selected Industrial Processes and Product Use (IPPU) emission sources. It requires the quantification of the flow (activity data) of each input, output, waste stream and the carbon content (material property) of each stream. The total carbon measured in the output and waste streams is deducted from the total carbon in the input stream to identify the carbon lost to the atmosphere as CO₂.

Site-specific CO₂ emission factors are then calculated by the Emissions Report as emissions per unit of the main product for the process activity.

Given that certain IPPU emission sources also result in secondary non-CO₂ emissions according to the 2006 IPCC Guidelines, e.g. CH₄ for ethylene production, the MP Template assumes that the facility will

compute such secondary non-CO₂ emissions based on the production value as per the 2006 IPCC Guidelines. Therefore, the facility is not required to create a separate emission source/stream in the MP Template for such secondary non-CO₂ emissions (refer to Section 5.6.4).

Method 2: Material Balance uses the following formula to calculate the CO₂ emissions and CO₂ emission factor:

$$E_{CO_2} = \left[\sum_i (QF_i \times CCF_i) - \left\{ \sum_j (QP_j \times CCP_j) + \sum_k (QS_k \times CCS_k) + \sum_l (QW_l \times CCW_l) \right\} \right] \times \frac{44}{12}$$

$$EF_{p,CO_2} = E_{CO_2} / Q_p$$

Table 1: Method 2: Material Balance equation parameters

Value ID	Value description	Units
E_{CO_2}	Emissions of CO ₂	tonne CO ₂
QF_i	Annual quantity of feedstock (i) consumed for the production of primary product and other secondary products and waste streams	tonne
CCF_i	Carbon content of feedstock (i)	% or ratio
QP_j	Annual quantity of primary product (j), produced	tonne
CCP_j	Carbon content of primary product (j)	% or ratio
QS_k	Annual quantity of secondary product (k) produced	tonne
CCS_k	Carbon content of secondary product (k)	% or ratio
QW_l	Annual quantity of waste stream (l) resulting from the production process	tonne
CCW_l	Carbon content of waste stream (l)	% or ratio
Q_p	Quantity of primary product produced for sub-process type (p)	Tonne
p	Sub-process type	
EF_{p,CO_2}	Emission factor for CO ₂ and primary product using sub-process type (p)	tonne CO ₂ /tonne

3.1.3 Method 3: Direct Measurement

Method 3: Direct Measurement involves the direct measurement of emissions at a point of emissions release, usually an exhaust stack or other ducting that allows measurement. The exhaust gas flow rate and the concentration of the GHG being measured are used to quantify the emissions over a sample period. The samples are then aggregated across the reporting period. The facility is required to report the final GHG emissions.

Direct measurement of GHG emissions is most commonly used in conjunction with other emissions monitoring such as SO_x emissions in power stations and IPPU emissions where direct measurement of emissions is the only option for measuring the emissions from a particular plant. The measurement of N₂O emissions from the production of various acids such as adipic and nitric acid are examples of IPPU emissions requiring direct measurement when abatement technology is used to reduce N₂O emissions. The performance of the abatement can vary from plant to plant and over time and cannot be accurately estimated from emission factors.

Method 3: Direct Measurement can be conducted continuously or periodically:

- i) For **Continuous Emissions Monitoring System (CEMS)**, the measurement instrument is normally permanently installed and expected to operate continuously. CEMS is usually the preferred method where the measurement instrument is already required for other purposes. For CEMS, the facility is not required to justify the use of Tier 4 conversion factor in the Monitoring Plan submission.
- ii) **Periodic Emissions Monitoring System (PEMS)** measures the emissions over a defined time period together with an activity data to determine an emission factor for the facility. The emission factor is then multiplied by the activity value over the whole reporting period to calculate the annual emissions to be reported. The PEMS must operate over a sufficient time period to obtain a representative profile of all operating modes of the plant.² For facilities using PEMS, the Monitoring Plan submission should include justifications and assumptions that the proposed operating time period(s) used to derive the activity data and/or conversion factor will be representative (including the selection of Tier 4 for conversion factor) of the entire reporting period.

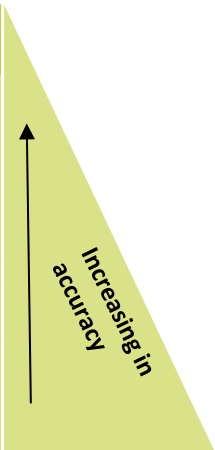
Method 3: Direct Measurement may not capture all emissions associated with an emission source type. For example, the small quantities of CH₄ and N₂O from fuel combustion may not be directly measurable. In this situation, the MP Template assumes that the CH₄ and N₂O from fuel combustion will be computed based on Method 1: Calculation Approach, and will automatically create an emission stream separately for CH₄ and N₂O.

Where there is combustion of multiple fuels using Method 3: Direct Measurement, for the measurement of combustion of subsequent fuel, the MP Template will create a new emission stream for the facility to record CH₄ and N₂O emissions arising from the combustion of the subsequent fuel.

3.2 Methods for estimating activity data and conversion factors: concept of tiers

Figure 3: Activity data tiers and conversion factor tiers (arranged in terms of decreasing accuracy or increasing uncertainty)

Tier	Activity data tiers	Conversion factor tiers
4	Measured using an instrument meeting a specific standard	Representative analysis
3	Invoiced quantity	Analysis done once every year or more frequent
2	Measured using typical industry approach	Analysis done less frequently than once a year
1	Engineering estimate	Default



² For example, this may require multiple time periods, such as pre and post replacement of abatement catalyst for an acid production plant. Two emission factors would be developed and used with the activity data over the appropriate time periods.

The tiers represent a hierarchy of measurement approaches of increasing accuracy (or decreasing uncertainty) for an **activity data** or **conversion factor** i.e. parameters used to quantify emissions. Tiers are used to help the facility describe and categorise the measurement approach that will be used to determine the activity data and conversion factor(s) of each emission stream. Within the MP Template, the tier selected by the facility will influence the uncertainty calculations of each emission stream. Although the M&R requirements do not mandate a particular or minimum tier, the Corporation shall select the most appropriate tier to ensure accurate computation of emissions.

3.2.1 Activity data tiers

Activity data refers to the amount of materials (including fuels and feedstock) consumed or produced by a process or activity, and is used to compute direct GHG emissions for the reporting period. The measurement approach used by a facility to obtain an activity data value can be categorised under one of the four activity data tiers in Table 2. The facility shall use the most appropriate activity data tier to ensure accurate computation of emissions.

The facility is required to specify the measurement process, including the activity data tier applicable to the facility, and comply with quality management procedures that ensure accuracy of the activity data value for reporting.

Examples of activity data include:

- i) quantity of fuel combusted, as measured by the quantity delivered or billed to the facility or adjusted to account for a change in stock holding;
- ii) quantity of fuel measured as a feedstock in a chemical process;
- iii) quantity of ethylene measured as a product produced from a particular feedstock; or
- iv) quantity of exhaust gas measured from a plant stack.

The difference between activity data Tier 2 and Tier 4 is not dependent on the type of measurement instrument used, but rather on how well the measurement instrument is maintained and calibrated. For example, a flowrate measured using a highly accurate flowmeter not subjected to the recommended periodic maintenance and calibration procedures would be classified as an activity data Tier 2, while a flowrate measured using a less accurate flowmeter that is subjected to the recommended periodic maintenance and calibration procedures would be classified as activity data Tier 4.

Table 2: Activity data tiers

Tier	Description	Details and typical application
4	Accurate measurement using an instrument meeting a specific standard	<ul style="list-style-type: none"> Activity data obtained from the use of a measurement instrument over the reporting period, where the measurement instrument is well maintained, calibrated and serviced according to: <ul style="list-style-type: none"> i) Manufacturer's recommended maintenance and calibration procedures/frequency; ii) Legal standard required for commercial transactions; or iii) Appropriate industry standard for the instrument type. A facility that uses activity data Tier 4 is required to provide supporting documents in the Monitoring Plan submission to justify how activity data Tier 4 is achieved, including: <ul style="list-style-type: none"> i) A statement of the measurement approach;

Tier	Description	Details and typical application
		<ul style="list-style-type: none"> ii) Reference to the applicable manufacturer documents or standards applied; and iii) Justification for the site-specific uncertainty (if any). <ul style="list-style-type: none"> Does not include third party measurement instruments used to establish the amount in a commercial transaction (refer to activity data Tier 3). All other measurement instruments that do not meet Tier 4 requirements will be classified as Tier 2. <p>Examples:</p> <ul style="list-style-type: none"> A flowmeter used to measure an activity data, where the flowmeter was installed and annually maintained and calibrated in accordance with an international standard. <p>Applications:</p> <ul style="list-style-type: none"> High-value fuel types that require measurement for operational or financial needs.
3	Invoiced quantity	<ul style="list-style-type: none"> Activity data based on the quantity specified on an invoice or related delivery statement that has been agreed between the vendor and purchaser. This includes the quantity that is derived from the billed amount in dollar value. This tier is the simplest approach for reporting fuels and other materials that are purchased and subject to commercial standards of measurement. <p>Examples:</p> <ul style="list-style-type: none"> The quantity of natural gas obtained during the reporting period from a supplier, where all the natural gas obtained were combusted during the reporting period. <p>Applications:</p> <ul style="list-style-type: none"> All purchased fuels and materials.
2	Measurement using typical industry approach	<ul style="list-style-type: none"> Activity data obtained using a measurement instrument over the reporting period. This tier is intended to include any measurement instrument that does not meet the requirements of activity data Tier 4. Does not include third party measurement instruments used to establish the amount in a commercial transaction (refer to activity data Tier 3). <p>Examples:</p> <ul style="list-style-type: none"> Any flowmeter or batch counter used to measure the input to, or output from, a process. <p>Applications:</p> <ul style="list-style-type: none"> Common flow measurement instruments.

Tier	Description	Details and typical application
		<ul style="list-style-type: none"> Liquid tank height measurement.
1	Engineering estimate based on related activity data	<ul style="list-style-type: none"> Activity data estimated based on other information obtained during the reporting period. No physical measurement of the activity data over the entire reporting period. Could include the measurement of past activity data together with production or other related activities that are known for the reporting period. The annual production value is then used to extrapolate the amount for the activity over the reporting period. Could include a material quantity or energy balance used to calculate a flow that is not measured. When activity data Tier 1 is used, the facility must provide a description of the engineering estimate (i.e. the methodology and assumption used) in the Monitoring Plan submission, as well as a justification that the engineering estimate (i) is appropriate, (ii) enable the GHG emissions to be accurately computed, and (iii) is based on technical or scientific considerations. <p>Examples:</p> <ul style="list-style-type: none"> Calculation of fuel use for electricity generation from the measurement of electricity generated and assumed generation efficiency, or measured run hours and assumed average load. <p>Applications:</p> <ul style="list-style-type: none"> Where there is no commercial transaction related to the delivery of the fuel to the facility such as fuel obtained off-site and used on-site by contractors for an activity. Apportionment of fuel consumption between fuel combusted and fuel used as feedstock.

3.2.2 Conversion factor tiers

Conversion factors are either (i) IPCC default conversion factors or (ii) site-specific conversion factors determined and substantiated by the facility. The analysis technique required is generally defined by the characteristics of the material being obtained. However, the frequency of analysis can usually increase the accuracy of the conversion factor over the reporting period.

Four (4) conversion factor tiers have been established and reflect the increasing accuracy of analysis based on the frequency, or representativeness of the sampling frequency. Advancing from Tier 1 to Tier 4 will decrease the uncertainty, but entails an increase in the measurement effort, frequency and complexity. The facility is encouraged to use the most appropriate conversion factor tier to ensure accurate computation of emissions. The four conversion factor tiers are further described in Table 3.

Examples of conversion factors include:

- i) material property factors such as the carbon content of a material (including a fuel combusted, fuel used as a feedstock, or a product or waste stream produced);
- ii) properties of the operation or performance of a plant equipment, such as the percentage of GHG destroyed or converted when used in the etching of semiconductor material; or
- iii) emission factors developed through experimentation or Method 3: Direct Measurement. This includes the default CH₄ and N₂O emission factors used for fuel combustion which have been developed through studies of typical installations.

Where the conversion factors are derived based on metering and analysis, or laboratory analysis, the facility is required to include in the Monitoring Plan submission, a description of the sampling and/or analysis procedures to be used, and methodology or process to derive the resulting conversion factors during the reporting period. The facility is also required to provide a reference to internal facility procedures for maintaining the accuracy of the instrument, and/or procedures for maintaining the representativeness of the sampling process.

Table 3: Conversion factor tiers

Tier	Description	Details
4	Representative analysis	<ul style="list-style-type: none"> Site-specific conversion factors based on analysis of one or more samples that are each representative of the material property over the reporting period for which the analysis is to be used. This tier is intended to allow the facility to highlight that the sampling frequency is providing an accurate representation of the material property over the reporting period. Representative analysis of the material property could include: <ul style="list-style-type: none"> Samples taken in accordance with an internationally accepted frequency for sampling (e.g. ISO 10715:1997 (natural gas), AS 4264.1—2009 (coal)); By sampling each delivery batch/shipment of the material, possibly provided by the supplier; Monthly sampling using a composite of samples collected daily through the month; or Continuous online monitoring i.e. CEMS/PEMS. The facility is required to demonstrate in the Monitoring Plan submission the representativeness of the samples over the reporting period and provide explanation for the conversion factor formulation. This is not required if the facility uses a CEMS. For PEMS, the facility is still required to justify that the proposed proposed operating time period(s) is representative of the entire reporting period (also see Section 0).
3	Analysis done once every year or more frequently	<ul style="list-style-type: none"> Site-specific conversion factors derived from measurement and analysis during each reporting period, with a scheduled frequency of once every year or more frequent e.g. annually, quarterly or monthly). Analysis done once a year or more frequently allows the facility to reflect any variability of the composition over the reporting period.

Tier	Description	Details
		<ul style="list-style-type: none"> The facility will be required to provide explanation in the Monitoring Plan submission for the selected sampling frequency and conversion factor formulation.
2	Analysis done less frequently than once a year	<ul style="list-style-type: none"> Site-specific conversion factors derived from measurement and analysis, with a scheduled frequency that is less frequent than once every year (e.g. bi-annually or once every three years). The facility will be required to provide explanation in the Monitoring Plan submission for the selected sampling frequency and conversion factor formulation.
1	Default	<ul style="list-style-type: none"> IPCC default factors provided by NEA; or Site-specific conversion factors specified and justified by a facility, based on other (i) reputable literature, industry guide, HQ's guidelines or reports, or (ii) historical measurement and analysis. The facility will be required to: <ul style="list-style-type: none"> specify the site-specific conversion factor value in the MP Template; provide reason(s) for using the site-specific conversion factor; provide supporting documents to substantiate that the site-specific conversion factor is appropriate e.g. representative of current processes and operations, and that it leads to a more accurate computation of emissions; and Explain why on-site metering and analysis (Tiers 2, 3 and 4) or other available international default conversion factors is not implemented or adopted.

3.2.3 Alternative approaches

The facility will be required to specify at least one alternative approach that would be used should the primary measurement approach (metering and analysis to derive the activity data and conversion factor) indicated in the MP Template become no longer suitable or available due to a certain scenario or event, e.g. process upset, shutdown, maintenance, failure and/or replacement of meters etc. The alternative approach is approved as part of the Monitoring Plan submission to ensure that there will be no data gaps and incomplete datasets for GHG emissions computation. The use of the activity data Tier 3: Invoiced quantity, or conversion factor Tier 1: Default does not require an alternative approach to be specified³.

The facility may use the alternative approach for up to 90 days in the whole reporting period, whether or not the days are consecutive. When the alternative approach is used during the reporting period, the facility will have to submit supporting documents of the measurement approach failure and the period of the measurement approach failure along with the Emissions Report.

³ An engineering estimate will need an alternative approach if it is based on any actual measurement data (i.e. production or feed etc.).

If the facility uses the alternative approach for more than 90 days in the whole reporting period, the facility must describe a new measurement approach within the MP Template and resubmit the MP Template, along with any relevant supporting documents to NEA within 30 days of identifying that the failure will or has exceeded 90 days in the whole reporting period. The new measurement approach (which can be the original alternative approach) can be a permanent or temporary measurement approach. The impact on the uncertainty of the emission stream over the reporting period due to the measurement approach failure (when exceeding cumulatively 90 days in the reporting period) can be assessed within the MP Template.

The description of the alternative approach could include:

- i) Calculation/estimation approach, including the formula, assumptions, details of each parameter and how each parameter is measured;
- ii) Benchmarking based on historical data; and
- iii) Alternative measurement instruments in the facility.

The description of the alternative approach should also include the alternative GHG quantification approach for the particular emission stream, should the primary approach becomes no longer applicable (as a result of the unavailability of the primary measurement approach for the activity data or conversion factor).

The description of the alternative approach, together with the relevant formulae and/or assumptions shall be submitted as part of the Monitoring Plan submission. Refer to Section 5.9 for details of how this would be included in the Monitoring Plan submission.

3.3 Uncertainty

3.3.1 Concept of uncertainty

Uncertainty is related to the degree of quality or accuracy of a measured or derived value e.g. GHG emissions quantity. According to the GHG Protocol on Uncertainty⁴, there are many factors that contribute to uncertainty, but uncertainty associated with quantifying parameters that are used in emissions quantification methods is most amenable to assessment.

Parameter uncertainty can be further categorised into (i) systematic and (ii) statistical uncertainty. Systematic uncertainty occurs when data is systematically biased, where the measured value is always less or greater than the true value. Systematic biases can arise from:

- i) incorrect or incomplete methods applied;
- ii) incomplete list of sources of emissions; and
- iii) the use of faulty measurement instrument.

Systematic biases or errors are typically eliminated when the facility implements a quality management system for its emissions inventory. The M&R requirements assume that the data compiled by the facility is free from these biases or errors, given the requirement for the facility to implement a Quality Management Framework (QMF). Therefore, the uncertainty assessment in this

⁴ *GHG Protocol guidance on uncertainty assessment in GHG inventories and calculating statistical parameter uncertainty* (September 2003) v1.0 issued by the World Business Council for Sustainable Development and World Resources Institute

Guidelines is focused on **statistical uncertainty** associated with the measurement of parameters used in the quantification of GHG emissions, assuming no bias of measurement.

In contrast to systematic uncertainty, statistical uncertainty results from the random variability of sample data, where repeat measurements will produce a randomly different result. According to existing literature, the causes of statistical uncertainty in measurement include:

- i) natural variation in the measured quantity or item – the quantity or item being measured may not be stable. For example, uncertainty associated with GHG emissions from fuel combustion is mainly attributable to variation in the composition of combusted fuels. Similarly, default conversion factors are likely to have a higher uncertainty value than site-specific conversion factors;
- ii) random errors in the general measurement process – given that real measurements are never made under perfect conditions, errors and uncertainties also arise from the measurement process itself depending on the level of difficulty, operator skill, changing operating conditions such as temperature and pressure, can affect both measurement instrument and/or item being measured. For example, uncertainty associated with GHG emissions from fuels is attributable to variation in the volume or composition of the fuels combusted; and
- iii) intrinsic uncertainty from the measurement instrument – dependent on the precision and accuracy i.e. quality of the instrument, apart from changes due to aging, electronic noise and mechanical vibration, drift between calibrations, etc.

Therefore, uncertainty of a measurement is concerned with the size of the margin of doubt about the result of a measurement, i.e. an evaluation of the degree of quality of the measurement value.

More importantly, statistical uncertainty can be reduced by (i) improving the quality of the measurement instrument/approaches, (ii) advancing to a higher activity data tier and hence, specifying a lower uncertainty), or (iii) deriving a site-specific conversion factor or increasing the frequency of sampling and analysis (i.e. advancing to a higher conversion factor tier).

Statistical uncertainty is usually presented by an uncertainty range expressed as +/- percent of the reported mean value of the quantity. The uncertainty range i.e. confidence interval establishes the lower and upper limits within which the true value of a measured quantity is situated for a given probability level, is typically set at 95%. A 95% confidence interval means that there is a 5% chance that the true value falls outside the confidence interval. For example, a reported emission value of 100 tCO₂e with an uncertainty value of 2.0% means that the true emission value lies between 98 and 102 tCO₂e with a probability of 95%.

3.3.2 Purpose of assessing uncertainty

Similar to quantifying GHG emissions, uncertainty is assessed from the emission stream level. An emission quantity is a function of a number of parameters including activity data and conversion factor(s). Similarly, the uncertainty of the emission quantity is a function of the uncertainties associated with each calculation parameter (refer to Section 3.3.4.).

The purpose of the uncertainty assessment is to provide the Corporation and NEA an indication on:

- i) the dominant emission stream(s) that dominate the overall facility-level emissions uncertainty and the relative uncertainty among various emission streams; and
- ii) the overall accuracy or uncertainty of the facility's annual emissions.

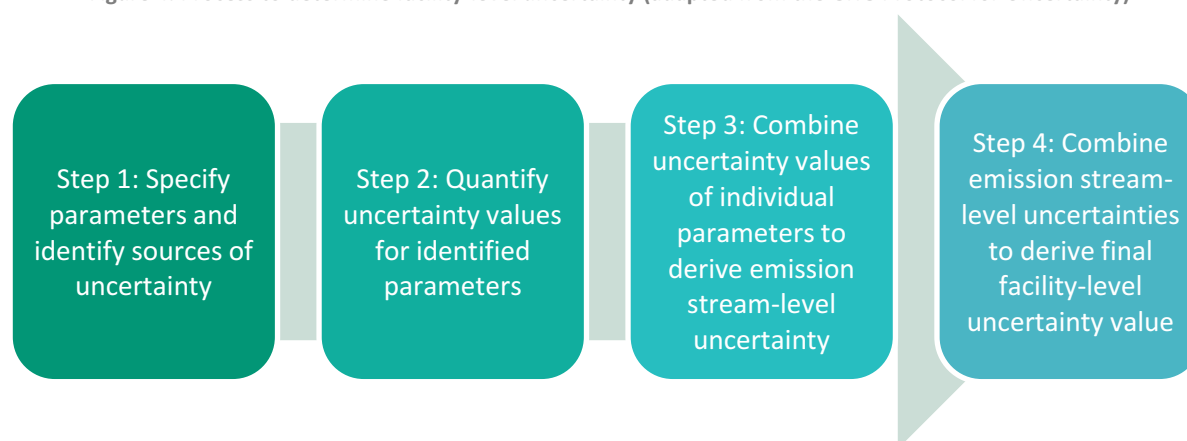
As reducing uncertainty is likely to entail a greater amount of measurement effort and cost, the uncertainty assessment serves as a guide for the Corporation in identifying the most cost-effective actions to improve data quality and accuracy.

As uncertainty is to be assessed within the MP Template, it is therefore based on forecast emissions. There is no uncertainty limit or threshold set by NEA, and it is not necessary to update the uncertainty assessment in the Emissions Report based on actual emissions. Uncertainty assessment is also not subject to third-party verification.

3.3.3 Specifying uncertainty values

According to the GHG Protocol on Uncertainty, uncertainty assessment can be broken down into four broad steps as follow.

Figure 4: Process to determine facility-level uncertainty (adapted from the GHG Protocol for Uncertainty)



To make the uncertainty assessment simple and easy for the facility, with the exception of requiring the facility's input on the forecast emissions at Step 4, the full process has been automated within the MP Template.

On Step 2, default uncertainty values for activity data and conversion factors have been built into the MP Template. In the context of the M&R requirements, the facility should note that uncertainty is broadly concerned with the (i) intrinsic quality of the measurement instrument or approach, and the (ii) frequency of sampling and any analysis used, notwithstanding existing statistical methods to quantify uncertainty values using sample data.

The default uncertainty values for activity data and conversion factors are tabulated in Table 4, Table 5 and Table 6.

For activity data, default uncertainty values are broadly categorised by the measurement approach i.e. tier; and where a measurement instrument is involved, the default uncertainty values would depend on the accuracy of the type of measurement instrument used. Activity data is assumed to be quantified by the facility continuously during the reporting period and hence the frequency of sampling would not impact the activity data uncertainty.

With regard to conversion factors, default uncertainty values would depend on the type of measurement instrument or laboratory analysis, and the frequency of the sampling and analysis. Where sampling and analysis is required to determine a conversion factor (conversion factor Tier 2, 3 and 4), the default uncertainty of the conversion factor is the uncertainty value of the measurement instrument type or laboratory analysis (tabulated in Table 5) further subject to a multiplier depending on the sampling and analysis frequency, as tabulated in Table 6. For conversion factors Tier 1: Default

where there is no sampling and analysis on the facility's part, the default uncertainty values provided are based on international, industry or third-party sources.

Table 4: Default uncertainty values for activity data tiers

Activity data tier	Default uncertainty	Remarks
1 – Engineering estimate based on related activity data	10%	Based on industry expert's judgment and experience.
2 – Measured using typical industry approach	1 to 12% (depending on instrument type)	For ease of calculation, default uncertainty values would be double of that of activity data Tier 4.
3 – Invoiced quantity	1.5%	Based on industry expert's judgment and experience. If the billed quantity would be determined via an accurate meter, the facility may specify 1% or otherwise depending on the default uncertainty of that meter. For integrated circuit or semiconductor production, uncertainty for invoiced quantity based on the default heel (10%) would be 1.8%.
4 – Measured using an instrument meeting a specific standard	0.5 to 6% (depending on instrument type)	Based on existing literature. Refer to the Appendix for full list of default uncertainty values and references.

Table 5: Default uncertainty values for measurement instrument types and laboratory analyses for conversion factors

Metering & Analysis for conversion factor	Default uncertainty (%) – based on conversion factor Tier 4: Representative	Remarks
Measurement instrument type		
Abatement control system timer	1	Refer to the Appendix for full list.
Density (gas)	0.5	
Density (liquid)	0.5	
Flue Gas Analyser	3	
Gas chromatograph	1	
Molecular weight	1	
Pressure	0.1	
Specific gravity	0.5	
Temperature	0.1	
Wobbe index	1.1	
Laboratory analysis		
Abatement system operating hours	1	Refer to the Appendix for full list.
Energy Content	1	
Composition - Carbon content	1	
GHG concentration in a gas sample	1	

Table 6: Default uncertainty values for conversion factor tiers

Conversion factor tier	Default uncertainty	Remarks
1 – Default	2% to 60% (depending on type of fuel, feedstock, or conversion factor associated with a particular emission source/stream). Site-specific conversion factors are assumed to be a fraction of the uncertainty specified by the IPCC.	<p>Based on international, industry or third-party sources i.e. 2006 IPCC Guidelines and the Australian National Greenhouse and Energy Reporting (Measurement) Determination 2008.</p> <p>Refer to the Appendix for the full list of default uncertainty values and references.</p> <p>Many IPCC uncertainty values are high due to the variability of process characteristics across industry and countries.</p> <p>A site-specific conversion factor is assumed to have lower uncertainty due to the site characteristics being known to the operator. The degree of reduction is dependent on the type of characteristics involved and capacity for the facility to control. The facility is allowed to overwrite this default uncertainty and propose a site-specific uncertainty value.</p>
2 – Analysis done less frequently than once a year	x3	<p>Based on industry expert's judgment and experience. For representative analysis, the sampling frequency is assumed to have negligible impact on the intrinsic uncertainty of the measurement instrument or analysis, i.e. x 1.</p> <p>Any analysis conducted during the reporting period is assumed to have twice the intrinsic uncertainty of the measurement instrument or analysis. Any less frequent analysis is assumed to have three times the intrinsic uncertainty. Hence, for conversion factor Tier 2 and Tier 3, the intrinsic uncertainty would be multiplied by 3 or 2 times respectively.</p>
3 – Analysis done once every year or more frequent	x 2	
4 – Representative analysis	x 1	

Apart for default uncertainty values of default conversion factors, all default uncertainty values in the MP Template can be overwritten with site-specific uncertainty values. The facility will be required to submit its justifications for site-specific uncertainty values as part of the supporting documents (also refer to Section 5.9.3).

The facility may refer to the following ways to specify uncertainty values, according to the GHG Protocol on Uncertainty:

- i) determine the instrument precision of any measurement instrument used, especially for activity data. This is usually listed by the manufacturer under the equipment specifications;

- ii) consult experts within the facility (e.g. maintenance team) or manufacturer to give an estimate of the uncertainty range of the data used⁵; or
- iii) use uncertainty ranges from reputable industry sources or practices e.g. uncertainties for conversion factors as published in guidelines such as the API Compendium⁶.

Uncertainty can also be assessed by statistical methods based on internationally accepted protocols such as the Joint Committee for Guides in Metrology (JCGM) Evaluation of measurement data — Guide to the expression of uncertainty in measurement⁷ (GUM). The guide provides a protocol for detailed assessment of the uncertainty of a measurement process including the effects of instrument accuracy, measurement resolution and data capture. Good practice guides based on the GUM include:

- i) ISO 5168:2005: Measurement of fluid flow— Procedures for the evaluation of uncertainties⁸
- ii) World Meteorological Organization (WMO) : Guidelines for the assessment of uncertainty of hydrometric measurements⁹
- iii) National Physical Laboratory (NPL), UK : A beginner’s guide to uncertainty of measurement¹⁰
- iv) NEL : Good practice guide – Flow measurement uncertainty and data reconciliation ¹¹

Other industry based guides such as the IPIECA-API guide on addressing uncertainty in oil and natural gas industry greenhouse gas inventories are available for the oil & gas industry¹². Most international standards for management of metering will provide details on the assessment of uncertainty for the metering involved.

3.3.4 Aggregating uncertainty at the emission stream level and facility level

This section details how the MP Template performs the aggregation calculations for deriving the emission stream-level uncertainty and the overall facility-level uncertainty.

In line with most uncertainty assessments, the assessments of uncertainty in the MP Template assume a normal distribution (i.e. where there are no systematic biases). This assumption is not likely to have an impact on the assessment.

⁵ Manufacturer or industry judgment may take into account the inherent accuracy of an instrument’s physical measurement process assuming effective maintenance including flow elements, the mechanical or hydraulic connection to the transducers, transducer accuracy and the inclusion of temperature and pressure correction as required.

⁶ *Compendium of greenhouse gas emissions methodologies for the oil and gas industry* (August 2009) issued by the American Petroleum Institute: http://www.api.org/~media/files/ehs/climate-change/2009_ghg_compendium.ashx

⁷ JCGM/JCGM 100:2008: <http://www.iso.org/sites/JCGM/GUM-introduction.htm>

⁸ *ISO 5168:2005 Measurement of fluid flow — Procedures for the evaluation of uncertainties* issued by the International Organization for Standardization (ISO): <https://www.iso.org/standard/32199.html>

⁹ *Guidelines for the assessment of uncertainty of hydrometric measurements* (February 2009) issued by the World Meteorological Organization (WMO): http://www.wmo.int/pages/prog/hwrf/Flow/flow_tech/documents/UA_Framework_Muste.pdf

¹⁰ *A beginner’s guide to uncertainty of measurement* (March 2001) issued by the National Physical Laboratory (NPL, UK): <http://www.npl.co.uk/publications/a-beginners-guide-to-uncertainty-in-measurement>

¹¹ Good practice guide – Flow measurement uncertainty and data reconciliation issued by the NEL, a former UK Government Laboratory: http://www.tuvel.com/~x90lbn/Flow_Measurement_Uncertainty_and_Data_Reconciliation.pdf

¹² *Addressing uncertainty in oil and natural gas industry greenhouse gas inventories* (February 2015) issued by the International Petroleum Industry Environmental Conservation Association (IPIECA) and the American Petroleum Institute (API): http://www.api.org/~media/Files/EHS/climate-change/Addressing_Uncertainty.pdf

In most cases, the calculation of emissions for a GHG is the product (multiplication) of a series of parameters e.g. activity data values and conversion factors. In this situation, the uncertainty of the emissions of GHG_i is calculated using Equation A below.

$$\text{Emission uncertainty of } GHG_i = \sqrt{\sum_i U_i^2} \text{ ---- Equation A}$$

Where U_i is the uncertainty of each parameter (i) in the emissions quantification calculation.

For example, the calculation of CO_2 emissions from a fuel combustion emission stream can be represented by the following equation:

$$CO_2 \text{ emissions} = \text{Fuel quantity} \times \text{Net Calorific Value (NCV)} \times CO_2 \text{ emission factor}$$

Therefore, the uncertainty of the calculated CO_2 emissions is:

$$\begin{aligned} &CO_2 \text{ emission uncertainty} \\ &= \sqrt{(\text{Uncertainty of quantity})^2 + (\text{Uncertainty of NCV})^2 + (\text{Uncertainty of } CO_2 \text{ emission factor})^2} \end{aligned}$$

If the emission stream calculation involves multiple GHGs, the aggregated uncertainty of the emission stream is calculated using Equation B below.

$$\text{Aggregated emission uncertainty} = \frac{\sqrt{\sum_i (U_i \times E_i)^2}}{\sum_i E_i} \text{ ---- Equation B}$$

Where U_i is the uncertainty of the GHG emissions for GHG_i
 E_i is the quantity of GHG emissions from GHG_i

Therefore, in the example of the fuel combustion emission stream where there are also CH_4 and N_2O emissions, the aggregated uncertainty of the emissions stream is:

$$\begin{aligned} &\text{Aggregated uncertainty} \\ &= \frac{\sqrt{(CO_2 \text{ uncertainty} \times CO_2 \text{ emissions})^2 + (CH_4 \text{ uncertainty} \times CH_4 \text{ emissions})^2 + (N_2O \text{ uncertainty} \times N_2O \text{ emissions})^2}}{CO_2 \text{ emissions} + CH_4 \text{ emissions} + N_2O \text{ emissions}} \end{aligned}$$

Equation B is also used to calculate the likely overall uncertainty for the facility's emission inventory. This requires the facility's forecast or estimate of the emissions from each emission stream. The estimated emissions do not need to be precise, as the uncertainty assessment is concerned with the relative quantity of the various emission streams to each other.

The nature of the square root of the sum of the squares formula in equations A and B is such that if one of the uncertainties in the equation A, or one of the products of uncertainty (in relation to the forecast emissions) in equation B is larger than the rest, that uncertainty will dominate the aggregated uncertainty.

3.3.5 Managing uncertainty

As explained in Section 3.3.2, there is no requirement for the facility to meet any uncertainty limit or threshold, or to reduce uncertainties. It is important to note that it is not fully possible to eliminate all sources of statistical uncertainty. For example, the carbon content of combustion fuels is likely to vary by nature. Nevertheless, managing uncertainties is key to ensuring data quality and accuracy.

The facility is encouraged to refer to the uncertainty assessment at the Tab **J. Summary** of the MP Template to identify the emission stream(s) that dominate the overall facility-level uncertainty (also refer to Section 5.7 for details of the MP Template Summary table). Some examples of how to reduce uncertainty are as follow:

- i) increase the tier for activity data measurement by ensuring that the instruments used for activity data are installed and maintained according to the manufacturer's recommendations or the metering standards detailed in Section 3.2.1 for Tier 4;
- ii) increase the tier for conversion factor analysis by adopting site-specific conversion factors (as opposed to using default conversion factors) or by increasing the frequency of sampling and analysis (moving up the conversion factor tiers); and
- iii) specifying a lower uncertainty within the tier i.e. adopting a more robust sampling and analysis regime in line with internationally accepted protocols or using an accredited laboratory for analysis. The facility could discuss the sampling process with the laboratory staff to ensure the use of suitable methods.

4. Quality Management Framework

4.1 Purpose

An effective Quality Management Framework (QMF) is crucial in ensuring data quality. Under the GHG M&R Regulations, the facility is required to develop, document, implement and maintain an appropriate QMF for the collection, computation, and reporting of GHG emissions data. As explained in Section 3.3.1, systematic biases or errors are assumed to be eliminated given the requirement for the facility to implement a QMF. The benefits of maintaining robust quality controls for the facility include:

- i) Reduced reputational risk arising from any material misstatement(s) or non-compliance(s) by having adequate quality controls;
- ii) Reduced costs, resources and effort required for internal or external verification processes through demonstration of the design and implementation effectiveness of controls;
- iii) More sustainable and efficient processes for reporting through improved control, documentation and clear accountability and delineation of responsibilities at corporate and site levels;
- iv) Improved inventory quality and data management, management oversight and understanding of the internal GHG emissions monitoring and measurement processes; and
- v) Documented procedures to mitigate the potential 'key person risk' by driving more consistent reporting over time even in the context of staff turnover.

The facility may have adopted internationally recognised quality management protocols for product quality control or environmental management; or implemented internal management controls and audit framework as required by your Corporation. These protocols can be adapted and used for the quality management of the facility's GHG measurement and reporting processes.

4.2 Underlying principles

In order to ensure the quality of data reported, the M&R requirements are based on five principles as defined in the **GHG Protocol**¹³:



The facility should adhere to these five principles when preparing its Monitoring Plan submission, performing measurements and monitoring, and preparing its annual Emissions Report.

¹³ *The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard (Revised Edition)* issued by the World Business Council for Sustainable Development and World Resources Institute.

Table 7: Key principles of GHG emissions measurement and reporting

Principle	Importance	Issues to be considered
Accuracy	The facility is responsible for ensuring that the information and data are accurate and credible to the degree that is achievable, using the emissions quantification methods and monitoring approach as outlined in the Monitoring Plan submission.	<ul style="list-style-type: none"> • Accurate measurement of activity data and other related parameters as specified in the Monitoring Plan submission • Formal procedures related to the management of metering equipment and analysis techniques required for reporting • Independent review of reported data by personnel with an understanding of the processes involved and parameters measured • Automated checks or review of data flow through the reporting process from data source to Emissions Report data entry • Use of higher tiers for measurement and analysis, thereby reducing uncertainty and improving accuracy
Completeness	<p>Completeness means that all emission sources within the scope of the M&R requirements are included.</p> <p>Incomplete reporting will lead to under-reporting of the facility's GHG emissions. For example, CH₄ and N₂O emissions from fuel combustion or flaring are often inadvertently excluded by the facility.</p>	<ul style="list-style-type: none"> • Comprehensive identification of emission sources and emission streams • Review of available methods to identify all applicable GHGs to be measured and reported
Consistency	<p>It is important to demonstrate the consistency of methods used to assess time series of emissions data. Change in methods/tiers to improve accuracy is encouraged, however, arbitrary changes of methods/tiers are not permitted.</p> <p>Thus, changes to the Monitoring Plan submission must also be reported in accordance with the GHG M&R Regulations. This includes changes to emissions quantification methods, emission sources and emission streams.</p>	<ul style="list-style-type: none"> • Clear and detailed Monitoring Plan submission linking emission streams to applicable on-site procedures • Adherence to requirements of the GHG M&R Regulations • Supporting documents are aligned with the MP Template, including the necessary references on how they relate to each other.
Relevance	Relevance means that the most material emission streams are identified to enable cost effective	<ul style="list-style-type: none"> • Application of higher tiers to the most material sources or those dominating

Principle	Importance	Issues to be considered
	<p>measurement and reporting. The uncertainty assessment in the MP Template helps the Corporation to focus the facility's attention on improving the relevant monitoring process to reduce uncertainty and potentially emissions.</p> <p>Relevance also means that all emissions quantification methods, steps and procedures are appropriate and representative of the facility's processes and operations.</p>	<p>the overall uncertainty of the facility's total emissions</p> <ul style="list-style-type: none"> • Application of site-specific conversion factors where there are metering and analyses in place, as opposed to using default factors provided by NEA.
Transparency	<p>Transparency means that all emission sources and streams, methods, and tiers used must be reported in a clear and factual manner. These shall also be made readily available to NEA or third-party verifiers for validation and verification purposes.</p> <p>A transparent Monitoring Plan submission will provide a clear understanding of the facility's measurement and reporting approaches, and on how the facility's Emissions Report would be prepared.</p>	<ul style="list-style-type: none"> • Clear description and presentation of information, supported with justifications • Clear documentation of the complete data flow, including steps on how the data would be gathered and processed, and the assumptions made • Provide a complete Monitoring Plan submission, including all supporting documents as identified in the MP Template

4.3 Elements of a Quality Management Framework

The facility is required to develop, document, implement and maintain a QMF containing the following elements. Examples of how these elements can be implemented, i.e. quality control (QC) activities, are briefly described below.

The facility is to submit to NEA an outline of its QMF describing its QC activities as part of its supporting documents for the Monitoring Plan submission (also refer to Section 2.1.2). In the outline, the planned/implemented QC activities should be described in relation to the different QMF elements, and in the facility's context. The facility could expand on the QMF elements in Table 8. During the course of emissions monitoring, the facility should also internally document the implementation of the QMF and QC activities to facilitate subsequent third-party verification of the Emissions Report.

Table 8: Elements of Quality Management Framework

Inventory development stages	QMF elements	Examples of QC activities
Inventory preparation and Management	Procedure to ensure that all emission sources and streams are reported in the MP Template	<ul style="list-style-type: none"> Establish and maintain a list of all processes and activities that result in GHG emissions occurring within the facility and under its operational control Identify emission sources and emission streams by checking through (i) the lists provided in the MP Template or (ii) external lists developed within the industry or by international guidelines/standards¹⁴ Check that knowledge and data gaps (e.g. novel processes where no emissions quantification methods have been established) that may result in incomplete emissions inventory are documented Confirm that all emission streams identified in the MP Template are measured and reported based on the approved Monitoring Plan submission.
	Procedure to determine that the selected GHG quantification methods are appropriate, including the approach to determine any site-specific conversion factors	<ul style="list-style-type: none"> Ensure that the justifications and assumptions for the selected emissions quantification methods, tiers are cited in the supporting documents Check the appropriate use of methods against international guidelines/standards and ensure that they result in robust accounting of GHG emissions Check the appropriate use of sampling and analysis techniques (ideally in accordance with international or standard practices to avoid bias and ensure that the samples obtained are representative).
	Quality assurance procedures to ensure that SOPs for maintaining and/or calibrating measurement instrument and IT tools are followed appropriately	<ul style="list-style-type: none"> Check that maintenance and calibration schedule and SOPs are adhered to Check that maintenance and calibration log is kept up-to-date Appoint appropriate personnel to maintain and update the quality assurance procedures
	Procedure to ensure no conflicts of interest between compilation/computation and counter-checking roles	<ul style="list-style-type: none"> Identify the various roles and the corresponding counter-checking roles, and check that there are no conflicting responsibilities or conflicts of interest among the allocated personnel/job titles Appoint authorised and independent employees to counter-check that calculations are complete and correct

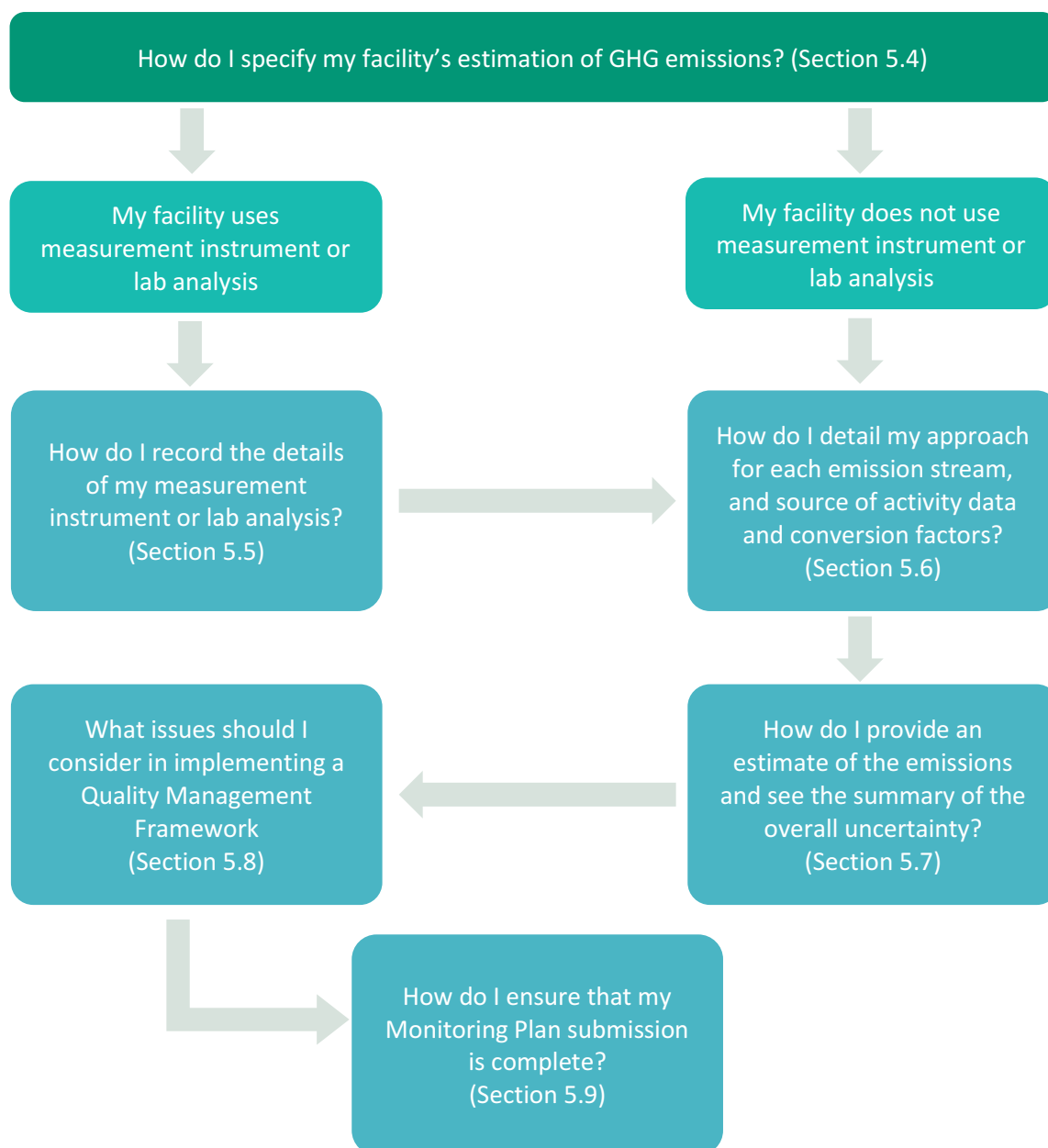
¹⁴ When identifying the emission source and/or emission stream from external lists developed within the industry or international guidelines/standards, if there are emission source and/or stream that is not explicitly included in the MP Template and Guidelines, the GHG Manager should report it under “Any other process of activity resulting in greenhouse gas emissions”.

Inventory development stages	QMF elements	Examples of QC activities
		<ul style="list-style-type: none"> Establish an internal audit team/committee to ensure proper governance and put in place necessary risk control measures.
Data gathering, input and handling	Procedures to ensure accurate collection and checking of activity data	<ul style="list-style-type: none"> Training of staff in measurement techniques, sampling procedures, etc. Confirm that data relationships and compilation are correctly represented as set out in data flow and processing diagrams Check that a sample of input data to confirm that movement of inventory data among processing steps are correct and is correctly transcribed between different intermediate calculations Maintain good records of measurement, calculations and any extra information that may be relevant (should past measurements be called into doubt) Check that data fields and units are properly labelled in calculation sheets
	Change management procedures to ensure proper documentation of updates to data collection and computation approaches	<ul style="list-style-type: none"> Check that version control procedures for electronic files have been implemented and are adequate Check that internal reporting processes are updated and that the changes in data management are documented and properly implemented
Data documentation, reporting and review	Procedure to check that data submitted in the Emissions Report is accurate, robust and complete	<ul style="list-style-type: none"> Confirm that the Emissions Report is consistent with the Monitoring Plan submission, including ensuring all emission streams identified in the MP Template are reported in the Emissions Report. Perform emissions trend analyses to check for anomalies Perform data comparisons where parallel systems are available, and material balances comparing inputs (invoices), outputs (end use measurement, production) and stock-change
	Procedure to review appropriateness of data compilation and computation	<ul style="list-style-type: none"> Review measurement approaches e.g. sampling and analysis frequency, calibration and maintenance schedule etc. Review measurement approaches based on new/updated international guidelines/standards

5. Completing the Monitoring Plan Template

This section details the step-by-step process for completing the MP Template.

Figure 5: Overview of the process for completing the MP Template



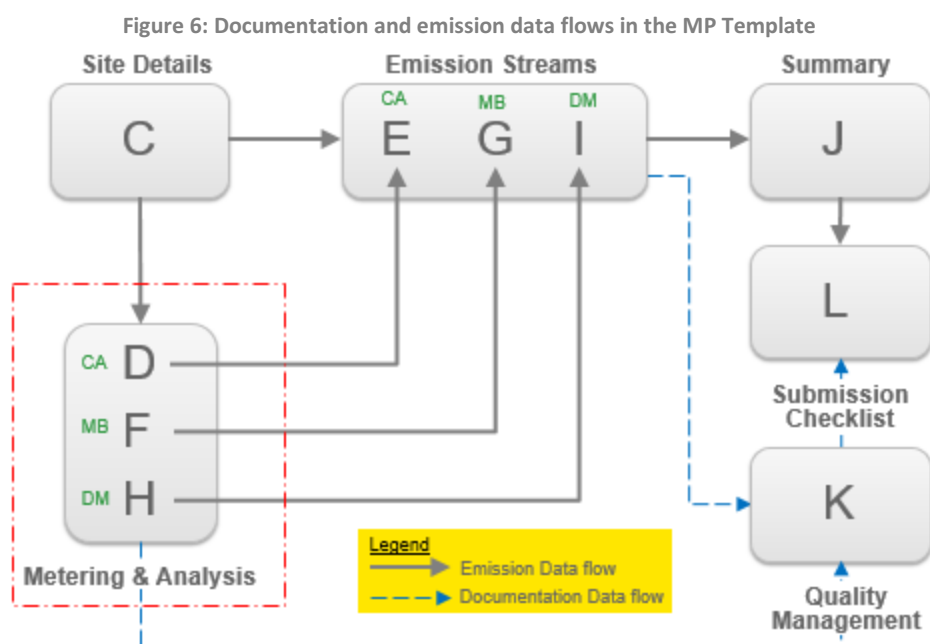
5.1 Structure of the Monitoring Plan Template

The Monitoring Plan Template ('MP Template') provided by NEA is a protected Microsoft Excel spreadsheet. The MP Template serves to:

- i) record details about the facility;
- ii) identify and specify GHG emission sources/streams (for both fuels combustion & IPPU emissions) at the facility;
- iii) identify and specify the measurement and reporting processes for the computation of GHG emissions;
- iv) declare the implementation of the key procedures in the Quality Management Framework; and
- v) declare the submission of supporting documents with the MP Template.

There are features incorporated within the MP Template to auto-populate the user input tables and forms based on the selections of the GHG Manager. The MP Template comprises several tabs that are easy to navigate using either the Contents page or the navigation area at the top of each tab.

The documentation flow between the tabs is shown in Figure 6 below:



An overview of the tabs in the MP Template is below:

- i) **'A. Contents'** – Contents of the MP Template.
- ii) **'B. Introduction'** - An introduction to the MP Template, the terminology used, the MP Template conventions and the MP Template overview.

- iii) **'C. Site Details'** – Records the Corporation information, facility information, the emission sources and streams in the facility, and the corresponding emissions quantification methods for each emission stream.
- iv) **Metering & Analysis** tabs – Each of the three emissions quantification method has a corresponding 'Metering & Analysis' tab: **'D. Calc Apch – Metering & Analysis'**, **'F. Mat Bal – Metering & Analysis'**, **'H. Direct – Metering & Analysis'**. These tabs record all activity data measurements and analysis process to derive each conversion factor. The 'Metering & Analysis' tab will remain blank if the facility does not use that particular emissions quantification method.
- v) **Emission Streams** tabs – Each of the three emissions quantification method has a corresponding 'Emission Streams' tab: **'E. Calc Apch – Emission Streams'**, **'G. Mat Bal – Emission Streams'**, **'I. Direct – Emission Streams'**. These tabs record the applicable data source of all activity data and all the conversion factors required to quantify GHG emissions for each emission stream. If an emissions quantification method is not required, the corresponding 'Emission Streams' tab will remain blank.
- vi) **'J. Summary'** – Displays a summary table of all emission streams. The GHG Manager must record an estimate of the emissions expected for each emission stream. The estimated emissions from each emission stream will be used to derive the overall uncertainty of the emissions to be reported in the Emissions Report.
- vii) **'K. Quality Management'** – Includes details on the Quality Management Framework developed for the measurement and reporting of GHG emissions.
- viii) **'L. Submission Checklist'** – Provides a summary table of documents that should be attached with the MP Template for the Monitoring Plan submission. The selections in the preceding tabs will generate a checklist that should be used to confirm that the attachments are included in the Monitoring Plan submission.

5.2 Tab A. Contents

Tab A. Contents contains the content page of the MP Template. There is a hyperlink to each section of the MP Template for easy navigation.

5.3 Tab B. Introduction

Tab B. Introduction contains an introduction to the MP Template, the terminology used, the MP Template conventions and the MP Template overview.

The MP Template cells are colour coded to allow the GHG Manager to identify the actions to be taken:

Section heading
Table heading
Dropdown selection

Section labels between major sections on a tab. Each section will have a hyperlink on the **Tab A. Contents**.

Table headers and footers

A user selection dropdown, where the GHG Manager selects one of the items in the dropdown selection. Flexibility is built in to allow the GHG Manager to select the blank, to turn the cell

into a user input cell (e.g. the emission stream type under fuel combustion in **Tab C. Site Details**)

User input	A text cell(s) to record text information or numeric data
✓	A user confirmation box. Double click the cell to display/hide the tick. Applicable to Tab L. Submission Checklist.
↑ ↓	A user control. Double click the cell to display/hide the instructions.
Protected formula	A protected formula cell that will display information or numerical data

5.4 Tab C. Site details

Tab **C. Site Details** records the Corporation information, facility information and all the emission sources and streams in the facility, and the corresponding emissions quantification methods for each emission stream.

5.4.1 Corporation information

Tab **C. Site Details** contains under the Corporation information section, a series of user entry cells for the Corporation and facility details. The GHG Manager is required to provide information on the (a) registered name of the Corporation, (b) unique entity number (UEN), (c) facility name and (d) the site address.

Figure 7: Corporate information entry form

1 Corporation information	
Please provide the same information as provided in the Emissions Data Monitoring and Analysis (EDMA) System.	
(a) Registered name of Corporation:	ABC Limited
(b) UEN:	T01230888
(c) Facility name (optional):	The ABC Refinery
(d) Site address:	DEF Building Street 8 Singapore 123098

5.4.2 Facility information

Under the facility information section, the GHG Manager is required to provide a description of the facility, its physical and operational boundaries, the location of each emission source within the facility and sufficient information for NEA to relate the description provided to the details in the **'Measurement & Analysis'** tabs and **'Emission Streams'** tabs.

An expanded user entry text cell is provided for the GHG Manager to provide a description of the facility, the facility's physical and operational boundaries, and overview of the facility's processes or activities resulting in GHG emissions in the user entry cell. The user entry cell only allows for text.

The description should be supported by an emission source diagram – which is an overall diagram(s) or map(s) showing the physical location of the processes or activities resulting in GHG emissions. The emission source diagram should be labelled with the internal identifiers in the MP Template for each

emission stream. A user entry cell is provided to specify a reference to the relevant Monitoring Plan submission supporting document (i.e. attachment title). The emission source diagram should be attached as part of the facility's Monitoring Plan submission. The emission source diagram should:

- i) Identify the facility's processes and activities that result in GHG emissions by labelling the emission sources and streams (consistent with the emission stream identifiers created by the MP Template); and
- ii) The physical location of relevant process plants or activities that generate GHG emissions.

The diagrams and descriptions are intended to provide additional context to the emission stream forms, to assist NEA in understanding the facility's measurement and reporting process.

5.4.3 Emission streams

As described in Section 2.2 of Part I of the Guidelines, the types of processes or activities resulting in GHG emissions are broadly categorised into (i) fuel combustion (i.e. energy use) and (ii) industrial processes and product use (IPPU) (i.e. non-energy use). The reporting of greenhouse gas emissions is at the emission-stream level. Under the Emission Streams section, the GHG Manager would have to specify each fuel combustion or IPPU emission stream in relation to its:

- i) Emission source: The source of fuel combustion emissions, or the relevant IPPU emission source;
- ii) Emission stream type: The type of fuel, sub-process type, product or feedstock type;
- iii) Emissions quantification method: The emissions quantification method to be used to quantify the resulting emissions, i.e. Method 1: Calculation Approach; Method 2: Material Balance or Method 3: Direct Measurement.

The rule of thumb is that each emission stream should have a unique (i) fuel type/IPPU emission source type, (ii) applicable emission stream type (e.g. sub-process type, GHG type), and (iii) emissions quantification method. If any of the parameter above is different, a separate emission stream should be created. For an integrated circuit or semiconductor production emission source, each emission stream is further differentiated by the type of greenhouse gas fed into the process.

For each emission source and its associated emission stream(s), the GHG Manager is required to provide an emission stream diagram linking the following components:

- i) Major equipment item(s) or system(s) representing the emission source and point(s) of emission release;
- ii) Fuel, feedstock or product flows; and
- iii) Measurement instrument(s), and measurement and sampling point(s). The measurement point descriptions should include the internal identifier/names as recorded on the '**Metering & Analysis**' tabs.

All components in the diagram(s) should be labelled by the facility, consistent with the emissions stream identifiers and internal identifiers/names in the MP Template, and be consistently used in other parts of the MP Template. For multiple emission sources, the GHG Manager is required to compile the diagram(s) into a document. A user entry cell is provided to specify a reference (i.e.

attachment title) to the relevant Monitoring Plan submission supporting documentation (i.e. attachment title). The emission stream diagram(s) should be attached as part of the facility's Monitoring Plan submission.

Based on the fuels, processes and emissions quantification method specified, the MP Template will automatically create an emission stream and populate the relevant **'Metering & Analysis'** tabs and/or **'Emission Streams'** tabs. Please ignore the relevant sub-section (3.1: Fuel Combustion or 3.2: Industrial Processes and Product Use) if non-applicable.

5.4.4 Fuel combustion

In this section, the GHG Manager is required to specify all fuel types that are combusted on site for the purpose of producing or providing energy. Non-energy uses, such as flaring (where there is no recovery of energy for energy uses), should be recorded in the "Industrial Process and Product Use" section (refer to section 5.4.5)

A blank fuel emission source type entry form is provided on the Tab **C. Site Details**. Additional entry forms can be added by selecting "Add a new row" under the 'Add emission stream' located below the form, as shown in Figure 8.

To remove an emission stream, first delete the 'Emissions quantification method' selection. This action will also automatically remove the Emission Stream form on the relevant **'Emission Stream'** tab. Then, select the 'Remove row option' at the right hand corner of the emission stream to remove the fuel emission source type entry form.

Figure 8: Adding a new fuel emission source type entry form

Figure 9 is an example of a fuel emission source type entry form (F1) for general diesel use on-site, using Method 1: Calculation Approach as its emissions quantification method.

Figure 9: Fuel emission source type entry form for general diesel use on-site (Method 1: Calculation Approach)

The fuel emission source type entry form contains:

- i) **A fuel stream identifier:** e.g. F1, F2, F3 in the blank MP Template. The fuel stream identifier is generated automatically by the MP Template, with a new sequential number added whenever a new row is added to the table. The fuel stream identifier and the selected emissions quantification method will define a unique emission stream identifier, e.g. CA_F1 for fuel stream F1 using Method 1: Calculation Approach or DM_F3 for fuel stream F3 using Method 3: Direct Measurement. This fuel stream identifier will be used throughout the MP Template.

- ii) Emission source: This is a free text cell requiring the GHG Manager to briefly describe the usage of the fuel (e.g. major equipment or system).
- iii) Emission stream type: The GHG Manager would be required to select the relevant fuel type combusted from the dropdown selection, or enter a specific fuel type if it is not found in the dropdown selection. For user-specified fuels, the MP Template would not have a default Tier 1 conversion factor and default uncertainty value.
- iv) Emissions quantification method: The GHG Manager would be required to select the emissions quantification method to be used for that particular emission stream from the dropdown selection. For fuel combustion, Method 2: Material Balance is not applicable and hence not available for selection.

Based on the emission stream type (fuel type) and emissions quantification method specified, the MP Template will automatically create an emission stream and populate the relevant '**Metering & Analysis**' tabs and '**Emission Streams**' tabs.

Example 1

When a GHG Manager selects Method 1: Calculation Approach for fuel stream F1, the MP Template will add a new emission stream entry CA_F1 in Tab **E. Calc Apch – Emission Streams**.

If the activity data or material property for the emission stream is obtained from any measurement instrument or material property analysis (either online or in a laboratory), the GHG Manager should record the details in Tab **D. Calc Apch – Metering & Analysis**.

The GHG Manager should then complete the emission stream form in Tab **E. Calc Apch – Emission Streams**.

Example 2

Method 3: Direct Measurement may not be suitable for all GHGs emitted from fuel combustion. For example, facility may be using Method 3: Direct Measurement for CO₂ emitted from fuel combustion of natural gas, but the small quantities of CH₄ and N₂O emitted may not be directly measurable.

In this situation, the MP Template assumes that when the facility uses Method 3: Direct Measurement for fuel combustion, CH₄ and N₂O emissions from fuel combustion will be computed based on Method 1: Calculation Approach, and will automatically create two emission streams within the MP Template:

- i) In Tab **I. Direct – Emission Streams** DM_F1
To allow the GHG Manager to specify the direct measurement of CO₂ emissions;
- ii) In Tab **E. Calc Apch – Emission Streams** CA_F1
To allow the GHG Manager to specify the calculation of CH₄ and N₂O emissions.

For the direct measurement of CO₂ emissions from the combustion of multiple fuels, there would be only one emission stream form created in Tab **I. Direct – Emissions Streams**. The MP Template allows for up to four monitoring points to be created in the emission stream form, where there is a distinct GHG concentration measurement data source and activity data measurement entry for each monitoring point. The MP Template will create a new emission stream for each fuel type in Tab **E. Calc Apch – Emission Streams** to record CH₄ and N₂O emissions arising from the combustion of each fuel type.

However, if the CH₄ and N₂O emissions are also directly measured, the facility is allowed to specify the GHG in the emission stream form in Tab **I. Direct – Emissions Streams**, and specify a site-specific value of 0 for CH₄ and N₂O emissions in Tab **E. Calc Apch – Emission Streams**.

The GHG Manager would be required to record details of the direct measurement of the exhaust stack flow and/or CO₂ concentration measurement, including any other GHGs measured, on Tab **H. Direct – Metering & Analysis**.

The GHG Manager would then complete the emission stream form for the fuel entry on Tab **I. Direct – Emission Streams** and Tab **E. Calc Apch – Emission Streams** as required.

If a fuel type has multiple end uses that are individually monitored, a fuel type entry could be recorded for each end use. However, if all of the end uses involve combustion of the same fuel type, and common default conversion factors or common material property analysis are to be used, the GHG Manager can create only one emission stream. The emission stream form allows multiple measurement approaches for fuel quantity to be recorded covering each fuel use, otherwise the fuel usage value based on the invoiced quantity can be used for reporting.

5.4.5 Industrial Processes and Product Use (IPPU)

The GHG Manager is required to specify all activities in the facility that generate GHG emissions by the applicable IPPU emission source type and sub-process type (i.e. industrial processes and activities that result in GHG emissions, from the use of GHGs in products and from non-energy uses of fossil fuel carbon). A blank IPPU emission source type entry form is provided in Tab **C. Site Details**.

Additional IPPU emission source type entry forms can also be added to the tab by selecting the “Add a new row” under the ‘Add emission stream’ located below the table. Refer to Figure 10.

To remove an emission stream, first delete the ‘Emissions quantification method’ selection. This action will also automatically remove the Emission Stream form on the relevant ‘**Emission Stream**’ tab. Then, select the ‘Remove row option’ at the right hand corner of the emission stream.

Figure 10: Adding a new IPPU emission source type entry form

3.2 Industrial processes and product use

Please record all industrial processes and product use (IPPU) emission sources, i.e., industrial processes and activities that result in GHG emissions, uses of GHGs in products and non-energy uses of fossil fuel carbon.

Emission sources under IPPU are automatically labelled with a process stream identifier, P1, P2, etc. It is automatically generated by the MP Template, with a new sequential number added whenever a new row is added to the table. The process stream identifier is incorporated into the applicable Emission Stream identifier on the Emission Streams tabs together with the selected emissions quantification method, e.g. MB_P1 for process stream entry P1 using the Material Balance method.

To remove an emission stream, first delete the Method selection. This action will also automatically remove the Emission Stream form on the Emission Streams tab for the specified method. Then, select the "Remove row option" at the right hand corner.

1. Under "Emission source", select the relevant the IPPU emission source. Please select "Any other process or activity resulting in GHG emissions" if none of the listed IPPU emission sources apply.
2. Under "Emission stream type", select the relevant sub-process type, product or feedstock type from the drop-down list.
3. Under "Method", select the applicable emissions quantification method from the drop-down list.

P1	Emission source: <input type="text"/>	Remove row option: <input type="button" value="Remove"/>
	Emission stream type: <input type="text"/>	

Add emission stream:

Figure 11 shows an IPPU emission source entry form describing the production of ethylene from the feedstock naphtha with emissions estimated using Method 2: Material Balance.

Figure 11: IPPU emission source entry form for production of ethylene (Method 2: Material Balance)

P1	Emission source: <input type="text" value="Ethylene production"/>	Remove row option: <input type="button" value="Remove"/>
	Emission stream type: <input type="text" value="Ethylene produced - Naphtha"/>	
	Emissions quantification method: <input type="text" value="Method 2: Material balance"/>	

Add emission stream:

The IPPU emission source type entry form contains:

- A process stream identifier:** e.g. P1, P2, P3 in the blank MP Template. The process stream identifier is generated automatically by the MP Template, with a new sequential number added whenever a new row is added to the table. The process stream identifier and the selected emissions quantification method will define a unique emission stream identifier, e.g. CA_P1 for process entry P1 using Method 1: Calculation Approach or MB_P2 for process entry P2 using Method 2: Material Balance. This process entry identifier will be used throughout the MP Template.
- Emission source:** The GHG Manager would be required to select the applicable IPPU emission source from the available dropdown selection. The dropdown selection is based on the individual process types available in the IPPU Emissions spreadsheet.¹⁵ Please select 'Any other process or activity resulting in GHG emissions' if none of the listed IPPU emission sources is applicable.
- Emission stream type:** The GHG Manager would be required to select the sub-process type, fuel, product or feedstock type from the dropdown selection.
- Emissions quantification method:** The GHG Manager would be required to select the emissions quantification method to be used for that particular emission stream from the dropdown selection.

Based on the emission source, emission stream type and emissions quantification method specified, the MP Template will automatically create an emission stream and populate the relevant '**Metering & Analysis**' and '**Emission Streams**' tabs.

¹⁵ The fugitive emissions process type has been disaggregated into Flares, Vents and Fugitives.

Example 3

When a GHG Manager selects Method 2: Material Balance* for process stream P1, the MP Template will add a new emission stream entry MB_P1 in the Tab **G. Mat Bal – Emission Streams**.

The GHG Manager should record the details of all applicable material flow measurements and carbon content analysis (either online or laboratory based analysis) in the Tab **F. Mat Bal – Metering & Analysis**.

The GHG Manager should then complete the emission stream form for the process entry in the Tab **G. Mat Bal – Emission Streams**.

**Note that Method 2: Material Balance can only be used to calculate CO₂ emissions. A number of IPPU emission sources that use the material balance (e.g. ethylene production) would also result in CH₄ emissions. The MP Template will assume that the CH₄ emissions will be calculated based on Method 1: Calculation Approach. The Method 2: Material Balance emission stream form will incorporate a section for the GHG Manager to specify the selection of an appropriate conversion factor and production activity data for an estimation of CH₄ emissions. The facility is not required to create a separate emission stream in the MP Template for the CH₄ emissions.*

In some situations, multiple process entries may be required for a particular sub-process type. An example of this situation is where a sub-process type uses multiple feedstocks (e.g. in the semiconductor and wafer fabrication industry where multiple fluorinated gases need to be used in etching).

Example 4

For the 'Integrated circuit or Semiconductor production' emission source, the emission stream is unique for each type of GHG. The GHG Manager would only be able to select the fluorinated gas in the relevant '**Emission Streams**' tab. Therefore, if the facility uses two fluorinated gas (e.g. CHF₃ and C₄F₆) in that particular emission stream type/process (e.g. plasma etching thin film), the GHG Manager would need to specify two emission streams in Tab **C. Site Details**.

- **CA_P1**
Emission source: Integrated circuit or Semiconductor production
Emission stream type: Plasma etching thin film
Emissions quantification method: Calculation Approach
- **CA_P2**
Emission source: Integrated circuit or Semiconductor production
Emission stream type: Plasma etching thin film
Emissions quantification method: Calculation Approach

Then, the GHG Manager would select the particular fluorinated gas in Tab **E. Calc Apch – Emission Streams**.

5.5 Tabs D, F, H. Metering and analysis

Each of the three emissions quantification methods has a corresponding '**Metering & Analysis**' tab (**D. Calc Apch – Metering & Analysis, F. Mat Bal – Metering & Analysis, H. Direct – Metering & Analysis**). These '**Metering & Analysis**' tabs record all (i) activity data metering information and (ii) conversion factor metering and analysis information. There is a table for the activity data measurement and two tables for conversion factors – one for on-site metering and analysis (e.g. gas chromatograph), and another for sampling and offline laboratory analysis.

5.5.1 Summary of emission streams

A summary of the emission streams using the particular emissions quantification method will be displayed at the top of the relevant '**Metering & Analysis**' tab. Figure 12 is an example of a summary of all emission streams that are using Method 1: Calculation Approach emissions quantification method.

Figure 12: Summary of emission streams using Method 1: Calculation Approach

1 Summary of emission streams using Calculation approach		
Emissions stream	Emissions source	Emissions stream type
CA_F1	General site use	Natural Gas
CA_F2	Site diesel use	Gas/Diesel Oil

5.5.2 Activity data – Metering information

An activity data value is required for every emission stream, and can be in the form of the quantity of fuel combusted or quantity of a product produced from a particular sub-process. If Tier 1: Engineering estimate, Tier 2: Measurement or Tier 4: Accurate Measurement is used for the quantification of activity data, the metering information of the activity data for the particular emission stream should be filled in the applicable '**Metering & Analysis**' tabs. Tier 3: Invoice can be selected in the applicable '**Emission Streams**' tabs, and an entry need not be created in the '**Metering & Analysis**' tab, unless the GHG Manager would like to enter a site-specific uncertainty value (refer to Figure 13 and Example 6 below). Additional rows can be added to the table. In general, if two measurement instruments are of the same type and calibrated based on the same procedures, only one entry is required to be specified in the applicable '**Metering & Analysis**' tabs.

Where a fuel is received at a facility with no storage on-site and used for two or more purposes with different measurement and reporting processes, the total use of the fuel should be aligned to the invoiced quantity. Any on-site metering of use should be used to apportion the invoiced quantity for reporting purposes.

Figure 13 shows six entries for three fuel combustion (F1, F2 and F3) and two IPPU emission source types (P1, P2 and P3). In this example, the electromagnetic flowmeter for P1 is used to capture a metering system (comprising more than one meters) and a user-specified instrument type has been recorded (widget counter). The default uncertainty for invoices can be overwritten by the creation of an activity data entry specifying Tier 3.

Figure 13: Activity data - Metering information entry table

Relevant emission stream(s)	Internal identifier/name	Type of measurement instrument or technique	Tier	Default uncertainty (±%)	Site-specific uncertainty (±%)	Management procedure name	Remove row options
F1	FL101-11 Diesel to engines	Vortex Flow Meter	2 - Measurement	4.0%		P101 Flow metering procedures	
F2	FL104-14 Natural gas to plant	Coriolis Flowmeter	4 - Accurate Measurement	1.0%		P101 Flow metering procedures	
P1	FL System 201-10 Ethylene flow	Electromagnetic Flowmeter	4 - Accurate Measurement	0.5%		P102 Production metering	
P2	Gas flow to flare	Engineering estimate	1 - Engineering estimate	10.0%	5.0%	P311 Flare Management	
P3	Count of widgets	Widget counter	2 - Measurement		2.0%	P 200 Widget production	
F3	Purchased natural gas Meter 1	Invoice	3 - Invoice	1.5%	0.5%	Singapore gas metering code	

Add additional rows option:

The GHG Manager is required to specify the following information for the relevant columns:

- Relevant emission stream(s):** The GHG Manager is required to link the measurement instrument or technique to the relevant emission stream(s). A particular measurement instrument or technique can be used for more than one emission stream(s). The GHG Manager can enter F1, F2 into the relevant emission stream(s) column to signify that the particular measurement instrument is being used for more than one emission stream(s).
- Internal identifier/name:** The GHG Manager is required to enter the internal identifier/name of the measurement instrument or technique in the text entry cell. The internal identifier/name recorded will be added to the activity data dropdown selection displayed on the relevant '**Emission Stream**' tabs. The GHG Manager is required to also include the internal identifier in the emission stream diagram(s) to be submitted in Tab **C. Site Details**. Each entry made in the 'internal identifier/name' column will generate a new instrument entry on Tab **L. Submission Checklist**. Invalid entries due to incorrect spelling or any other entry error can be updated. However, the invalid entry (cell highlighted in yellow) will need to be removed manually from Tab **L. Submission Checklist**.
- Type of measurement instrument or technique:** The GHG Manager is required to pick from the dropdown selection the measurement instrument or technique (i.e. engineering estimate) that is being used to measure the activity data. If the type of measurement instrument cannot be found in the dropdown selection, the GHG Manager would be able to enter the type of measurement instrument in the text entry cell and enter a site-specific uncertainty for the measurement instrument.
- Tier:** The GHG Manager must select one of the four activity data tier from the dropdown selection. If 'Engineering estimate' or 'Invoice' is selected as the measurement instrument/technique type, the Tier must be set to '1 - Engineering estimate' and '3 - Invoice' respectively. Any other selection will be colour coded as invalid (text will be formatted red). There is a default option for invoices under 'activity data measurement' in the Emission Stream tabs. The GHG Manager should only create an entry for invoices in the Metering & Analysis tabs (Tabs D, F, H) should the facility wish to overwrite the default uncertainty of 1.5%.

Example 5

The facility is encouraged to maintain its meters in accordance to Tier 4: Accurate Measurement. If the measurement instrument is maintained in accordance to Tier 4: Accurate Measurement: where the measurement instrument is well maintained, calibrated and serviced as defined in Section 3.2.1, the GHG Manager should select Tier 4: Accurate Measurement. Otherwise, the GHG Manager should select Tier 2: Measurement.

When choosing Tier 4: Accurate Measurement, the GHG Manager is required to provide supporting documents in the Monitoring Plan submission to justify how Tier 4 is achieved, including:

- i) A description of the measurement approach;
- ii) Reference to the applicable manufacturer documents or standards applied; and
- iii) Justification for the site-specific uncertainty (if any).

- v) Default uncertainty: When the GHG Manager selects an instrument type from the dropdown selection, the respective default uncertainty value is displayed. Refer to the Appendix for full list of default uncertainty values and references.
- vi) Site-specific uncertainty: The GHG Manager can key in a site-specific uncertainty value to overwrite the default uncertainty values. For user-specified instrument type, the GHG Manager must provide a site-specific uncertainty value as there is no default value provided. The site-specific uncertainty value will overwrite the default uncertainty value when the instrument ID is specified on the relevant '**Emission Streams**' tabs. The GHG Manager is required to provide supporting information on how the site-specific uncertainty values were derived as part of the Monitoring Plan submission.

Example 6

Only if the GHG Manager wants to provide a site-specific uncertainty value for invoice data (e.g. if the supplier can provide a site-specific uncertainty value or the uncertainty value is specified on the invoice etc.), the GHG Manager should select the following:

- i) Type of measurement instrument or technique column: **Invoice** and;
- ii) Tier column: **Tier 3: Invoice**.

Otherwise, an entry need not be created for Tier 3: Invoice in the '**Metering & Analysis**' tab.

- vii) Management procedure name¹⁶: The GHG Manager should provide a reference or name for any applicable on-site procedure(s) that are used to maintain the accuracy of the measurement instrument. When a new entry is recorded, an entry is auto populated in Tab **K. Quality Management**. This allows the GHG Manager to select the same site procedure(s) name entry from the dropdown selection in the later rows. The management procedure is not required to be submitted as part of the supporting documents. Invalid entries due to incorrect spelling or any other entry error can be updated. However, the invalid entry will need to be removed manually from Tab **K. Quality Management**.

¹⁶ There may not be a management procedure for engineering estimates, for example when there are no measurement instruments involved.

For each measurement instrument or technique, the Monitoring Plan submission must include supporting documents containing details on the following:

- i) For Tier 1: Engineering estimate¹⁷, Tier 2: Measurement and Tier 4: Accurate Measurement, an alternative approach (i.e. procedure for estimating the activity data quantity if the data is lost or an error occurs in the case of an instrument error or failure. Refer to Section 3.2.3 for details on alternative approach;
- ii) For Tier 1: Engineering estimate, details on how the activity data value is derived, including assumptions and use of any other relevant activity data;
- iii) Justification for the use of Tier 4: Accurate Measurement or Tier 1: Engineering estimate; and
- iv) Justification for any site-specific uncertainty.

5.5.3 Conversion factors – Metering & Analysis information

Conversion factors (e.g. net calorific value (NCV) of a fuel combusted or the carbon content of a process input or product) are required for almost all emission streams. This section is for any on-site measurement to derive a site-specific conversion factor. If a measurement instrument is to be used to derive a site-specific conversion factor, an entry must be made in the metering and analysis information table of the applicable **‘Metering & Analysis’** tabs. In general, if two measurement instruments are of the same type, measures the same conversion factor, and calibrated based on the same procedures, only one entry is required to be specified in the applicable **‘Metering & Analysis’** tabs.

Figure 14 shows two entries for fuel stream F1. In this example, a gas chromatograph is used to measure NCV and carbon content for the calculation of CO₂ emission factor.

Figure 14: Conversion factors - Metering & Analysis information table

Relevant emission stream(s)	Internal identifier/name	Type of measurement instrument	Conversion factor	Default uncertainty (+/-%)	Site-specific uncertainty (+/-%)	Management procedure name	Remove row options
F1	AN 201 Gas chrom - Energy	Gas chromatograph	Energy Content	1.0%		Site metering management	
F1	AN 201 Gas chrom - Carbon	Gas chromatograph	Composition - Carbon content	1.0%		Site metering management	

Add additional rows option:

The GHG Manager is required to specify the following information for the relevant columns:

- i) Relevant emission stream(s): The GHG Manager is required to link the measurement instrument to the relevant emission stream(s). A particular measurement instrument can be used for more than one emission stream(s). The GHG Manager can enter F1, F2 into the relevant emission stream(s) column to signify that the particular measurement instrument is being used on more than one emission stream(s).
- ii) Internal identifier/name: The GHG Manager is required to enter the internal identifier of the measurement instrument in the text entry. The internal identifier/name recorded and the conversion factor specified will be added to the conversion factor dropdown selection

¹⁷ An engineering estimate will require an alternative approach if it is based on any actual measurement data (i.e. production or feed etc.)

displayed on the relevant '**Emission Streams**' tabs. The GHG Manager is required to also include the internal identifier in the emission stream diagram(s) to be submitted in Tab **C. Site Details**. Each entry made in the 'Internal identifier/name' column will generate a new measurement instrument entry on Tab **L. Submission Checklist**. Invalid entries due to incorrect spelling or other entry error can be updated, however the invalid entry (cell highlighted in yellow) will need to be removed manually from Tab **L. Submission Checklist**.

- iii) Type of measurement instrument: The GHG Manager is required to pick from the dropdown selection for the instrument that is used to measure the activity (e.g. flow rate), used to derive the conversion factor. A dropdown selection of typical instrument types is provided. If the type of measurement instrument cannot be found in the dropdown selection, the GHG Manager would be able to enter the type of measurement instrument in the text entry cell.
- iv) Conversion factor: The GHG Manager is required to pick from the dropdown selection for the conversion factor parameter being measured. A series of conversion factors parameters are provided. If the type of conversion factor parameter cannot be found in the dropdown list, the GHG Manager can enter a different conversion factor parameter.

Example 7

A particular measurement instrument can be used to derive more than one type of conversion factor. An entry is required for each conversion factor parameter being measured. If the particular measurement instrument is used to measure the NCV and the carbon content, the GHG Manager would need to fill in the particular analyser twice, i.e. one entry for each conversion factor parameter.

A site-specific conversion factor may be derived from more than one measurement instruments. In this scenario, the facility can specify one entry for the group/system of measurement instruments, and provide an aggregated site-specific uncertainty value. Supporting information to explain how the conversion factor is derived from the group/system of measurement instruments will need to be provided.

- viii) Default uncertainty: When the GHG Manager selects a measurement instrument type from the dropdown selection, the respective default uncertainty value is displayed. Refer to the Appendix for full list of default uncertainty values and references.
- v) Site-specific uncertainty: The GHG Manager can key in a site-specific uncertainty value. The GHG Manager must provide a site-specific uncertainty value if a user-specified measurement instrument and/or conversion factor parameter is recorded. The site-specific uncertainty value will overwrite the default uncertainty value when the instrument internal identifier/name is specified on the relevant '**Emission Streams**' tab. The GHG Manager is required to provide supporting information on how the site-specific uncertainty values were derived as part of the Monitoring Plan submission.

The site-specific uncertainty value should assume a continuous measurement process. The uncertainty value (both default and site-specific) will be scaled in the relevant '**Emission Stream**' tab depending on the tier selected based on:

- a) Tier 2 – analysis done less frequently than once a year, x3 (tripled of Tier 4: Representative);

- b) Tier 3 – analysis done once every year or more frequent, x2 (doubled of Tier 4: Representative); or
 - c) Tier 4 – representative, no change.
- vi) **Management procedure name:** The GHG Manager should provide a reference or name for any applicable on-site procedure(s) that are used to manage accuracy of the measurement instrument. When a new entry is recorded, an entry is auto populated in Tab **K. Quality Management**. This allows the GHG Manager to select the same site procedure(s) name entry from the dropdown selection in the later rows. The management procedure is not required to be submitted as part of the supporting documents. NEA may however call upon the facility to produce evidence of the management procedure during the validation of the MP. Invalid entries due to incorrect spelling or any other entry error can be updated. However, the invalid entry will need to be removed manually from Tab **K. Quality Management**.

For each measurement instrument, the Monitoring Plan submission must include supporting documents containing details on the following:

- i) Alternative approach (i.e. procedure for estimating the conversion factor if the data is lost, or an error occurs in the case of instrument error or failure) (refer to Section 3.2.3);
- ii) Conversion factor formulation and explanation for the planned sampling frequency (if relevant); and
- iii) Justification for any site-specific uncertainty.

5.5.4 Conversion factors – Laboratory analysis information

Conversion factors (e.g. NCV of a fuel combusted or the carbon content of a process input for the product), are required for almost all emission streams. This section is for laboratory analyses that are used to derive a site-specific conversion factor, e.g. carbon content. If laboratory analysis is used to derive a site-specific conversion factor, an entry must be made in the laboratory analysis information table of the applicable **'Metering & Analysis'** tabs.

Figure 15 shows two entries for fuel streams F1 and F2. In this example, a laboratory is providing NCV and carbon content for the calculation of CO₂ emission factor. The laboratory is used to provide material property data for two fuel types. Only one entry is required to specify the analysis process for multiple fuels.

Figure 15: Conversion factors - Laboratory analysis information table

Relevant emission stream(s)	Internal identifier/name	Laboratory name	Conversion factor	Default uncertainty (+/-%)	Site-specific uncertainty (+/-%)	Management procedure name	Remove row options
F1, F2	Fuel sampling	Viswa Lab	Energy Content	1.0%		P 301 Fuel property sampling	
F1, F2	Fuel sampling	Viswa Lab	Composition - Carbon content	1.0%		P 301 Fuel property sampling	

Add additional rows option:

The GHG Manager is required to specify the following information for each entry:

- i) **Relevant emission stream(s):** The GHG Manager is required to link the laboratory analysis to the relevant emission stream(s). A particular laboratory analysis can be used for more than

one emission stream. The GHG Manager can enter F1, F2 into the relevant emission stream(s) column to signify that the particular laboratory analysis is used on more than one emission stream.

- ii) Internal identifier/name: The GHG Manager is required to enter the internal identifier of the laboratory analysis in the text entry. The internal identifier/name recorded will be appended and added to the conversion factor dropdown selection displayed on the relevant '**Emission Streams**' tabs. The GHG Manager is required to also include the internal identifier in the emission stream diagram(s) to be submitted in **Tab C. Site Details**. Each entry made in the 'Internal identifier/name' column will generate a new instrument entry on **Tab L. Submission Checklist**. Invalid entries (cell will be highlighted in yellow) due to incorrect spelling or other entry error can be updated, however the invalid entry will need to be removed manually from **Tab L. Submission Checklist**.
- iii) Laboratory name: The GHG Manager is required to specify the laboratory that does/will be doing the analysis. If more than one laboratory is used, the GHG Manager should list each laboratory.
- iv) Conversion factor: This is a description of the conversion factor parameter being measured. A series of conversion factors parameters are provided. If the type of conversion factor parameter cannot be found in the dropdown selection, the GHG Manager can enter a different conversion factor parameter.
- v) Default uncertainty: When the GHG Manager selects a conversion factor parameter from the dropdown selection, the respective default uncertainty value is displayed. Refer to the Appendix for full list of default uncertainty values and references.
- vi) Site-specific uncertainty: The GHG Manager can provide a site-specific uncertainty value. The GHG Manager must provide a laboratory specific uncertainty value if a user-specified conversion factor parameter is recorded. The site-specific uncertainty value will overwrite the default uncertainty value when the laboratory internal identifier/name is specified on the relevant '**Emission Streams**' tabs. The GHG Manager is required to provide supporting information on how the site-specific uncertainty values were derived as part of the Monitoring Plan submission.

The site-specific uncertainty value should assume a representative measurement process. The uncertainty value (both default and site-specific) will be scaled in the relevant '**Emission Streams**' tab depending on the tier selected based on:

- Tier 2 – analysis done less than once a year, x3 (tripled of Tier 4: Representative);
 - Tier 3 – analysis done once every year or more frequent, x2 (doubled of Tier 4 - Representative); or
 - Tier 4 – representative, no change.
- vii) Management procedure name: The GHG Manager should provide a reference or name to any applicable on-site procedures that are used to manage the sampling process to maintain the representativeness of the sample. When a new entry is recorded, an entry is also made on **Tab K. Quality Management**. This allows the GHG Manager to select the same entry in the drop-down list in later rows. The management procedure is not required to be submitted as part of the supporting documents. NEA may however call upon the facility to produce evidence of the management procedure during the validation of the MP. Invalid entries due to incorrect

spelling or any other entry error can be updated. However, the invalid entry will need to be removed manually from Tab **K. Quality Management**.

The Monitoring Plan submission must be accompanied by supporting information for each laboratory derived conversion factor specified. Tab **L. Submission Checklist** displays a checklist table for each laboratory entry showing what additional information is required including:

- i) Alternative approach (i.e. procedure for estimating the conversion factor if the data is lost or an error occurs in the sampling or analysis process) Refer to Section 3.2.3 for details on alternative approach;
- ii) Conversion factor formulation and explanation for the planned sampling frequency;
- iii) Justification for any site-specific uncertainty;
- iv) Details of the test conducted by the laboratory and any applicable standards used; and
- v) Any applicable accreditation held by the laboratory. This could include any general laboratory accreditations for data quality management and accreditation specific for the tests to be conducted.

A list is maintained on Tab **K. Quality Management** of all procedures recorded in the MP Template used to maintain the accuracy of metering systems. Once recorded, the reference is available in the dropdown selection in the **'Metering & Analysis'** tab tables.

5.6 Tabs E, G, I. Emission streams

5.6.1 Summary of emission streams

Each **'Emission Streams'** tab contains a summary table of the emission streams using the particular emissions quantification method. This is provided to prompt/remind the GHG Manager on the emission streams required to be covered under the respective **'Emission Streams'** tab.

Figure 16: Summary of emission streams

1 Summary of emission streams using Calculation approach		
Emissions stream	Emissions source	Emissions stream type
CA_F1	General site use	Natural Gas
CA_F2	Site diesel use	Gas/Diesel Oil

Each of the three emissions quantification methods has an **'Emission Streams'** tab that is used to record the sources of all activity data and conversion factors required to quantify GHG emissions for each emission stream using the applicable method.

The emission stream forms are added to the **'Emission Streams'** tabs in the order that the method is specified on Tab **C. Site Details** tab. If a method is changed on Tab **C. Site Details** tab, the emission stream is removed from the original **'Emission Streams'** tab and then added to the new **'Emission Streams'** tab corresponding to the new method. The new emission stream will be added at the bottom of the group of forms.

5.6.2 Emission stream forms

Regardless of the selected emission stream type and emissions quantification method, each emission stream form contains the following common elements:

Emission stream form header

Each emission stream form will include a header identifying the emission stream. Figure 17 shows the header of the Method 1: Calculation Approach emission stream form.

Figure 17: Emission stream form header

CA_F1		Emission source: General site use
		Emission stream type: Natural Gas
(a)	GHG quantification approach description:	
	Natural gas has one delivery point metered by our supplier. Monthly invoice data is used to report the quantity. Our supplier has provided a set of average energy content (NCV) and carbon content that we have converted to a CO2 emission factor. Default emission factors are used for CH4 and N2O.	
(b)	Additional attachment to elaborate on the GHG quantification approach:	
	Yes	
	Document reference/name: GHG emission reporting basis of preparation	

The content of an emission stream form header includes:

- i) Emission stream identifier: Each emission stream is labelled with a unique identifier based on the fuel (e.g. F1) or process stream identifier (e.g. P.1) and the selected emissions quantification method based on the following format. The emission stream identifier is auto-populated based on the information recorded in Tab C. **Site Details**.
 - Method 1: Calculation Approach: CA_F#
 - Method 2: Material Balance: MB_P#
 - Method 3: Direct Measurement: DM_P#.
- ii) Emission source: This is the fuel combustion or IPPU emission source earlier identified in Tab C. **Site Details**.
- iii) Emission stream type: This is the fuel combustion or IPPU emission stream type earlier identified in Tab C. **Site Details**.
- iv) GHG quantification approach description: The GHG Manager is required to provide a concise description of the overall approach used to compute the GHG emissions for that particular emission stream. In order to describe the approach in full, the GHG Manager is encouraged to provide a detailed description in a separate document. The Monitoring Plan submission should:
 - a. Set out every method, step and procedure (including calculation formulae), to be used to compute GHG emissions for each emission stream;
 - b. Substantiate the methods, steps and procedures based on technical and scientific considerations, making reference to any protocol, standard or guidelines; and
 - c. Identify all activity data required for, and conversion factors to be adopted in any emissions quantification method.

- v) Additional attachment to elaborate on the GHG quantification approach: The GHG Manager is encouraged to provide the detailed GHG quantification approach description in a separate document. A dropdown selection is provided for the GHG Manager to select “Yes” and confirm that a more detailed description is included in the submission. A document reference/name should be recorded.

Activity data details

Almost all emissions quantification methods require one or more activity data values that represent a material quantity. A typical activity data details section is shown in Figure 18.

Figure 18: Activity data details section

Activity data measurement:	Tier:	Uncertainty:
FL 201 natural gas to Plant A	2 - Measurement	4.0%
Vortex Flow Meter		

Options to manage activity data entries: [Green Button]

Overall Activity data uncertainty: 4.00%

The contents of the activity data details section include:

- i) Activity data measurement: Select the appropriate source of the activity data from a dropdown list. The options will include:
 - Invoice – When the material is obtained commercially, the quantity delivered during the reporting period is recorded by invoices or related documents used for reporting.
 - Internal identifier/name of activity data measurement instruments and engineering estimates as specified in the ‘**Metering & Analysis**’ tabs. The measurement instrument type will be displayed automatically below the internal identifier/name.
- ii) Activity data tier: The activity data tier is displayed automatically based on selection of the source of the activity data. The activity data tier will correspond to the activity data measurement instrument and metering tier as specified on the ‘**Metering & Analysis**’ tab.
- iii) Uncertainty of the activity data measurement process: The uncertainty of the activity data measurement process is displayed automatically. The uncertainty displayed is either the default, or the site-specific uncertainty for the selected activity data measurement instrument.
- iv) Overall activity data uncertainty: This is the aggregated uncertainty of the activity data measurements across the one or more measurement instruments specified.

Options to manage activity data entries

The activity data of an emission stream may have more than one activity data measurement/source. The facility is allowed to add/remove additional activity data measurement using the dropdown selection labelled ‘Options to manage activity data entries’ as shown in Figure 18.

The dropdown selection cell has the following options:

- i) ‘Add new activity data entry’ – adds additional activity data measurement instruments to the activity data details section. The MP Template caters for up to eight individual activity data measurement instruments for Method 1: Calculation Approach, and up to four activity data

measurement instruments for Method 2: Material Balance and Method 3: Direct Measurement.

- ii) 'Remove blank activity data entry' – removes any redundant activity data measurement instrument that is blank (have no activity data source selected).

For cases where the number of activity data measurement instruments exceeds the maximum number (i.e. 8) allowed in the MP Template, the facility can create an aggregated metering system in the relevant 'Metering & Analysis' tabs, and specify the site-specific uncertainty value for the aggregated metering system.

When more than one activity data measurement is specified, the following additional information is required:

- i) Active from: This is the date from which the activity data measurement selected is active for the measurement of the activity data value. By default, all activity data measurements are specified as active from 01-Jan-19, which is the start of the first reporting period. If a new activity data measurement is added, the first day of operation of the measurement should be entered.
- ii) Active to: This can be used to inform an upcoming change in the activity data measurement, for example where an existing activity data measurement will no longer be used from the specified date. If there is no anticipated end use date for the activity data entry, the cell can be left blank (i.e. open ended).
- iii) Proportion: This should be used to apportion the anticipated quantity of the activity data value being measured (e.g. fuel use or production) between the individual activity data entries. This allows an overall activity data uncertainty to be calculated. The proportion is a forecast and is only expected to be an estimate. The uncertainty calculation for multiple activity data entries assumes that the different entries are operating in parallel i.e. simultaneously.

Figure 19 shows an example where a plant has two measurement instrument measuring natural gas flow. One measurement instrument is to be replaced with a more accurate measurement instrument at the end of June. An 'Active to' date has been entered for the meter being replaced and the same date entered for the 'Active from' date for the replacement meter. The proportion of flow from each measurement instrument is assumed to be the same at 50:50.

Figure 19: Multiple activity data measurement entries

Options to manage activity data entries:						
Activity data measurement:	Tier:	Uncertainty:	Active from	Active to	Proportion	
FL 201 natural gas flow Vortex Flow Meter	2 - Measurement	4.0%	01-Jan-19	30-Jun-19	50.00	
Activity data measurement:	Tier:	Uncertainty:	Active from	Active to	Proportion	
FL 202 natural gas flow Coriolis Flowmeter	4 - Accurate Measurement	1.0%	30-Jun-19		50.00	
Overall Activity data uncertainty:						2.06%

Conversion factor details

Almost all emissions quantification methods require one or more conversion factors that represent a material property, emission factor or process characteristic. Figure 20 shows four conversion factors relevant to fuel combustion. In this example, a measurement instrument is used to calculate the site-

specific CO₂ emission factor and a Tier 1 site-specific conversion factor for NCV is indicated. The default emission factors for CH₄ and N₂O emissions are also selected.

Under “data source”, the selection of the appropriate source of the conversion factor from a dropdown selection will trigger conditional formatting, creating the appropriate data entry fields. The options are:

- i) Default – Tier 1 default conversion factors according to the 2006 IPCC Guidelines.
- ii) Site-specific – a Tier 1 site-specific conversion factor in which the facility locks in a pre-determined site-specific conversion factor in the MP Template (refer below for more information).
- iii) Internal identifier/name of conversion factor measurement instruments or laboratory analysis as specified on the ‘**Metering & Analysis**’ tabs. The facility is then required to select the planned frequency of analysis i.e. Tiers 2, 3 or 4.

Figure 20: Conversion factor details sections

Conversion factor:	Energy Content	Data source:	Site-specific	Energy Content Conversion Factor:	33.70	GJ/tonne	Site-specific uncertainty (+/- %):	1.0%
Benchmark/justification document reference/name:	Supplier X - Natural gas properties							
Uncertainty:	1.0%							

Conversion factor:	Carbon dioxide	Emission factor	Data source:	AN 201 Gas chrom - Carbon - Composition - Carbon content				
Frequency of analysis:	4 - Representative							
Uncertainty:	1.0%							

Conversion factor:	Methane	Emission factor	Data source:	Default				
Uncertainty:	50.0%							

Conversion factor:	Nitrous oxide	Emission factor	Data source:	Default				
Uncertainty:	50.0%							

Uncertainty Assessment	Emission stream uncertainty:	1.4%						
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Site-specific conversion factors

Although NEA provides default conversion factors whenever available, the GHG Manager is able to choose and substantiate site-specific conversion factors. The site-specific conversion factors may be sourced from (i) reputable literature, industry guidelines, HQ’s guidelines and reports, historical analysis and measurements (conversion factor Tier 1), or based on (ii) sampling and analysis (conversion factor Tiers 2, 3 or 4).

Figure 21: Site-specific conversion factors

Conversion factor:	Energy Content	Data source:	Site-specific	Energy Content Conversion Factor:	33.70	GJ/tonne	Site-specific uncertainty (+/- %):	1.0%
Justification document reference/name:	Supplier X - Natural gas properties							
Uncertainty:	1.0%							

Figure 21 shows that the GHG Manager selects the Tier 1 site-specific option as the data source. The GHG Manager should only select the site-specific option if the facility would like to lock in a pre-determined site-specific conversion factor in the MP Template (i.e. the conversion factor will be used for several reporting periods or is unlikely to change in the future). Refer to Section 3.2.2 for more information. The form will automatically request the following information:

- i) Conversion factor: The GHG Manager should record the proposed value and its units. The proposed conversion factor will be subjected to NEA's approval.
- ii) Site-specific uncertainty: When available, the GHG Manager is encouraged to specify the site-specific uncertainty for the conversion factor.
- iii) Justification document reference/name: The GHG Manager is required to specify the document reference/name to be submitted with the Monitoring Plan submission to justify the site-specific value.

Emission stream uncertainty

The MP Template will auto-compute the overall uncertainty each emission stream based on the relevant conversion factor and activity data uncertainties for that emission stream.

In Figure 19, the uncertainty of each activity data measurement and the overall assessment for activity data are shown. These are aggregated by applying Equation B (refer to Section 3.3.4) to each meter's uncertainty and proportion of flow.

Figure 20 shows the uncertainty of each conversion factor. Equation A (refer to Section 3.3.4) is applied to the overall activity data uncertainty, NCV and each emission factor, to calculate the uncertainty of the CO₂, CH₄ and N₂O emissions respectively.

Equation B is then used to calculate the overall uncertainty of the emission stream (refer to Figure 20) by aggregating each GHG based on default emission factors.

The overall uncertainty of the facility's emissions will be computed in **Tab J: Summary** based on the uncertainty and the estimated annual emissions of each emission stream.

5.6.3 Method 1: Calculation Approach forms

Most emission stream forms for Method 1: Calculation Approach are similar. The only variables are the number of material property values required and the IPCC defaults available for selection.

Some calculation approach forms contain additional functionality specific to the process type. An example is the 'Integrated circuit or Semiconductor production' process type. Refer to the Appendix for specific characteristics of the emission stream forms for each process type.

The Method 1: Calculation Approach forms contain:

- i) A header (refer to Figure 17);
- ii) Activity data details (refer to Figure 18 and Figure 19);
- iii) A number of conversion factor details sections, depending on the process type and sub-process type (refer Figure 20); and
- iv) An emission stream uncertainty value (refer to Figure 20).

Further information on the specific requirements of each process emission type is available in the Appendix.

5.6.4 Method 2: Material Balance forms

The emission stream forms for Method 2: Material Balance have a similar layout. The only variables are additional activity data and conversion factors required to quantify non-CO₂ emissions, usually CH₄, for some process types. Examples of completed forms for emission types that use Method 2: Material Balance are shown in the Appendix.

Method 2: Material Balance forms contain:

- i) A header (refer to Figure 17).
- ii) A series of material stream entries. There should be at least two material stream, i.e. a feedstock and a product stream. Figure 22 shows three material streams, one for the feedstock, one for the primary product and the third for a secondary product (propylene). Additional streams can be added for secondary feedstock, product and waste streams. Each material stream contains:
 - activity data details section showing how the material stream will be quantified.
 - carbon content conversion factor section detailing how the carbon content of the material stream will be derived.
- iii) An additional activity data section for the specification of the 'activity data for reporting production and determining Methane emissions' (refer to Figure 16). In cases such as for Ethylene production, this will be the primary production value used to estimate CH₄ emissions.
- iv) A conversion factor section for the specification of the source of conversion factor for the estimation of additional GHG emissions. In Figure 16, a methane emission factor is specified for ethylene production.
- v) An emission stream uncertainty value.

The uncertainty assessment for Method 2: Material Balance requires an estimate of the proportion of carbon from feedstock that is expected to be in the emission stream. The example shown in Figure 22, 50% of the carbon is expected to be contained in the ethylene product. An additional 10% is expected to be contained in the propylene production, giving a total of 60% as the 'Proportion of product/waste Stream' that is displayed in the top right corner of Figure 22.

The uncertainty of the measurement of carbon in each material stream sets the absolute uncertainty of the carbon balance. The higher percentage of carbon in the measured streams increases the relative uncertainty of the carbon balance compared to the estimated emissions released.

If two or more feedstocks are used, the proportion of carbon derived from each feedstock must be known to apply Equation B to the assessment of the total carbon available. The GHG Manager is required to provide a proportion of carbon in each feedstock if one or more feedstocks are used. A value of 100% should be used for one feedstock.

Figure 22: Method 2: Material Balance emission stream entry form

MB_P1	Emission source: Ethylene production
	Emission stream type: Ethylene produced - Naptha

(a) GHG quantification approach description:

Ethylene is produced from Naptha with propylene as a secondary product. The Naptha is measured at the entry point to the facility. Ethylene and propylene are measured at the entry to the storage tanks. Reconciliation is undertaken daily on the product amounts against tank level and dispatch for reporting official production. The on-site laboratory is used to analyse product by shift for purity and carbon content. Naptha is analysed by shipment received.

(b) Additional attachment to elaborate on the GHG quant **Yes**

Document reference name: GHG emission reporting Basis of Preparation

Options to manage material stream entries: **Proportion of feedstock stream: 100%**
Proportion of product/waste Stream: 60%

Activity data for this material stream 1

Material stream type: **Feedstock**

Feedstock type: **Naptha**

Proportion of total Feedstock carbon in this Feedstock material stream: **100%**

Options to manage activity data entries:

Activity data measurement:	Tier:	Uncertainty:
FL 101 Feedstock Flow Vortex Flow Meter	2 - Measurement	4.0%

Overall Activity data uncertainty: **4.00%**

Conversion factor: Carbon content

Data source: **Carbon content analysis - Composition - Carbon content**

Frequency of analysis: **4 - Representative**

Uncertainty: **1.0%**

Activity data for this material stream 2

Material stream type: **Production (Primary)**

Describe the material: **Ethylene production**

Proportion of total Feedstock carbon in this Product/Waste material stream: **50%**

Options to manage activity data entries:

Activity data measurement:	Tier:	Uncertainty:
FL 201 Ethylene production Ultrasonic Doppler Flowmeter	4 - Accurate Measurement	0.5%

Overall Activity data uncertainty: **0.50%**

Conversion factor: Carbon content

Data source: **Carbon content analysis - Composition - Carbon content**

Frequency of analysis: **4 - Representative**

Uncertainty: **1.0%**

Activity data for this material stream 3

Material stream type: **Production (Secondary)**

Describe the material: **Propylene production**

Proportion of total Feedstock carbon in this Product/Waste material stream: **10%**

Options to manage activity data entries:

Activity data measurement:	Tier:	Uncertainty:
FL 201 Ethylene production Ultrasonic Doppler Flowmeter	4 - Accurate Measurement	0.5%

Overall Activity data uncertainty: **0.50%**

Conversion factor: Carbon content

Data source: **Carbon content analysis - Composition - Carbon content**

Frequency of analysis: **4 - Representative**

Uncertainty: **1.0%**

Activity data for reporting production and determining Methane emissions

Options to manage activity data entries:

Activity data measurement:	Tier:	Uncertainty:
FL 201 Ethylene production Ultrasonic Doppler Flowmeter	4 - Accurate Measurement	0.5%

Overall Activity data uncertainty: **0.50%**

Conversion factor: Methane Emission factor

Data source: **Default**

Uncertainty: **10.0%**

Emission stream uncertainty: **10.4%**

5.6.5 Method 3: Direct Measurement Forms

The emission stream forms for Method 3: Direct Measurement have a similar layout. The only variables are additional activity data for the measurement of production and any conversion factors required to quantify non-CO₂ emissions that are not measured. Examples of completed forms are shown in the Appendix for emission types that use Method 3: Direct Measurement.

The Method 3: Direct Measurement forms contain:

- i) A header (refer to Figure 17).
- ii) A series of monitoring point entries. Refer to Figure 23 where one monitoring point entry is shown. Additional monitoring points can be added and redundant monitoring points can be removed. Each monitoring point contains:
 - Specification of the greenhouse gas measured;
 - An estimate of the proportion of GHG emissions from this measurement point. This is used with Equation B (refer to Section 3.3.4) to estimate the overall uncertainty of the emission stream;
 - An activity data details section that includes dropdown selections to confirm if temperature and pressure are corrected¹⁸; and
 - A GHG concentration measurement conversion factor section.
- iii) An additional activity data details section to record the measurement of production (refer to Figure 23). This additional section requires the specification of the activity data to be used for determining Methane emissions for certain process emission types. This section is not included for fuel combustion emission streams.

¹⁸ The default uncertainty values for the default measurement instruments assume that temperature and pressure have been corrected. If not, the facility should enter a larger site-specific uncertainty value.

Figure 23: Method 3: Direct Measurement emission stream entry form

DM_P1		Emission source: Ethylene production																
		Emission stream type: Ethylene produced - Ethane																
(a) GHG quantification approach description:																		
<p>Ethylene is used as the feedstock with oxygen from air intake for the production of ethylene oxide. Ethylene is the only feedstock. Ethylene oxide as an aqueous solution and gas stream, and a high purity CO₂ are the three output streams. No abatement is available for the CH₄ emissions with the default factor for CH₄ selected.</p> <p>CO₂ is captured during the recovery stage and sold as demand and storage allow. Following the recovery stage the flue gas is monitored for flow and CO₂</p>																		
(b) Additional attachment? Yes																		
Document reference / name: GHG Reporting - Basis of Preparation																		
Options to manage monitoring point entries:																		
<table border="1"> <tr> <td>Activity data for monitoring point #1</td> <td>Gas being measured: Carbon dioxide</td> </tr> <tr> <td>Proportion of forecast emissions (CO₂-e) from this monitoring point:</td> <td>100%</td> </tr> <tr> <td colspan="2">Options to manage activity data entries:</td> </tr> <tr> <td>Activity data measurement:</td> <td>Tier: Uncertainty:</td> </tr> <tr> <td>FL-101 Stack flow</td> <td>4 - Accurate Measurement 1.5%</td> </tr> <tr> <td>Venturi Tube</td> <td></td> </tr> <tr> <td>Temperature correction: Yes</td> <td>Pressure correction: Yes</td> </tr> <tr> <td colspan="2">Overall Activity data uncertainty: 1.50%</td> </tr> </table>			Activity data for monitoring point #1	Gas being measured: Carbon dioxide	Proportion of forecast emissions (CO ₂ -e) from this monitoring point:	100%	Options to manage activity data entries:		Activity data measurement:	Tier: Uncertainty:	FL-101 Stack flow	4 - Accurate Measurement 1.5%	Venturi Tube		Temperature correction: Yes	Pressure correction: Yes	Overall Activity data uncertainty: 1.50%	
Activity data for monitoring point #1	Gas being measured: Carbon dioxide																	
Proportion of forecast emissions (CO ₂ -e) from this monitoring point:	100%																	
Options to manage activity data entries:																		
Activity data measurement:	Tier: Uncertainty:																	
FL-101 Stack flow	4 - Accurate Measurement 1.5%																	
Venturi Tube																		
Temperature correction: Yes	Pressure correction: Yes																	
Overall Activity data uncertainty: 1.50%																		
<table border="1"> <tr> <td>Conversion factor: GHG concentration measurement</td> <td>Data source: FG - 100 Gas analyser - GHG concentration in gas sample</td> </tr> <tr> <td></td> <td>Frequency of analysis: 4 - Representative</td> </tr> <tr> <td></td> <td>Uncertainty: 3.0%</td> </tr> </table>			Conversion factor: GHG concentration measurement	Data source: FG - 100 Gas analyser - GHG concentration in gas sample		Frequency of analysis: 4 - Representative		Uncertainty: 3.0%										
Conversion factor: GHG concentration measurement	Data source: FG - 100 Gas analyser - GHG concentration in gas sample																	
	Frequency of analysis: 4 - Representative																	
	Uncertainty: 3.0%																	
<table border="1"> <tr> <td>Activity data for Production</td> <td>Options to manage activity data entries:</td> </tr> <tr> <td>Activity data measurement:</td> <td>Tier: Uncertainty:</td> </tr> <tr> <td>FL - 311 Ethylene production</td> <td>4 - Accurate Measurement 0.5%</td> </tr> <tr> <td>Electromagnetic Flowmeter</td> <td></td> </tr> <tr> <td colspan="2">Overall Activity data uncertainty: 0.50%</td> </tr> </table>			Activity data for Production	Options to manage activity data entries:	Activity data measurement:	Tier: Uncertainty:	FL - 311 Ethylene production	4 - Accurate Measurement 0.5%	Electromagnetic Flowmeter		Overall Activity data uncertainty: 0.50%							
Activity data for Production	Options to manage activity data entries:																	
Activity data measurement:	Tier: Uncertainty:																	
FL - 311 Ethylene production	4 - Accurate Measurement 0.5%																	
Electromagnetic Flowmeter																		
Overall Activity data uncertainty: 0.50%																		
<table border="1"> <tr> <td>Conversion factor: Methane Emission factor</td> <td>Data source: Default</td> </tr> <tr> <td></td> <td>Uncertainty: 10.0%</td> </tr> </table>			Conversion factor: Methane Emission factor	Data source: Default		Uncertainty: 10.0%												
Conversion factor: Methane Emission factor	Data source: Default																	
	Uncertainty: 10.0%																	
Emission stream uncertainty: 3.3%																		

5.7 Tab J. Summary of emission streams and overall uncertainty

All of the emission streams specified on Tab C. **Site Details** are displayed in a summary table in Tab J. **Summary**. The GHG Manager is required to provide an estimate or forecast of the emissions from each emission stream. This could be an extrapolation of historical emissions. The values recorded are regarded as an estimate and are only used to calculate the likely overall uncertainty of the Emissions Report.

Figure 24 shows an example of the summary table. The uncertainty of each emission stream is shown with estimates of emissions recorded by the GHG Manager. Equation B (refer to Section 3.3.4) is used to calculate the overall uncertainty for the facility. The 'Indicative contribution to overall uncertainty' values are the percentage contribution from each emission stream as calculated from Equation C below.

$$\text{Aggregated emission uncertainty} = \frac{\sqrt{\sum_i (U_i \times E_i)^2}}{\sum_i E_i} \quad \text{Equation B}$$

$$\text{Indicative contribution to overall uncertainty} = \frac{(U_i \times E_i)^2}{\sum_i (U_i \times E_i)^2} \quad \text{Equation C}$$

Figure 24: Tab J. Summary of emission streams and overall uncertainty

1 Emission streams and Overall uncertainty					
Please enter the forecast annual emissions of each emissions stream in the table below.					
The table summarises the indicative contribution of each emissions stream to the overall uncertainty. Please refer to the Guidelines for more information on uncertainty assessment and reducing uncertainty.					
Total forecast annual emissions (tonnes CO ₂ -e):		377,500			
Overall uncertainty:		4.6%			
Emissions stream	Emissions source	Emissions stream type	Emissions stream uncertainty	Forecast annual emissions (tonne CO ₂ -e)	Indicative contribution to overall uncertainty
CA_F1	General site use	Natural Gas	3.2%	10,000	0%
MB_P1	Ethylene production	Ethylene produced - Naphtha	7.2%	216,000	81%
CA_F2	Site diesel use	Gas/Diesel Oil	3.2%	1,500	0%
DM_P2	Vents	Process Vents - Steam methane reforming (hydrogen plants)	5.0%	150,000	19%

The square root of the sum of the squares ($\sqrt{\sum_i (U_i \times E_i)^2}$) in Equation B is such that the overall uncertainty is dominated by the emission stream, or streams, that have the highest absolute uncertainty as calculated by $(U_i \times E_i)$. In Figure 20, the uncertainty values are relatively similar with the two small emission streams not having a large impact. The emission levels are similar for ethylene production and nitric acid production; however, the uncertainty is higher for ethylene production, making it the largest contributor.

To improve the accuracy of the overall uncertainty assessment, the emission estimates of these two emission streams could be reviewed. To reduce the overall uncertainty, the measurement and reporting process for the two emission streams could be reviewed, potentially increasing the tier for the activity data and conversion factors. Refer to Section 3.3.5 for more details.

5.8 Tab K. Quality management

Tab K. **Quality Management** requires the facility to establish, document, implement and maintain a Quality Management Framework (QMF) to ensure robust and accurate GHG data.

5.8.1 Quality Management Framework

The GHG Manager would be required to specify the reference name of the QMF outline to be submitted by the facility in Tab K. **Quality Management**.

The GHG Manager is required to submit to NEA an outline of its QMF describing its QC activities as part of its supporting documents for the Monitoring Plan submission. In the outline, the planned/implemented QC activities should be described in relation to the different QMF elements and in the facility's context.

Figure 25 shows the QMF elements to be covered under the QMF. The GHG Manager should check the tick boxes to affirm that the submitted QMF has incorporated details of the facility's quality management procedures with regard to each QMF element.

Figure 25: Tab K. Quality Management Framework elements and checklist

Document reference/name	
Facility X GHG Quality Management Framework	
Inventory preparation and management	<input checked="" type="checkbox"/> Procedure to ensure that all emission sources and streams are reported in the Monitoring Plan
	<input checked="" type="checkbox"/> Procedure to determine that the selected emissions quantification methods are appropriate, including the approach to determine any site-specific conversion factors
	<input checked="" type="checkbox"/> Quality assurance procedures to ensure that SOPs for maintaining and/or calibrating measurement instruments and IT tools are followed appropriately
	<input checked="" type="checkbox"/> Procedure to ensure no conflicts of interest between compilation/computation and counter-checking roles
Data gathering, input and handling	<input checked="" type="checkbox"/> Procedures to ensure accurate collection and checking of activity data
	<input checked="" type="checkbox"/> Change management procedures to ensure proper documentation of updates to data collection and computation approaches
Data documentation, reporting and review	<input checked="" type="checkbox"/> Procedure to check that data submitted in the Emissions Report is accurate, robust and complete
	<input checked="" type="checkbox"/> Procedure to review appropriateness of data compilation and computation approaches

5.8.2 List of personnel and responsibilities

The GHG Manager would be required to detail the job titles or roles of personnel and their responsibilities for the measurement and reporting process as shown in Figure 26.

This information could also be outlined in a tree diagram or organisational chart attached to the facility's QMF outline.

Figure 26: Tab K. List of personnel and responsibilities for the measurement and reporting process

Job title/role	Responsibilities
Energy Manager	Preparation of the emissions report, monitoring plan and internal monthly GHG reporting
Engineering Manager	Validation of emissions report, on a monthly basis via monthly GHG report
HSE Manager	Overall accountability for all energy and GHG external reporting. Resource management and budgets
General Manager	Signoff of the site report to corporate prior to Coe authorisation
Instrumentation engineer	Management and adherence to site procedures for instrument procedures

5.8.3 List of management procedures for metering and analysis

When recording any metering or analysis in the '**Metering and Analysis**' tabs, the GHG Manager is requested to specify a reference or name of any applicable on-site procedure(s) that are used to maintain the accuracy of the measurement instrument, or to manage the sampling process to maintain the representativeness of the sample. The management procedure reference/name will be recorded automatically in the Procedures referenced table on Tab **K. Quality Management**.

Figure 27: Tab K. Summary of management procedures

2 Summary of site procedures	
The following site based procedures have been referenced within the Monitoring Plan. This list is maintained to allow procedure names to be re-used. If a name has been entered incorrectly, please use the Remove row option.	
Procedures referenced	Remove row options
SoP - Production reporting	
P101 Flow metering procedures	
AN101 On-site analysis procedures	
P 301 Fuel property sampling	

Each individual document specified on the '**Metering and Analysis**' tabs will be displayed in the table. Once recorded in the table, the document name will be available in the dropdown selection in the '**Metering and Analysis**' tab forms. Invalid entries due to incorrect spelling or other entry errors can be removed using the '*Remove row options*'.

5.8.4 List of GHG quantification approach documents

As detailed in Section 2.1.2, the facility must provide a detailed description of the quantification approach for each emission stream. The document reference name is specified in each emission stream form and displayed on Tab **K. Quality Management** tab and Tab **L. Submission Checklist**.

Tab **K. Quality Management** records each unique name specified on the '**Emission Streams**' tabs. In Figure 28, the GHG Manager has specified a single 'Basis of Preparation' document.

Figure 28: Tab K. Summary of approach documents

3 Approach documents	
The following document(s) have been referenced within the monitoring plan as detailing the approach taken to quantify emissions from each emissions stream. This list is maintained to allow the document names to be re-used. If a name has been entered incorrectly, please use the Remove row option.	
Documents referenced	Remove row Options
GHG Reporting - Basis of preparation	

Each unique document name specified on the '**Emission Streams**' tabs will be displayed in the table. Once recorded in the table, the document name will be available in the dropdown selection in the emission stream forms. Invalid entries due to incorrect spelling or other entry errors can be removed using the '*Remove row Options*'.

5.9 Tab L. Submission checklist

As detailed in Section 2.1.2, the MP Template is required to be substantiated with a series of supporting documents. Tab L. **Submission Checklist** provides a summary of the documents required to be attached, and a series of checklists of the required additional information based on the M&R approach detailed in the MP Template. The GHG Manager is required to double click the green check box column cells to display the ticks, and hence confirming that the supporting documents have been attached and submitted with the MP Template.

5.9.1 Facility documentation

The GHG Manager is required to submit the following facility documentation:

- Emission source diagram: A diagram of the physical layout of facility and the location of all emission sources with reference to the internal identifiers specified on the **‘Metering & Analysis’** tabs.
- Emission stream diagram(s): A series of diagrams covering each emission stream, linking the following components:
 - a. major equipment item(s) or system(s) representing the emission source and emission point(s);
 - b. fuel, feedstock or product flows; and
 - c. measurement instrument(s), measurement and sampling point(s).
- Quality Management Framework for the facility (refer to Section 4).

Figure 29 shows an example of the submission attached documents table where the GHG Manager has confirmed that the three documents are attached.

Figure 29: Tab L. Facility documentation

1 Facility documentation		
The following table list the documents that are to be attached to the Monitoring Plan submission.		
Please also indicate the titles of the supplementary documents that provide the information as required in the following tables below.		
Emissions source diagram:	Site map of emission sources.pdf	✓
Emissions Stream diagram:	Emission streams diagrams.pdf	✓
Quality management framework:	Facility X GHG Quality management framework	✓
List of supplementary document(s):	Add additional rows Option: <input type="text"/>	Remove row Options
	GHG Reporting - Basis of preparation	

The submission checklist shown in Figure 29 also allows the GHG Manager to specify a list of supporting documents names that have been included in the Monitoring Plan submission. These document may contain the information requirements detailed in later sections. In Figure 29, the GHG Manager has specified that the ‘GHG Reporting – Basis of Preparation’ document contains the information required.

Multiple supporting documents can be added by selecting the “Add additional rows Option”, or removed by selecting the ‘Remove row Option’.

5.9.2 GHG quantification approach documents

As detailed in Section 2.1.2, the facility must provide a detailed description of the quantification approach for each emission stream. The document reference name is specified in each emission stream form and displayed on Tab **L. Submission Checklist** tab and Tab **K. Quality Management**.

Tab **L. Submission Checklist** tab records each emission stream and the associated approach document specified on the '**Emission Streams**' tabs. In Figure 30, the GHG Manager has specified a single 'Basis of Preparation' document for all emission streams. The GHG Manager is required to confirm that the document(s) are attached. Where a document is common for multiple emission streams, only one confirmation is required.

Figure 30: Tab L. Emission stream documentation

2 Emissions stream documentation		
Emissions stream	GHG quantification approach description document	
CA_F1	GHG Reporting - Basis of preparation	✓
MB_P1	GHG Reporting - Basis of preparation	
CA_F2	GHG Reporting - Basis of preparation	
DM_P2	GHG Reporting - Basis of preparation	

5.9.3 Evidence to justify site-specific conversion factors

The submission should include evidence to justify the use of all site-specific conversion factors and any site-specific uncertainty recorded in the MP Template (refer to Section 2.1.2). As each site-specific value is recorded, an entry is made on Tab **L. Submission Checklist** detailing the site-specific conversion factor and any site-specific uncertainty.

The example in Figure 31 shows four site-specific values specified by the GHG Manager. The table lists the applicable emission stream identifier, conversion factor name, proposed value and reference specified to justify the value.

The green highlighted cells in the 'Document Included' columns should be used by the GHG Manager to confirm that the document is included in the Monitoring Plan submission.

Figure 31: Tab L. Site-specific conversion factor table

Related emissions stream identifier	Conversion factor	Site-specific value	Justification reference document reference/name	Submission requirements	
				Justification document for site-specific value	Justification for site-specific uncertainty
CA_F1	Energy Content	33.7	Supplier X - Natural Gas properties	✓	✓
CA_F1	Carbon dioxide Emission factor	51	Supplier X - Natural Gas properties	✓	

5.9.4 Metering and Analysis documentation

The use of any engineering estimates, metering or analyses for the determination of activity data and site-specific conversion factors, as recorded in the '**Metering & Analysis**' tabs, will require additional supporting documents (refer to Section 2.1.2). The GHG Manager should list the names of all supporting documents. The GHG Manager can add as many rows as required to list the supporting documents.

Tab **L. Submission Checklist** contains a series of checklists to assist the GHG Manager to confirm that all additional supporting document required for metering and analysis is included. Refer to Figure 32 below.

The checklists for the metering and analysis supporting documents include:

- i) An alternative approach must be provided for each measurement instrument and analysis (for both activity and conversion factors). Refer to Section 3.2.3 for details of the requirement.
- ii) For any engineering estimate specified, an explanation must be provided detailing the basis of the calculation and any assumptions (refer to Section 3.2.1).
- iii) For any activity data values that have been specified as Tier 4, the GHG Manager should provide details of the measurement approach and the standard applied for the maintenance and calibration of the measurement instrument (refer to Section 3.2.1).
- iv) For Tier 4 conversion factors, assumptions and justifications to substantiate that the samples are representative must be submitted to NEA.
- v) For conversion factors Tiers 2, 3 and 4, explanation for the selected sampling and analysis frequency and description of the metering and analysis process (including conversion factor formulation) to be used to derive all Tiers 2, 3 and 4 conversion factors.
- vi) For any site-specific uncertainty values recorded, the GHG Manager must provide a description of how the uncertainty value was derived. This should include:
 - The protocol used to undertake the assessment and a summary of the calculations involved; or
 - A reference (and copy if readily available) to the instrument or installation documentation that specifies the uncertainty value.
- vii) Details of test methods/standards used by the laboratories and accreditation details of laboratories used (if relevant). This could include any general laboratory accreditations for data quality management and specific accreditation for the tests to be conducted.

Figure 32: Tab L. Metering & Analysis supporting documentation

Activity data - Metering documentation				Submission requirements			
Internal identifier/name	Relevant emission stream(s)	Type of instrument	Supporting document for management procedure	Alternative approach description	Explanation for engineering estimates (Tier 3) or accurate measurement (Tier 4)	Justification for site-specific uncertainty	Remove row options
FL 201 natural gas to Plant A	F1	Vortex Flow Meter	P101 Flow metering procedures	✓			
FL 202 natural gas to Plant A	F1	Coriolis Flowmeter	P101 Flow metering procedures	✓	✓		
FL 201 Feedstock flow	P1	Vortex Flow Meter	P101 Flow metering procedures	✓			
FL 201 Ethylene production	P1	Ultrasonic Doppler Flowmeter	P101 Flow metering procedures	✓	✓		
FL 202 Propylene production	P1	Ultrasonic Doppler Flowmeter	P101 Flow metering procedures	✓	✓		
FL 401 Flue gas flow	P2	Pitot Tubes	P101 Flow metering procedures	✓	✓		

Conversion factors - Metering & Analysis documentation				Submission requirements			
Internal identifier/name	Relevant emission stream(s)	Type of instrument - Conversion factor	Supporting document for management procedure	Alternative approach description	Explanation for sampling frequency (Tiers 2-4) and conversion factor formulation	Justification for site-specific uncertainty	Remove row options
AN 201 Gas crom - NCV	F1	Gas chromatograph - Energy Content	AN101 On-site analysis procedures	✓	✓		
Carbon content	P1	Gas chromatograph - Composition - Carbon content	0	✓	✓		
AN 401 Flue gas CO2 %	P2	Flue Gas Analyser - GHG concentration in gas sample	P101 Flow metering procedures	✓	✓		

Conversion factors - Laboratory analysis documentation				Submission requirements					
Internal identifier/name	Relevant emission stream(s)	Conversion factor	Supporting document for management procedure	Alternative approach description	Explanation for sampling frequency (Tiers 2-4) and conversion factor formulation	Justification for site-specific uncertainty	Test methods or standards used by lab	Laboratory Accreditation	Remove row options
Fuel sampling	F1, F2	Energy Content	P 301 Fuel property sampling	✓	✓		✓	✓	
Fuel sampling	F1, F2	Composition - Carbon content	P 301 Fuel property sampling	✓	✓		✓	✓	

6. Definitions

Activity data	Activity data is the amount of materials (including fuels and feedstock) consumed or produced by a process or activity, and used or to be used to compute direct GHG emissions.
Activity data tiers	<p>The measurement approach used by a facility to obtain an activity data value can be classified into four activity data tiers which reflect increasing accuracy of measurement. The facility shall use an activity data tier that is appropriate and ensures the direct GHG emissions are accurately computed.</p> <ul style="list-style-type: none"> • Tier 1: Engineering estimate • Tier 2: Measured using typical industry approach • Tier 3: Invoiced quantity • Tier 4: Measured using an instrument meeting a specific standard
CO₂ equivalent (CO₂e)	The carbon dioxide equivalent of a greenhouse gas obtained by multiplying the mass of the gas by the global warming potential (GWP). It is a universal unit of measurement to indicate the GWP of the GHG emissions. It is used to quantify different GHG emissions using a common basis.
Conversion factors	<p>A quantity, ratio or fraction that measures the correlation between two variables, and is used to compute the quantity of GHG emissions. Conversion factors are obtained from:</p> <ul style="list-style-type: none"> i) Defaults provided by NEA, which are based on IPCC factors; or ii) Site-specific factors specified by a facility and substantiated with supporting documents.
Conversion factors tiers	<p>The measurement approach used by a facility to obtain a conversion factor can be classified into four conversion factor tiers which reflect increasing accuracy of analysis. The facility shall use a conversion factor tier that is appropriate and ensures the direct GHG emissions are accurately computed.</p> <ul style="list-style-type: none"> • Tier 1: Default • Tier 2: Analysis done less frequently than once a year • Tier 3: Analysis done once every year or more frequent • Tier 4: Representative analysis
Direct GHG emissions	Greenhouse gas emissions that are released directly into the atmosphere from the facility and from emission sources that are owned or controlled by the reporting Corporation. Also known as scope 1 emissions.
Emissions Data Monitoring and Analysis (EDMA) system	The online reporting system for registration and submission matters for the GHG M&R requirements. The EDMA system will be modified to enable the (i) uploading of the MP Template and necessary supporting

	documents, and (ii) reporting of emissions via a user interface (which represents the Emissions Report).
Emissions quantification method	This refers to the three main methods available for the quantification of GHG emissions, i.e. Method 1: Calculation Approach, Method 2: Material Balance, Method 3: Direct Measurement.
Emission source	A process or activity that generates GHG emissions, which are broadly categorised into (i) fuel combustion (i.e. energy use) and (ii) IPPU (i.e. non-energy use).
Emission stream	An emission stream refers to a specific emission source, emission stream type and its emissions quantification method. Measurement and reporting of GHG emissions are disaggregated at the emission-stream level. Emission stream is labelled based on its emissions quantification method in the MP Template (e.g. CA_F1, MB_P2 etc.)
Emission stream type	An emission stream type refers to a specific process type, or a specific fuel, feedstock or product type that is included in the emissions quantification method.
Emission stream forms	This is referring to the forms in Tab ‘E. Calc Apch – Emission Streams’, ‘G. Mat Bal – Emission Streams’ and ‘I. Direct – Emission Streams’, of the MP Template.
Facility	The term ‘facility’ has been used in the Guidelines to refer to a business activity that is subject to the GHG M&R requirements.
Fuel combustion	<p>Fuel combustion refers to the burning of fuels to generate electricity, steam, heat, power or any energy commodity in a stationary equipment such as a boiler, furnace etc. This will result in the release of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) emissions. Flares are not reported as a fuel combustion emission source, but as an IPPU emission source. A fuel combustion emission stream is typically defined by the individual fuel type.</p> <p>Emissions from fuel combustion are predominantly computed using the Method 1: Calculation Approach.</p>
Fugitive emissions	Emissions that are not physically controlled as a result of unintentional releases of GHGs. Fugitive emissions include evaporative and flashing losses from storage, filling and unloading activities, and equipment leaks through pipe leakages, joints etc., waste oil treatment facilities and cooling tower. This does not include flaring and venting.
Global Warming Potential	A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one unit of carbon dioxide (CO ₂).
Greenhouse gases (GHG)	<p>For the purposes of this Guidelines, GHG refers to the greenhouse gas covered in the GHG M&R Regulations:</p> <ul style="list-style-type: none"> Carbon dioxide (CO₂)

	<ul style="list-style-type: none"> • Methane (CH₄) • Nitrous oxide (N₂O) • Sulphur hexafluoride (SF₆) • Nitrogen trifluoride (NF₃) • Hydrofluorocarbons (HFCs) • Perfluorocarbons (PFCs)
Industrial Processes and Product Use (IPPU) emission source	<p>An IPPU emission source refers to any industrial process or activity that result in GHG emissions, from the use of GHGs in products (e.g. for integrated circuit or semiconductor production) and from non-energy uses of fossil fuel carbon e.g. as feedstock (e.g. petrochemical production). The known types of IPPU emission sources can be found in the Appendix, and in the existing Energy Conservation (Energy Management Practices) Regulations. Process emission source has a process type (e.g. flare, vents), and most have a sub-process type (e.g. sinter plant or coke oven). This differentiates the process type into unique units that may have different estimation techniques or characteristics required for the estimation of GHG emissions.</p> <p>Generally, IPPU emissions are quantified by Method 1: Calculation Approach or Method 2: Material Balance. However, for some IPPU emissions (e.g. nitrous oxide (N₂O) emissions from nitric acid production), Method 3: Direct Measurement can be used.</p>
Industrial Processes and Product Use (IPPU) emission spreadsheet	The Energy Use Report (GHG from non-fuel combustion processes or activities) spreadsheet currently used for reporting IPPU emissions under the ECA, and then uploaded to the EDMA system.
Intergovernmental Panel on Climate Change	The leading international body for the assessment of climate change. The IPCC reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change, and provides the world with a scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.
Material property	An intrinsic quality of a material (i.e. fuel, feedstock, product) that is used as a conversion factor in an emissions quantification method. On-site material property analysis can improve the accuracy of reporting. Examples of material property analysis include continuous emissions monitoring system (CEMS) which measures the concentration of the GHG emissions in the exhaust gas, or laboratory analysis which determines the carbon content of the waste solvent.
Measurement instrument	This term is used in the Guidelines to refer to any measurement or analysis systems, equipment, tools and devices that the facility uses to assist in its quantification of emissions (e.g. meters, analysers etc.).
Plant	This term is used in the Guidelines to refer to an equipment or sets of equipment within a facility e.g. Hydrogen plant, Ethylene plant.

Third-party verification	An independent third-party assessment or audit of the reliability (considering completeness and accuracy) of an Emissions Report.
Uncertainty	Uncertainty is related to the degree of quality or accuracy of a measured or derived value e.g. GHG emissions quantity, activity data. Refer to Section 3.3 for more information.
United Nations Framework Convention on Climate Change (UNFCCC)	Signed in 1992 at the Earth Summit in Rio de Janeiro, the UNFCCC is a milestone Convention on Climate Change treaty that provides an overall framework for international efforts to mitigate climate change. The Kyoto Protocol and the Paris Agreements are protocols to the UNFCCC.