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WASTE SECTOR USERS' GUIDEBOOK

IPCC Inventory Software, version 2.95

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This Guidebook is prepared by IPCC TFI TSU.
It has not been a subject to the formal IPCC review process
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Contents

Abbreviations

AD	activity data
BOD	biochemical oxygen demand
C	carbon
CF	carbon fraction
CH_4	methane
CO_2	carbon dioxide
COD	chemical oxygen demand
CRT	common reporting tables
dm	dry matter
DOC	degradable organic carbon
DOC_f	fraction of DOC which decomposes
EF	emission factor
ETF	enhanced transparency framework
FOD	first order decay
FC	fossil carbon
FCF	fossil carbon fraction
Gg	gigagram
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
MCF	methane correction factor
MSW	municipal solid waste
N	nitrogen
N_2O	nitrous oxide
OX	Oxidation factor
NGHGI	national greenhouse gas inventory
SWDS	solid waste disposal site
TC	total carbon
TSU	Technical Support Unit
Wetlands Supplement	*2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*
2006 IPCC Guidelines	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*
2019 Refinement	*2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*

Introduction

Goal

The guidebook for the IPCC Inventory Software (*Software*) is produced by the Technical Support Unit (TSU) of the IPCC Task Force on National Greenhous Gas Inventories (TFI) to support inventory compilers in the use of the *Software* for the preparation of national greenhouse gas (GHG) inventories. The guidebook describes the complete procedure, from activity data (AD) organization and input to emission factor (EF) selection and input, to GHG estimation and reporting.

Software users must be familiar with the *2006 IPCC Guidelines* methods and the User Manual of the IPCC Inventory Software (downloadable from the "Help" menu) before going through this guidebook. This guidebook does not replace guidance provided in the *2006 IPCC Guidelines*.

Scope

The guidebook covers all methodological tiers and approaches provided in the *2006 IPCC Guidelines* and the *Wetlands Supplement*[1] to estimate anthropogenic GHG emission and removals from each Waste sector inventory category as well as cross-cutting elements. Elements of the *2019 Refinement*[2] are introduced in limited cases, where needed to enable interoperability between the *Software* and United Nations Framework Convention on Climate Change (UNFCCC) electronic reporting tool for Common Reporting Tables (CRT).

Structure

Each category, as defined in the *2006 IPCC Guidelines*[3], and each associated GHG is presented as a section in this guidebook, providing practical information to help the user enter information and estimate GHG emissions and removals. While the majority of sections cover just one category, multiple categories (e.g., 4.A, 4.A.1, 4.A.2 and 4.A.3) are grouped together when the underlying instructions are the same for entering information in the *Software*. Table 1 below provides the definitions of various categories, as well as a hyperlink to the relevant section of the guidebook where further information may be found.

Each section follows a consistent structure. Firstly, general information on the category and gas(es) covered is provided, along with the relevant equations from the *2006 IPCC Guidelines* used to estimate GHG emissions and removals in the *Software*. Next the worksheet(s) contained in the *Software* that are to be used to enter relevant AD, EFs and other parameters are introduced with a "User's work Flowchart" to help illustrate the user's series of steps to enter this information. Data may be entered either within a single nation-wide aggregate (i.e. "country name" subdivision or "unspecified") or within a national disaggregation such as administrative units (e.g., provinces, regions, states) or production units (e.g., companies, facilities, or any other aggregation according to which the user collects AD). Finally, the relevant AD data and EF input is elaborated on and how results are presented is highlighted.

Methodological Tiers

The *Software* provides functionalities - calculation worksheets and data managers - to prepare estimates according to any of the methodological tiers for which IPCC provides equations. In this guidebook the following definitions are used to indicate the methodological tier of the relevant equations, and the correspondence with tiers in a national greenhouse gas inventory (NGHGI):

IPCC Tier 1 refers to the IPCC Tier 1 equations and default EFs/parameters.

IPCC Tier 2 refers to:

- ✓ either the IPCC Tier 2 equations, with IPCC default values or user-specific EFs/parameters, different from IPCC Tier 1 equations in the level of stratification and/or in the variables/parameters,
- ✓ or, when a Tier 2 Equation is not provided, the IPCC Tier 1 equation and user-specific EFs/parameters.

IPCC Tier 3 is the IPCC methodology different in the level of stratification and/or in the variables/parameters, from the IPCC Tier 1 and Tier 2 methodologies.

Tips

Aggregation and disaggregation in calculations

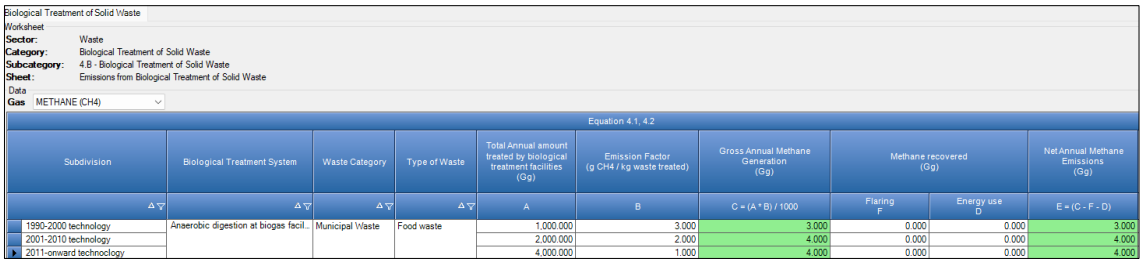
[1] Elements derived from the *Wetlands Supplement* are clearly distinguishable because of the lilac colour used to mark those.
[2] Elements derived from the *2019 Refinement* are clearly distinguishable because of magenta colour used to mark those.
[3] In few instances, denoted by magenta colour, from the *2019 Refinement*.

Stratification[4] of variables[5] used to calculate GHG emissions according to IPCC methodologies is a key element to promote accuracy and precision of estimates. Thus, the *Software* allows an unlimited disaggregation of AD, and associated EF[6]s, within a category and allows any combination of different levels of disaggregation/Tiers.

This is implemented in two ways, by dividing the category into segments (subdivisions) and applying a single methodological tier to all subdivisions, or by dividing the category into subdivisions and applying different methodological tiers to different subdivisions. Thus, within a category, those segments for which data are available, e.g., a specific practice for which EFs are known, are singled out while all remaining activities are reported within a single aggregation, e.g., as unspecified.

However, the *Software* only allows the user to enter one of each combination of variables, i.e., subdivision/biological treatment system/waste category/type of waste. If further disaggregation of such a combination is required across the timeseries a time-prefix can be included in the subdivision name. For instance, where the emission rate of a technology changes across time, the addition of a prefix that indicates the technology before and after a certain date where the change in the emission rate occurred, allows the user to implement such technological evolution within the current structure of stratification of the variables.

Example of using a time-indication to stratify time series of data to deal with variability in the EF



Biological Treatment of Solid Waste

Worksheet

Sector: Waste
Category: Biological Treatment of Solid Waste
Subcategory: 4.B - Biological Treatment of Solid Waste
Sheet: Emissions from Biological Treatment of Solid Waste

Data
Gas METHANE (CH4)

Equation 4.1, 4.2

Subdivision	Biological Treatment System	Waste Category	Type of Waste	Total Annual amount treated by biological treatment facilities (Gg)	Emission Factor (g CH4 / kg waste treated)	Gross Annual Methane Generation (Gg)	Methane recovered (Gg)		Net Annual Methane Emissions (Gg)
				A	B	C = (A * B) / 1000	Flaring F	Energy use D	E = (C - F - D)
1990-2000 technology	Anaerobic digestion at biogas facil..	Municipal Waste	Food waste	1,000.000	3.000	3.000	0.000	0.000	3.000
2001-2010 technology				2,000.000	2.000	4.000	0.000	0.000	4.000
2011-onward technology				4,000.000	1.000	4.000	0.000	0.000	4.000

Worksheet sub-layers

Often worksheets have sub-layers that the user needs to access to enter data. To do so, click on the element ⊞ on the left-hand side of the worksheet. Once a sub-layer is displayed, the element ⊞ changes to ⊟.

Downloading data

Data entered in the calculation worksheets can be downloaded in an excel format from the **I.4. Uncertainty and Time Series data entry** functionality; although, the current version of the *Software* does not allow it for category 4.A and its subcategories. GHG estimates can be downloaded from the *Report* Menu in the main ribbon of the *Software*.

Data entry for user-specific Tier 3 methodologies

Recognizing that the *2006 IPCC Guidelines* allow reporting estimates produced with a Tier 3 user-specific[7] methodology, Tier 1 equations can be used to enter AD and Implied EFs (calculated by dividing the Tier-3 estimated GHG emissions with the underlying AD required by the IPCC Tier 1 equation(s)), to reproduce the estimated Tier 3 emissions.

Interoperability with the UNFCCC ETF GHG Inventory Reporting Tool

The *Software* has been upgraded to be interoperable with the UNFCCC electronic reporting tool for the CRT under the Enhanced Transparency Framework of the Paris Agreement.[8] In practice, that means that users of the *Software* can estimate GHG emissions and removals for categories and gases that are required to be reported pursuant to the UNFCCC CRT. Once data are entered into the *Software*, users wishing to use these data to facilitate reporting to the UNFCCC must generate a file in the *Software* (in JSON format) that may then subsequently be uploaded and further processed through the UNFCCC ETF GHG Inventory Reporting Tool, a separate UNFCCC platform.

A separate guidebook, titled IPCC Inventory Software: UNFCCC Interoperability- CRT Export Quick Start Guide, has been developed to assist users in generating the JSON file for upload to the UNFCCC CRT. Annex I of this guidance also illustrates the mapping of AD and GHG estimates for categories/gases from the *Software* to the corresponding UNFCCC CRT category/categories.

[4] The larger the number of strata, the more accurate and precise the estimates are.
[5] Stratification is the act of sorting data into distinct groups or layers.
[6] CSCs, Carbon Stock Change Factors
[7] User-specific methodologies need to be in accordance with IPCC good practice to satisfy the Transparency, Completeness, Consistency, Accuracy and Comparability reporting principles.
[8] As requested by Parties in decision 5/CMA.3, paragraphs 19 and 20.

4 Waste Sector

For the Waste sector, the IPCC Inventory Software estimates GHG emissions from solid waste disposal, biological treatment of solid waste, incineration and open burning of waste and wastewater treatment and discharge, implementing methods (Tier 1, Tier 2 and Tier 3) provided in Volume 5 of the *2006 IPCC Guidelines* and Chapter 6 of the *Wetlands Supplement*. Additionally, the *Software* implements methods provided in Chapter 6, Volume 5 of the *2019 Refinement* for estimation of N_2O emissions from industrial wastewater treatment and discharge as there is no method provided in the *2006 IPCC Guidelines* for this category.

CO_2 emissions of biogenic origin are not included in emissions from the Waste sector because any net change in carbon (C) stock of biogenic origin is covered in the Agriculture, Forestry and Other Land Use (AFOLU) sector. Only CO_2 emissions of fossil origin are estimated and included in the Waste sector.[9] Emissions from waste incineration without energy recovery are reported in the Waste sector, while emissions from incineration with energy recovery are reported in the Energy sector.

[9] The *Software* also estimates CO_2 emissions of biogenic origin from waste incineration and open burning for the purposes of interoperability with the UNFCCC ETF GHG Inventory Reporting Tool.

Table 1 all categories included in the Waste sector of the *2006 IPCC Guidelines*

Category	Definition	Gas	Guidebook
4.A Solid Waste Disposal	Methane is produced from anaerobic microbial decomposition of organic matter in solid waste disposal sites. Carbon dioxide (CO_2) is also produced but CO_2 from biogenic or organic waste sources is covered by the AFOLU sector. Emissions of halogenated gases should be accounted in IPPU. Long-term storage of carbon in SWDS is reported as an information item.	CH_4	4.A. Solid Waste Disposal (4.A, 4.A.1, 4.A.2, 4.A.3)
4.A.1 Managed Waste Disposal Sites	A managed solid waste disposal site must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and fires) and will include at least one of the following: cover material; mechanical compaction; or levelling of the waste. This category can be subdivided into aerobic and anaerobic.	CH_4	4.A. Solid Waste Disposal (4.A, 4.A.1, 4.A.2, 4.A.3)
4.A.2 Unmanaged Waste Disposal Sites	These are all other solid waste disposal sites that do not fall into the above category. This category can be subdivided into deep and shallow.	CH_4	4.A. Solid Waste Disposal (4.A, 4.A.1, 4.A.2, 4.A.3)
4.A.3 Uncategorised Waste Disposal Sites	Mixture of above 4.A.1 and 4.A.2. Countries that do not have data on division of managed/unmanaged may use this category.	CH_4	4.A. Solid Waste Disposal (4.A, 4.A.1, 4.A.2, 4.A.3)
4.B Biological Treatment of Solid Waste	Solid waste composting and other biological treatment. Emissions from biogas facilities (anaerobic digestion) with energy production are reported in the Energy sector (1.A.4).	CH_4 N_2O	4.B. Biological Treatment of Solid Waste
4.C Incineration and Open Burning of Waste	Incineration of waste and open burning of waste, not including waste-to-energy facilities. Emissions from waste burnt for energy are reported under the Energy sector, 1.A. Emissions from burning of agricultural wastes should be reported under AFOLU (3.C.1). All non-CO_2 greenhouse gases as well as CO_2 from fossil waste should be reported here for incineration and open burning.	CO_2 CH_4 N_2O	4.C. Incineration and Open Burning of Waste
4.C.1 Waste Incineration	Combustion of solid wastes in controlled incineration facilities.	CO_2 CH_4 N_2O	4.C.1. Waste Incineration
4.C.2 Open Burning of Waste	Combustion of waste in the open-air or in an open dump.	CO_2 CH_4 N_2O	4.C.2. Open Burning of Waste

4.D Wastewater Treatment and Discharge	Methane is produced from anaerobic decomposition of organic matter by bacteria in sewage facilities and from food processing and other industrial facilities during wastewater treatment. N_2O is also produced by bacteria (denitrification and nitrification) in wastewater treatment and discharge.	CH_4 N_2O	4.D. Wastewater Treatment and Discharge
4.D.1 Domestic Wastewater Treatment and Discharge	Treatment and discharge of liquid wastes and sludge from housing and commercial sources (including human waste) through wastewater sewage systems collection and treatment systems, open pits / latrines, anaerobic lagoons, anaerobic reactors and discharge into surface waters. Emissions from sludge disposed at SWDS are reported under category 4.A.	CH_4 N_2O	4.D.1. Domestic Wastewater Treatment and Discharge
4.D.2 Industrial Wastewater Treatment and Discharge	Treatment and discharge of liquid wastes and sludge from industrial processes such as: food processing, textiles, or pulp and paper production. This includes anaerobic lagoons, anaerobic reactors, and discharge into surface waters. Industrial wastewater released into domestic wastewater sewage should be included under 4.D.1.	CH_4 N_2O	4.D.2. Industrial Wastewater Treatment and Discharge
4.E Other	Release of GHGs from other waste handling activities than listed in categories 4.A to 4.D.	CO_2 CH_4 N_2O	4.E. Other

I General

I.1 Waste Type Manager

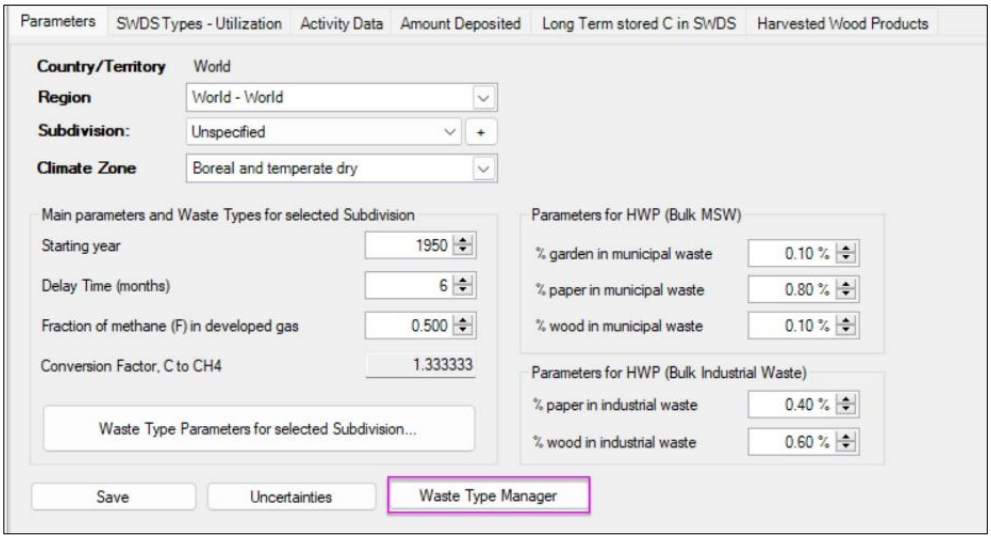
Before starting the estimation of emissions from the Waste sector, the **Waste Type Manager** should be populated with data and information that will be used by the *Software* to estimate GHG emissions from **solid waste**.

The **Waste Type Manager** includes the list of waste types relevant for the NGHGI along with parameters, that the *Software* uses to calculate associated GHG emissions. It is relevant for source-categories **4.A**, **4.B** and **4.C**, excluding the incineration of fossil liquid waste (in 4.C). It also does not apply to source-category **4.D**.

To access the **Waste Type Manager**:

1. Either, on the **Administrate** tab click **Waste** and then **Waste Type Manager.**

2. Or, as only Superusers have access to the **Administrate** tab, other users may access the **Waste Type Manager** in the lower right-hand corner of the category-level worksheets.



The **Waste Type Manager** has two levels of stratification of the solid waste:

I. **Waste Category**, by default containing the following categories:
   - ✓ *Industrial Waste*
   - ✓ *Municipal Waste*
   - ✓ *Sludge*
   - ✓ *Other Waste*

II. **Waste/Industry Type**, by default containing the following types of solid waste:
   - ✓ *Industrial Waste*:
     - ➢ *Bulk Industrial Waste* (this is alternative to all other default types for industrial waste)
     - ➢ *Food, Beverages & Tobacco*
     - ➢ *Petroleum Products, Solvents, Plastics* (do not decay to CH_4)
     - ➢ *Rubber* (do not decay to CH_4)
     - ➢ *Construction & Demolition*
     - ➢ *Wood & Wood Products*
     - ➢ *Pulp & Paper*
     - ➢ *Textile*
   - ✓ *Municipal Waste*:
     - ➢ *Bulk Municipal Waste* (this is alternative to all other default types for municipal waste)
     - ➢ *Food waste*
     - ➢ *Garden & Park*
     - ➢ *Glass* (do not decay to CH_4)
     - ➢ *Metal* (do not decay to CH_4)
     - ➢ *Plastics* (do not decay to CH_4)
     - ➢ *Rubber & Lather*
     - ➢ *Wood*
     - ➢ *Disposable Nappies*
     - ➢ *Paper & Cardboard*
     - ➢ *Textile*
   - ✓ *Sludge*,:
     - ➢ *Industrial sewage sludge*
     - ➢ *Municipal sewage sludge*
   - ✓ *Other Waste*:
     - ➢ *Clinical waste*
     - ➢ *Hazardous waste*

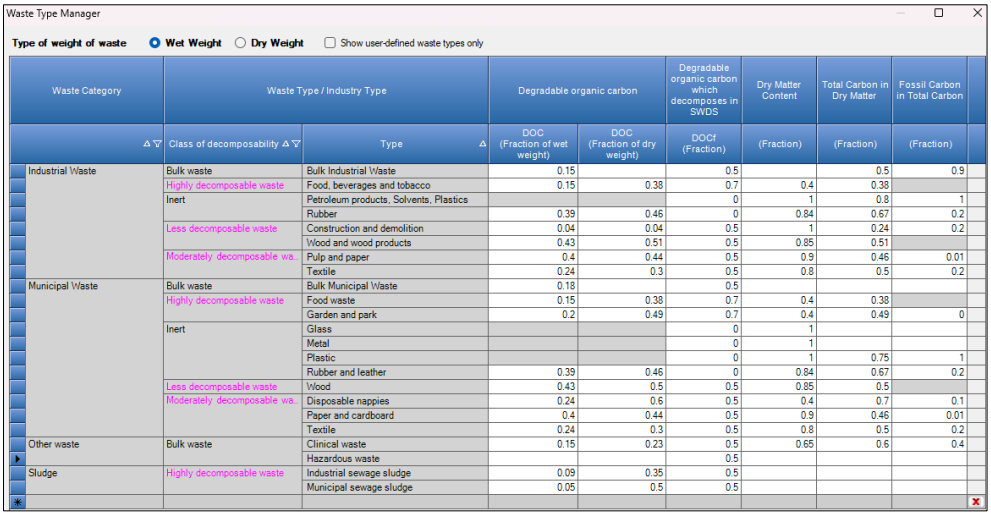
Users can enter any additional type, as needed.

For each *Waste type* the following parameters are included: *Decomposability class*, *Degradable Organic Carbon (DOC)*, *DOC Fraction that decays in anaerobic conditions (DOCf)*[10], *Dry Matter Content (dm)*, *Total Carbon in Dry Matter (CF)* and *Fossil Carbon in Total Carbon (FCF)*.

The values entered in the **Waste Type Manager** for the parameters: *Decomposability class*, *Degradable Organic Carbon (DOC)*, *DOC Fraction that decays in anaerobic conditions (DOCf)*, are used to calculate CH_4 emissions in 4.A.

The values entered in the **Waste Type Manager** for the parameters: *Dry Matter Content (dm)*, *Total Carbon in Dry Matter (CF)*, *Fossil Carbon in Total Carbon (FCF)* are used in 4.C and accordingly the *Software* maps those values from the **Waste Type Manager** to the calculation worksheets **Waste Incineration** and **Open Burning of Waste**. Nevertheless, in those calculation worksheets, users may overwrite the value mapped from the **Waste Type Manager** for those parameters, or directly enter a value if one is not included in the **Waste Type Manager.**

[10] DOC_f does not include the DOC fraction that decays under aerobic conditions. It is the product of DOC and MCF, where MCF is the Methane Correction Factor. This correction factor is used to remove the aerobically decomposed fraction of DOC from the total DOC available for decay under anaerobic conditions.



Waste Category	Waste Type / Industry Type		Degradable organic carbon		Degradable organic carbon which decomposes in SWDS	Dry Matter Content	Total Carbon in Dry Matter	Fossil Carbon in Total Carbon
	Class of decomposability	Type	DOC (Fraction of wet weight)	DOC (Fraction of dry weight)	DOCf (Fraction)	(Fraction)	(Fraction)	(Fraction)
Industrial Waste	Bulk waste	Bulk Industrial Waste	0.15		0.5		0.5	0.9
	Highly decomposable waste	Food, beverages and tobacco	0.15	0.38	0.7	0.4	0.38	
	Inert	Petroleum products, Solvents, Plastics			0	1	0.8	1
		Rubber	0.39	0.46	0	0.84	0.67	0.2
	Less decomposable waste	Construction and demolition	0.04	0.04	0.5	1	0.24	0.2
		Wood and wood products	0.43	0.51	0.5	0.85	0.51	
	Moderately decomposable wa..	Pulp and paper	0.4	0.44	0.5	0.9	0.46	0.01
		Textile	0.24	0.3	0.5	0.8	0.5	0.2
Municipal Waste	Bulk waste	Bulk Municipal Waste	0.18		0.5			
	Highly decomposable waste	Food waste	0.15	0.38	0.7	0.4	0.38	
		Garden and park	0.2	0.49	0.7	0.4	0.49	0
	Inert	Glass			0	1		
		Metal			0	1		
		Plastic			0	1	0.75	1
		Rubber and leather	0.39	0.46	0	0.84	0.67	0.2
	Less decomposable waste	Wood	0.43	0.5	0.5	0.85	0.5	
	Moderately decomposable wa..	Disposable nappies	0.24	0.6	0.5	0.4	0.7	0.1
		Paper and cardboard	0.4	0.44	0.5	0.9	0.46	0.01
		Textile	0.24	0.3	0.5	0.8	0.5	0.2
Other waste	Bulk waste	Clinical waste	0.15	0.23	0.5	0.65	0.6	0.4
		Hazardous waste			0.5			
Sludge	Highly decomposable waste	Industrial sewage sludge	0.09	0.35	0.5			
		Municipal sewage sludge	0.05	0.5	0.5			

Note: to allow the *Software* to estimate CH_4 emissions from 4.A subcategories, a value SHALL be contained in the **Waste Type Manager** for all those relevant parameters; while to estimate CH_4 emissions from 4.C, where the **Waste Type Manager** does not contain[11] a value for any of the relevant parameters, users can enter the value directly in the calculation worksheets.

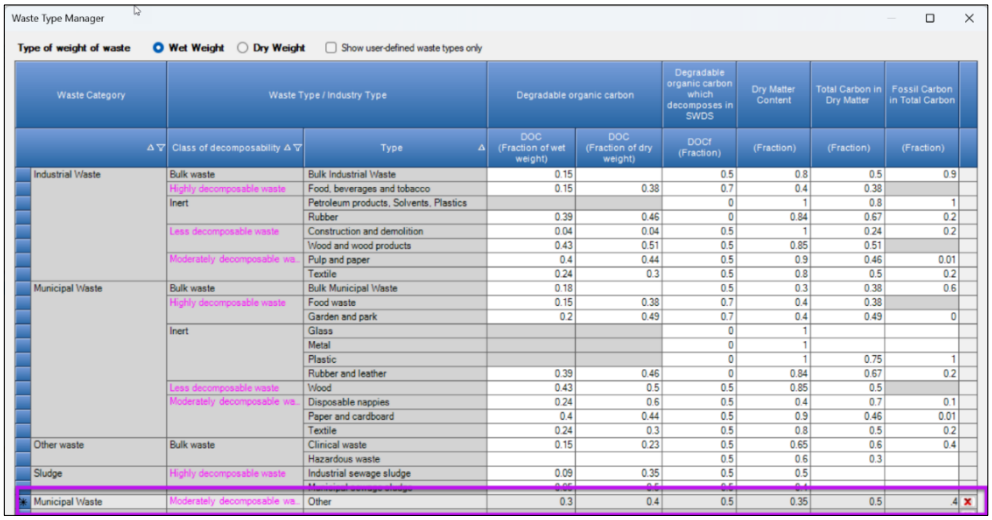
Note: the *DOC* value[12] for *Bulk Industrial Waste* type is the value provided by IPCC for the Bulk Municipal waste. Users are thus recommended to replace it with a value from their statistics.

[11] Waste types with a greyed-out cell in the FCF column in the **Waste Type Manager** will not have a value automatically completed by the *Software* in the relevant calculation worksheets of category 4.C for Dry Matter Content (dm) and Total Carbon in Dry Matter (CF). Users shall thus enter a 0 (zero) value for these waste types.

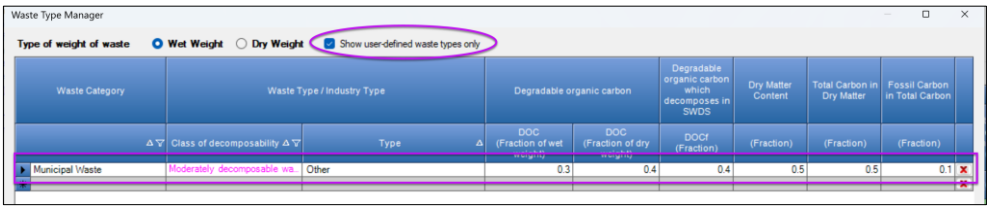
[12] IPCC TFI TSU will likely revise this value in next versions of the *Software*.

New waste types can be added to the **Waste Type Manager**. This is done on the bottom-most row, the one identified by an asterisk, by:

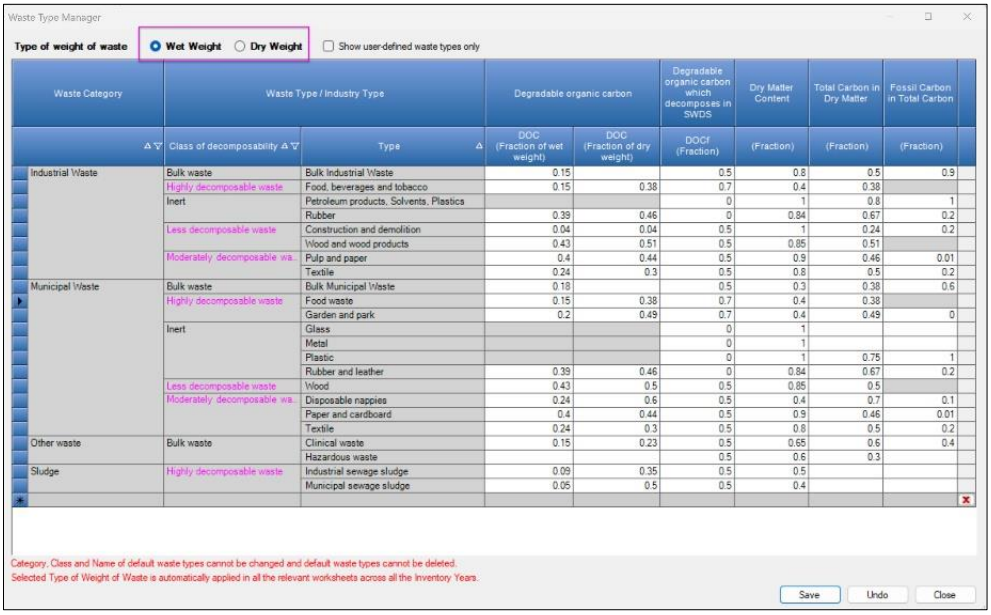
1. Column |Waste Category|: select *Waste Category* from the drop-down menu.
2. Column |[Waste] Type|: enter the additional waste type.
3. Column |Class of decomposability|: select the degree of decomposability of the additional waste type from the drop-down.
4. In the remaining columns: enter the value associated with the additional waste type for each of the parameters
5. Click the **Save** button at the bottom of the window, critical to avoid losing data entered.
6. Click the **Close** button at the bottom of the window once entry of additional waste types and/or user-specific values for the parameters is complete.



To see the user-defined waste type(s) only, tick in the box **Show user-defined waste types only** on the top of the **Waste Type Manager** TAB.



Users can also select to use AD in *Wet Weight* or in *Dry Weight*. To do so, users check the relevant checkbox at the top of the TAB. By default, the *Software* requires AD in in *Wet Weight*.

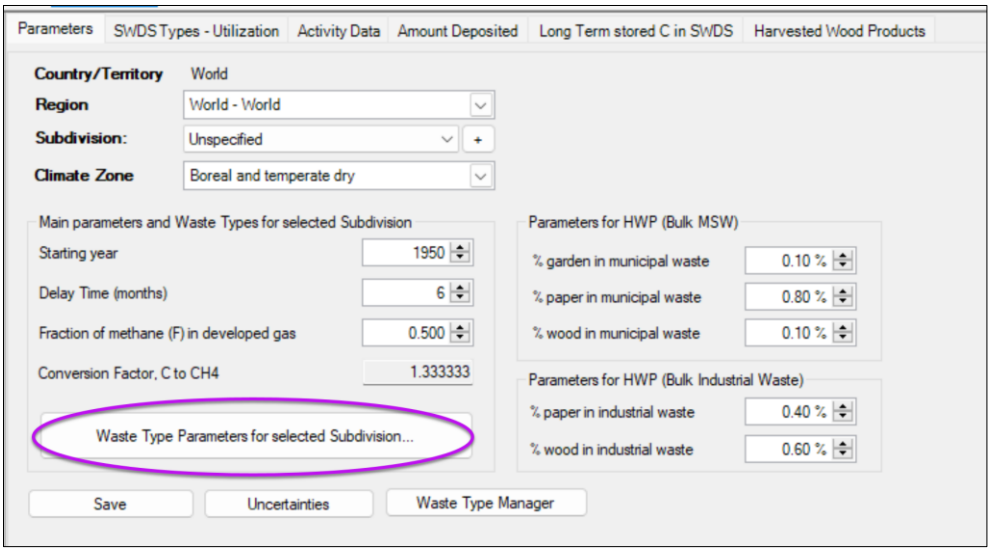


RECALL: interoperability with UNFCCC CRTs requires AD in wet weights

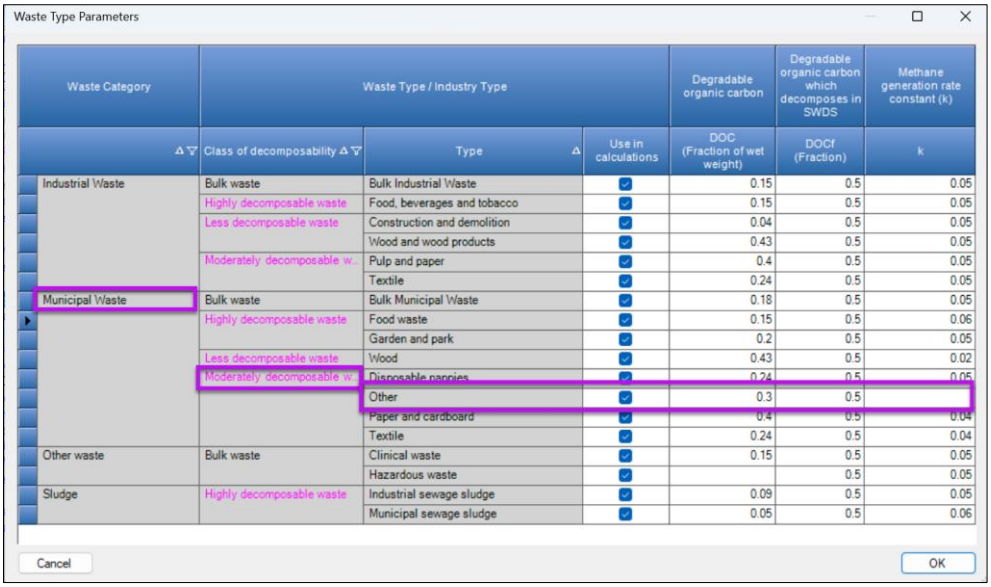
Waste Type Parameters for selected Subdivision…

The *Software* allows users to have a different list of waste types and different values of associated parameters *Degradable Organic Carbon (DOC)*, *DOC Fraction that decays in anaerobic conditions (DOCf)*, *Methane generation rate (k)* in each *Subdivision* set in the NGHGI. To set different waste types and parameters for each relevant subdivision, users:

I. Open TAB *Waste Type Parameters* by clicking **Waste Type Parameters for selected Subdivision…** button in worksheet **Parameters** of category *4.A Solid Waste Disposal.*



The TAB **Waste Type Parameters** opens, where all waste types that contain degradable organic carbon entered in the **Waste Type Manager**, including any additional waste type entered by users, are listed.



II. In Column |Use in Calculation|, check or uncheck the waste types that apply to the calculation of CH_4 emissions from the relevant subdivision. By default, all waste types are checked[13].

Given both typologies of waste -i.e. bulk[14] *vs* disaggregated[15] types- are selected by default, users **shall** decide for waste categories *Municipal Waste* and *Industrial Waste* whether to prepare estimates based on the bulk quantity of waste or based on the quantities of the various fractions of waste. Accordingly:

✓ If users apply bulk type of waste, then deselect all non-bulk waste types of the relevant waste category. E.g., if bulk waste is being used for *Industrial waste* data the following selection applies:

[13] Which means the *Software* provides by default that waste type in the relevant calculation worksheets.
[14] Bulk waste option.
[15] Waste components option.

Waste Category	Waste Type / Industry Type		
	Class of decomposability	Type	Use in calculations
Industrial Waste	Bulk waste	Bulk Industrial Waste	☑
	Highly decomposable waste	Food, beverages and tobacco	☐
	Less decomposable waste	Construction and demolition	☐
		Wood and wood products	☐
	Moderately decomposable w...	Pulp and paper	☐
		Textile	☐

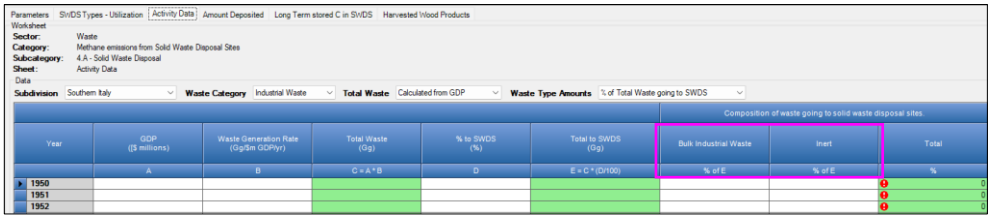
✓ If users apply disaggregated types of waste, then deselect the bulk waste type of the relevant waste category. E.g., if disaggregated waste types are being used for *Municipal waste* data the following selection applies:

Waste Category	Waste Type / Industry Type		
	Class of decomposability	Type	Use in calculations
Industrial Waste	Bulk waste	Bulk Industrial Waste	☑
	Highly decomposable waste	Food, beverages and tobacco	☐
	Less decomposable waste	Construction and demolition	☐
		Wood and wood products	☐
	Moderately decomposable w...	Pulp and paper	☐
		Textile	☐
Municipal Waste	Bulk waste	Bulk Municipal Waste	☐
	Highly decomposable waste	Food waste	☑
		Garden and park	☑
	Less decomposable waste	Wood	☑
	Moderately decomposable w...	Disposable nappies	☑
		Paper and cardboard	☑
		Textile	☑

The *Software* structures the worksheets *Activity Data*, *Amount Deposited*, *Long term stored C in SWDS* according to the checked list of waste types.

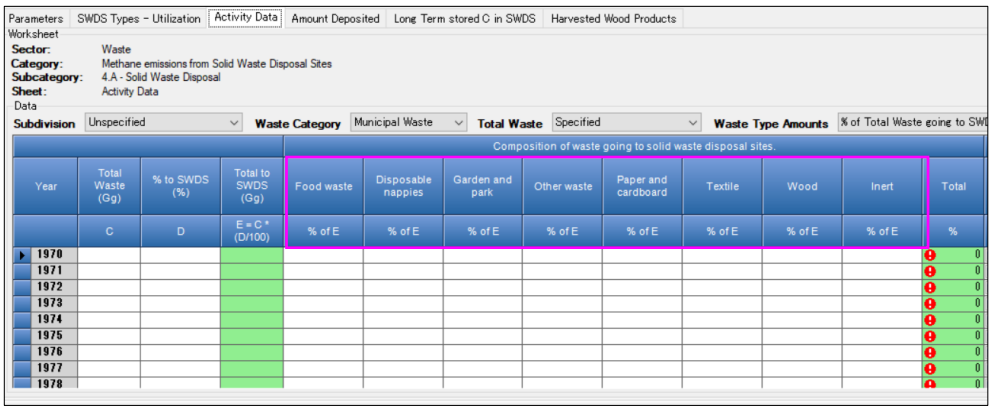
For instance, for the *Industrial waste* category example given above only two waste types are in the worksheet **Activity Data**: *Bulk Industrial Waste* and *Inert*.

Example: Bulk waste option



Similarly, for the *Municipal waste* category example all IPCC default waste types are in the worksheet *Activity Data*, with in addition a generic type *Inert*.

Example: Waste components option



Note: regardless of the selection of waste types used in the calculation, the *Software* always includes a generic column |Inert| in worksheets *Activity Data* and *Amount Deposited*, where AD of all inert waste types[16,17] are to be entered combined. **However**, the IPCC Tier 1 method includes the inert fraction of waste in the bulk waste AD and EF; thus, when the IPCC Tier 1 method is applied, the value to be entered in column |Inert| should be zero (0) for the entire time series, regardless of the unit of this column, i.e. *Gg* or *%*.

Similarly, when applying higher tiers, if the AD entered for *Bulk Industrial Waste* or *Bulk Municipal Waste* includes the inert fraction, then a value of zero should entered in column |Inert| for the entire time series.

III. Revise[18] values, to be applied to that subdivision only[19], for any of the parameters *Degradable Organic Carbon (DOC)* and *DOC Fraction that decays in anaerobic conditions (DOCf)* as required for any of the waste types.

IV. Enter[20] values for *Methane generation rate (k)*.

[16] The IPCC default waste types of inert class of decomposability in the *Municipal waste* category are: (1) *glass*, (2) *metal*, (3) *plastic*, (4) *rubber and lather*. Although *Rubber and lather* contains degradable organic carbon, it is qualified as inert given the IPCC default value for *DOCf* is zero (0).

[17] The IPCC default waste types of inert class of decomposability in the *Industrial waste* category are: (1) *Petroleum products, Solvents, Plastic*, (2) *Rubber*. Although *Rubber* contains degradable organic carbon, it is qualified as inert given the IPCC default value for *DOCf* is zero (0).

[18] Enter a different value to replace a value carried in the TAB from the **Waste Type Manager**, including replacing a 0 value or a non-value i.e. blank cell.

[19] This means that the revised values for those parameters do not overwrite those present in the **Waste Type Manager**, and thus that different values can be used for different subdivisions of category *4.A Solid Waste Disposal* and consequently of its subcategories *4.A.1*, *4.A.2*, *4.A.3*.

[20] In version 2.95 of the *Software*, the IPCC default values are presented in a drop-down menu, from which the users can select a value or alternatively directly type a user-specific value.

I.2 Use of multiple tiers for reporting

The 2006 IPCC Guidelines provide methodological guidance to estimate anthropogenic GHG emissions and removals according to three methodological tier levels: Tier 1, Tier 2, Tier 3. Where Tier 1 is the common default methodological approach that the IPCC Guidelines provide to all inventory compilers, higher tiers are based on user-specific and multivariable-dependent rates of GHG emissions and CO_2 removals, and likely requires data with a higher spatial and temporal resolution.

For some sectors, Tier 2 may apply a different methodological approach, but in the Waste sector it follows the Tier 1 methodology approach with user-specific values for parameters and EFs. The AD may also be further disaggregated to apply condition-specific values of parameters and EFs.

Tier 3 is generally[21] a user-specific methodology that maintains consistency with IPCC good practice, although it is designed to better cope with the user-specific statistical population for which GHG emissions/removals are estimated or it is based on the direct monitoring of the source of GHG emissions. When applying a user-specific Tier 3 methodology, it is important that the users incorporate the relevant AD and GHG emissions in the *Software*, to ensure that the *Software* reflects a complete NGHGI, covering all sources and sinks in the country. Depending on the nature of the Tier 3 method there may be alternative ways to incorporate the Tier 3 estimates. What is important is that the emissions are included in a transparent manner and described in any accompanying inventory report.

Given that the *Software* can calculate GHG emissions and removals for each source/sink category using any of the methodological tiers provided in the *2006 IPCC Guidelines* and its *Wetlands Supplement*, the user may apply a single methodological tier to the entire category or may use instead a combination of different tiers according to the significance of subcategories and data availability.

While, as described above, users may use a combination of tiers within a single source category, they may also wish to apply multiple tiers to the same activity as a means of quality control through comparative analysis (e.g., Tier 1 *vs* Tier 2 or Tier 2 *vs* Tier 3). Although this is a legitimate use of the *Software*, for those comparative analysis it is recommended that this is done in a separate database not used for reporting the GHG inventory, to avoid double counting GHG emissions from a source.

Where a user-specific Tier 3 method, which cannot be calculated by the *Software*, is used to prepare estimates of GHG emissions that need to be included in the NGHGI for completeness, the user can use the relevant calculation worksheet(s) to report it as it follows:

1. Enter in the *Software* the AD required by the IPCC default methodology.
2. Back-calculate CO_2 and/or CH_4 and/or N_2O IEFs, as the total emissions of the relevant GHG calculated through the user-specific Tier 3 method divided by the AD required at bullet 1 above and enter those in the *Software*.
3. The *Software* then reproduces the user-specific Tier 3 GHG estimates.

A dedicated subdivision could be entered, e.g., specifically titled as "Tier 3" with any other identifying information, as appropriate.

[21] In some cases, the IPCC also provides a Tier 3 methodology, as for instance for N_2O emissions from incineration of waste.

I.3 Reporting of Subdivisions

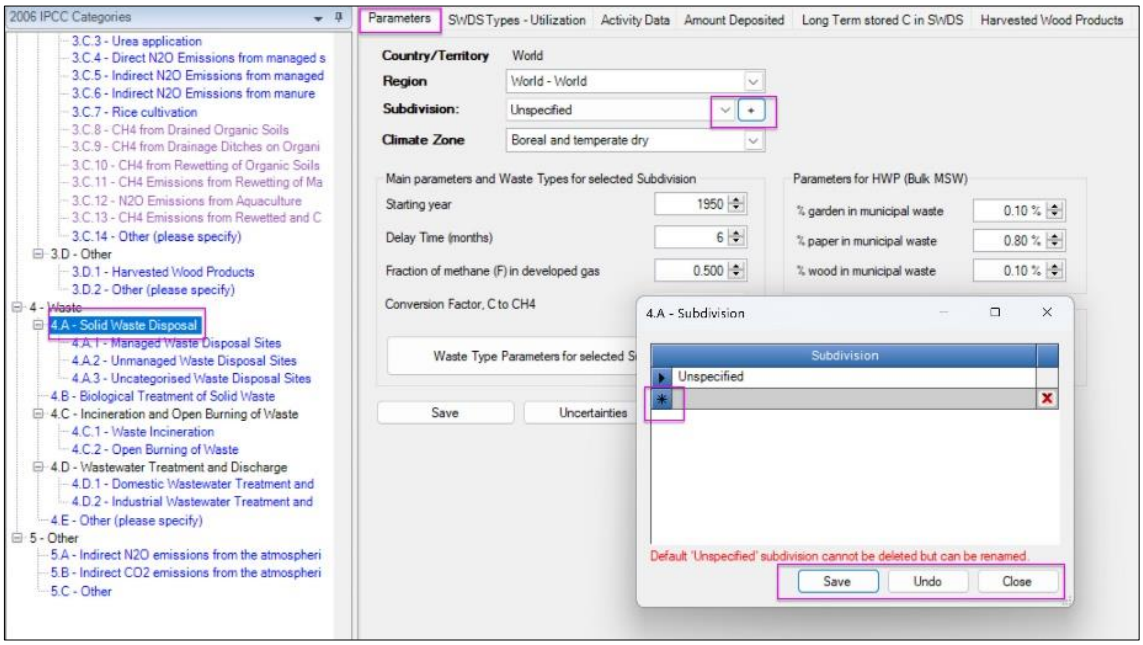
GHG emissions and removals can be calculated at multiple levels of aggregation (e.g., facility, regional, national) to meet various domestic and international needs. Thus, *Subdivisions* can be defined for all source categories in the Waste sector.

Where the user is interested in calculating GHG estimates at a single level of aggregation, e.g., national, in column |Subdivision| either "Unspecified" is to be selected from the dropdown menu or a single univocal name/code is to be entered e.g., *a country name*.

Where the user is interested in calculating GHG estimates for multiple subdivisions; users have full flexibility to name those subdivisions based on user-specific circumstances. Nevertheless, care shall be taken to ensure that subdivisions do not overlap, resulting in double counting of some emissions/removals.

In the **Waste sector** there are two ways to enter user information on subdivisions, depending on the category

- For category *4.A Solid Waste Disposal* and all its subcategories (4.A.1, 4.A.2, 4.A.3), to enter a new subdivision or to rename the default unique subdivision *Unspecified*:
  1. Select **4.A Solid Waste Disposal** from the category tree.
  2. Select TAB **Parameters.**
  3. In the third row down click on the "**+**" sign next to **Subdivision**, to open a new TAB.



   a. To rename the default unique subdivision *Unspecified*, click on it and enter the user's name.

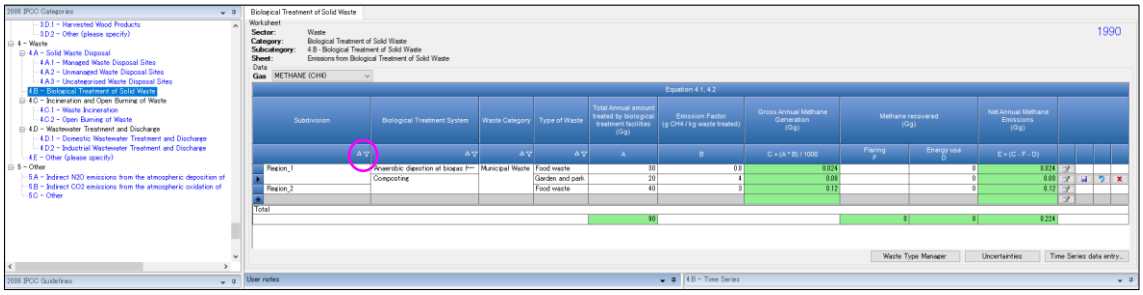
   b. To enter a new subdivision, click the bottom-most row (the one with an asterisk) and enter the subdivision's name.

  4. Once data has been entered, click the **Save** button at the bottom and then **Close**.
     Note: for each subdivision, users have to select in the Waste Type Parameters TAB the waste types, among those listed in the Waste Type Manager, Users can also modify DOC, DOCf and k values entered in the Waste Type Manager and those modified values apply to that[22] subdivision only.

- For all other categories, enter the univocal name/code for each subdivision in column |Subdivision|.

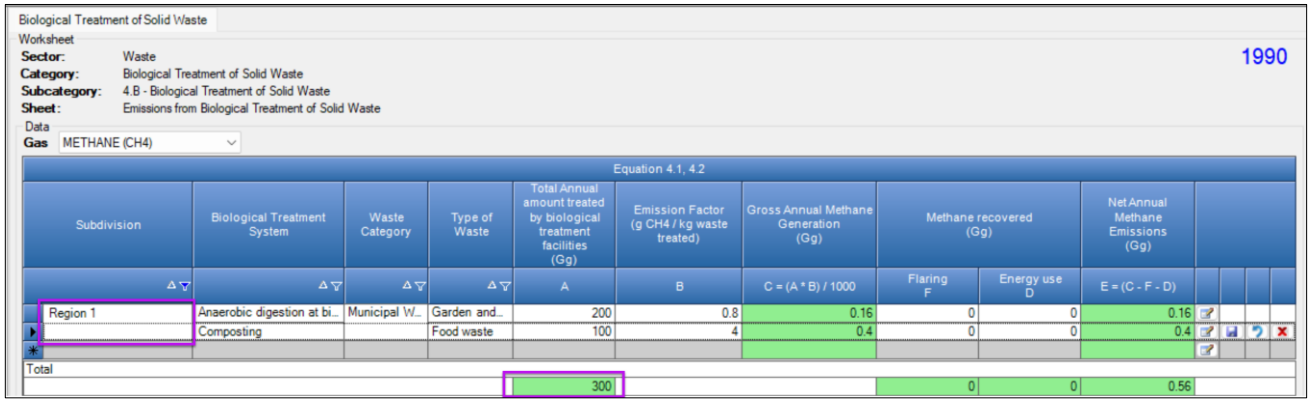
  Calculation worksheets include filters to enable the user to view data entry, by subdivision.

Example: **Subdivisions and applying filter**



[22] This means that new values entered for *DOC and/or DOCf* in the Waste Type Parameters do not modify values of those parameters entered in the **Waste Type Manager**.

Example: **Viewing filtered results**



Biological Treatment of Solid Waste

Worksheet

Sector: Waste
Category: Biological Treatment of Solid Waste
Subcategory: 4.B - Biological Treatment of Solid Waste
Sheet: Emissions from Biological Treatment of Solid Waste

1990

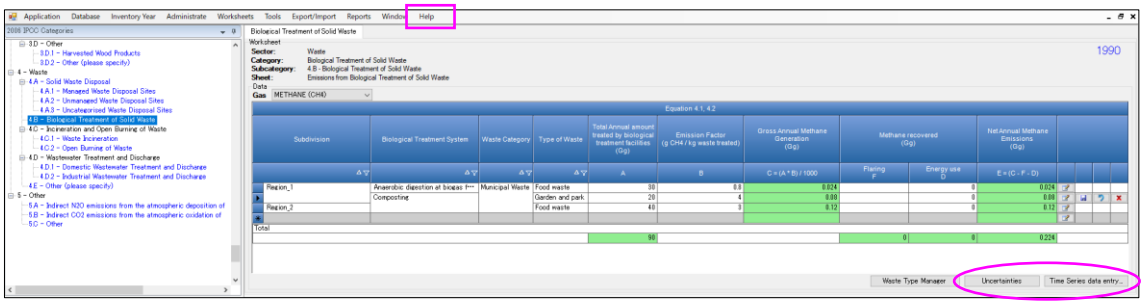
Data

Gas METHANE (CH4)

Equation 4.1, 4.2									
Subdivision	Biological Treatment System	Waste Category	Type of Waste	Total Annual amount treated by biological treatment facilities (Gg)	Emission Factor (g CH4 / kg waste treated)	Gross Annual Methane Generation (Gg)	Methane recovered (Gg)		Net Annual Methane Emissions (Gg)
				A	B	C = (A * B) / 1000	Flaring F	Energy use D	E = (C - F - D)
Region 1	Anaerobic digestion at bi...	Municipal W...	Garden and...	200	0.8	0.16	0	0	0.16
	Composting		Food waste	100	4	0.4	0	0	0.4
Total				300			0	0	0.56

I.4. Uncertainty and Time Series data entry

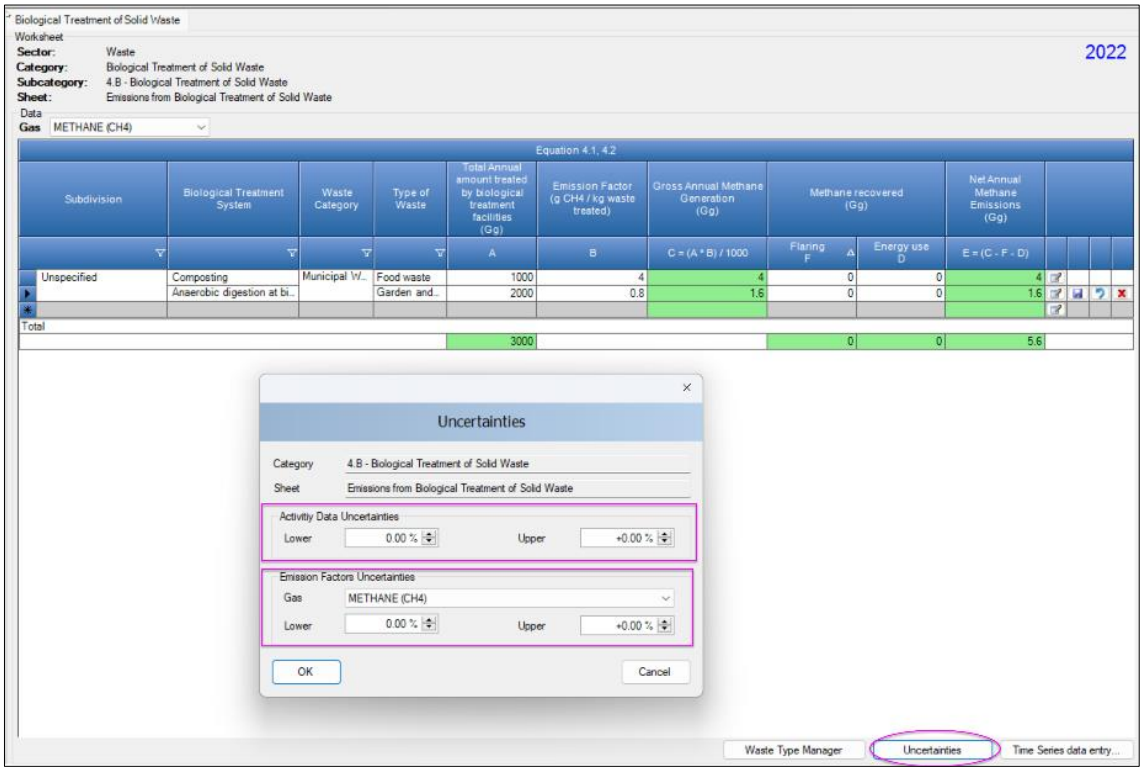
To enter data on *Uncertainties* or *Time Series data*, calculation worksheets have dedicated tabs that can be accessed through buttons placed at the lower right-hand side of the calculation worksheets. Users are prompted to learn about how to use these functionalities in the *User Manual* of the *Software* (accessible at *Help* tab).



Uncertainty:

Default uncertainties for AD and EFs will be incorporated in the *Software* but users can enter user-specific data on uncertainties overwriting the values currently entered in the *Software* (0.00%).

Clicking the button Uncertainties, a pop-up window opens where users can enter lower and upper ranges of uncertainties for both AD and EF.

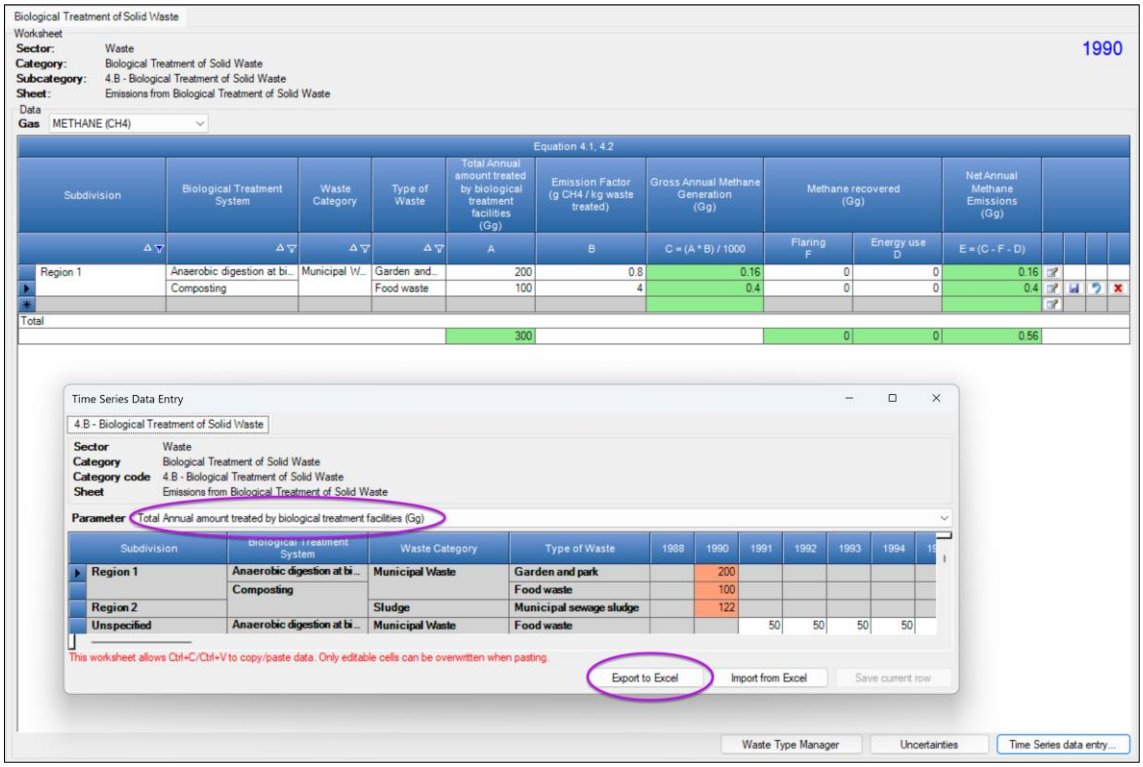


Further information on the underlying sources of uncertainty and the default uncertainty values that can be used when user-specific information is not available can be found in the *2006 IPCC Guidelines* in sections titled Uncertainty Assessment for each source category.

Please note that the Uncertainty Analysis has not yet been enhanced in this version of the *Software*, so this section will be revised in the next future.

To use the time Series data entry functionality:

1. Select **Time Series data entry** in any worksheet, as shown in the screenshot below, and a pop-up window opens.
2. Select from the drop-down list, the **parameter** for which a user wants to upload a time series of data.
3. Press the button **Export to Excel**, name the file and save it to your computer.
4. Open the exported Excel file and for the entire time series, or for any fraction of it, enter data or make changes to data already present.
5. Once data are compiled, the file is imported back into the *Software* by clicking the button **Import from Excel.**



In addition, users can also edit or make changes for the selected parameters directly in orange or white cells (editable cells for the current inventory year and other years, respectively). The changes made will be transferred to relevant calculation worksheets of the *Software*.

4.A. Solid Waste Disposal (4.A, 4.A.1, 4.A.2, 4.A.3)

Information

The *Software* implements the *First Order Decay* (FOD) method to estimate CH_4 emissions from decay of organic matter in SWDSs. It also estimates the organic C stored for long term in the SWDS for each waste type and for each harvested wood product (HWP).

Solid Waste Disposal source categories are shown in Table 1. Methodological guidance on estimation of GHG emissions from solid waste disposal are provided in Chapter 3, Volume 5 of the *2006 IPCC Guidelines*. Furthermore, Chapter 3, Volume 5 of the *2019 Refinement* provides an updated guidance including new types of solid waste disposal site (SWDS) and corresponding default values.

GHGs

The Software estimates the following GHGs for SWDS categories.

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
	X					

Treatment and disposal of municipal, industrial and other solid waste produces significant amounts of CH_4. In addition to CH_4, biogenic carbon dioxide (CO_2) and smaller amounts of N_2O are also produced but they are not included in the Waste sector of the *Software*. CO_2 emissions are not estimated in Waste sector as the carbon (C) is of biogenic origin and net emissions of biogenic CO_2 are estimated and included in the AFOLU sector. The *2006 IPCC Guidelines* do not provide a methodology for N_2O emissions from SWDS, given these are not significant.

IPCC Equations

- ✓ Tier 1: IPCC Tier 1 equations 3.1; 3.2, 3.4, 3.5 and 3.6.
- ✓ Tier 2: IPCC FOD method, although with AD on current and historical waste disposal at SWDS.
- ✓ Tier 3: either (1) the IPCC FOD method with user-specific AD and nationally developed key parameters, or (2) measurement derived country-specific parameters.

As explained in section I.2 Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates CH_4 emissions using worksheets:

I. **Waste Type Manager**: contains parameter data for each waste type, and the selection for AD between wet[23] or dry weight.

II. **Category 4.A. Solid Waste Disposal:** contains **six** worksheets for entering AD on annual production of Solid Waste, its composition and its final disposal to the various SWDS types in categories:

- *4.A.1 Managed Waste Disposal Sites*, (managed anaerobic SWDS; managed poorly, semi-aerobic SWDS; managed well, semi-aerobic SWDS; managed poorly, active aeration SWDS; managed well, active aeration SWDS),
- *4.A.2 Unmanaged Waste Disposal Sites,*
- *4.A.3 Uncategorised Waste Disposal Sites.*

- ➢ **Parameters**: for each subdivision, contains *Region* and *Climate Zone*, *Waste types* and *Parameters* to calculate the decay of landfilled waste to CH_4.
- ➢ **SWDS Types - Utilization**: for each subdivision, contains percentage share of each *Waste category* solid waste disposed to each SWDS type.
- ➢ **Activity Data**: for each subdivision, contains annual amount of waste generated[24] for each *Waste category*, and the fraction[25] and composition of waste going to SWDS.

[23] The UNFCCC NGHGI requires wet weights.
[24] The *Software* allows the user to either enter the amount of solid waste generated directly or to calculate it from the population (i.e., Municipal Waste) or the GDP (i.e., Industrial Waste) according to IPCC default methodology.
[25] The *Software* allows the user to either enter the amount of each waste type of the relevant waste category or to enter its percentage share of the total amount of the waste category.

- **Amount deposited**: for each subdivision, contains total mass (Gg) of each waste type deposited in SWDS as calculated by the *Software* from information entered in worksheets **SWDS Types - Utilization** and **Activity Data**.
- **Long-Term stored C in SWDS**: for each subdivision, contains mass per year (Gg/year) of organic C stored for long-term[26] in SWDS for each[27] type of waste deposited, as calculated by the *Software* from data in worksheet **Activity Data** and parameters provided in TAB **Waste Type Parameters for selected Subdivision…..**.
- **Harvested Wood Products**: for each subdivision, contains mass per year (Gg/year) of organic C stored for long-term[28] in SWDS for each type of wood-based[29] waste, as well as: accumulated long-term stored C, CH_4 generated and CH_4 emitted; as calculated by the *Software*.

III. Each of the three subcategories of **Category 4.A. Solid Waste Disposal** [4.A.1 Managed Waste Disposal Sites, 4.A.2 Unmanaged Waste Disposal Sites, and 4.A.3 Uncategorised Waste Disposal Sites.] contains **three** worksheets where CH_4 emissions from each of the SWDS types are estimated:

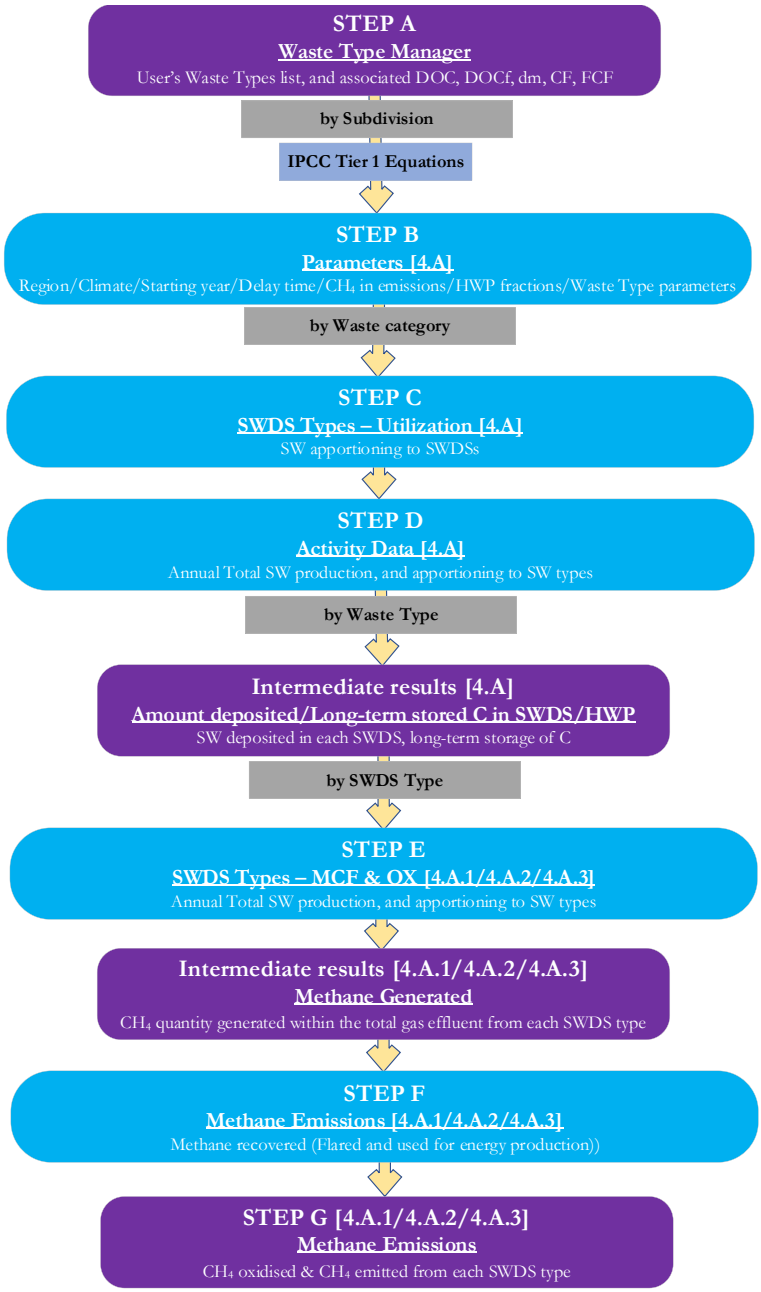
- **SWDS Types – MCF and OX** allows users to enter *Methane Correction Factor (MCF)*[30] and *Oxidation factor (OX)* values for each type of SWDS in each subdivision.
- **Methane Generated**: for each subdivision, calculates CH_4 generated for each type of SWDS/Waste category/Waste type.
- **Methane Emissions contains data**: for each subdivision, contains data on CH_4 recovered, flared or used for energy production, and calculates CH_4 emissions based on CH_4 generated, the amount of CH_4 recovered, and the amount of CH_4 oxidized.

[26] IPCC Equation 3A1.19.
[27] Each of those that contain organic matter.
[28] IPCC Equation 3A1.19.
[29] I.e., garden, paper and wood waste.
[30] To correct DDOCm (i.e., the amount of organic carbon that is under anaerobic conditions in SWDS) by the fraction of total amount of Degradable Organic Carbon disposed (WT*DOC) that instead decomposes under aerobic conditions. The value of MCF ranges from 0 to 1; where an MCF = 0 means that all carbon decomposes aerobically and an MCF = 1 that all carbon is under anaerobic conditions.

User's work Flowchart

Consistent with the key category analysis and the decision tree Figure 3.1, Chapter 3, Volume 5 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific and/or technology-specific EFs and parameters.

Solid Waste Disposal – flowchart



Step A, **Waste Type Manager**, users (1) enter values for parameters for which an IPCC default value is not precompiled, or (2) replace the value precompiled with their own user-specific values; and (3) enter user-specific waste types, if any, and associated values for parameters.

Then, for each subdivision, if any:

Step B, worksheet **Parameters [4.A]**, users define Region and Climate zone, then enter FOD parameters and waste type and associated parameters.

Then, for each Waste category:

Step C, worksheet **SWDS Types-Utilization [4.A]**, users enter fractions (percentage) to allocate the total waste of the relevant waste category to each SWDS type.

Step D, worksheet **Activity Data [4.A]**, users enter/calculate amount of waste disposed to SWDS and its composition in relevant waste types.

The *Software* calculates **intermediate variables** by *Waste type* in worksheets **Amount deposited** -SW deposited in each SWDS-, **Long-term stored C in SWDS** -long-term storage of organic C in each waste type and HWP-associated CH_4 emissions-, **Harvested Wood Products** -long-term storage of organic C in each HWP-.

Then, for each SWDS type, in each subdivision of each category 4.A.1/4.A.2/4.A.3:

Step E, worksheet **SWDS Types - MCF and OX**, users enter *Methane Correction Factor (MCF)* value, which the *Software* uses to calculate the amount of waste that is under anaerobic conditions[31] in each SWDS, and *Oxidation factor (OX)* value, which the *Software* uses to calculate the quantity of CH_4 generated that is oxidised in the SWDS and thus not emitted.

The *Software* calculates, as an **intermediate variable**, CH_4 generated by each *Waste type* in worksheet **Methane generated**.

Step F, worksheet **Methane Emissions**, users enter amount of CH_4 recovered, either *flared* or recovered for *energy use*. Then, the *Software* calculates CH_4 emissions.

[31] A fraction of which decomposes (i.e., *DOCf*) while the remaining fraction cumulates for long term.

Set FOD model

IPCC methodology applies a first order decay model to estimate the decay of the decomposable[32] fraction of organic carbon contained in waste disposed to SWDS. Accordingly, it estimates the CH_4 emissions as a fraction of the C decayed[33], the one anaerobically decayed, while the remaining decayed carbon is oxidised to CO_2 and thus not included in the Inventory total GHG emission.

Before entering AD and EF, users:

- (1) set and (2) characterize relevant waste types,
- (3) set subdivisions, and (4) for each subdivision:
  - ✓ assign the relevant waste types, and revise, where needed, associated values of parameters *DOC, DOCf, dm, CF* and *FCF*,
  - ✓ characterize FOD parameters.

Note when the estimates are being completed in the *Software* for the first time, users enter data for the entire timeseries; thereafter only data of the new inventory year to be estimated needs to be entered.

[32] The other fraction does not decompose, and it is thus long-term stored in the SWDSs, as e.g., lignin.
[33] Through the Methane Correction Factor (MCF).

Thus, users:

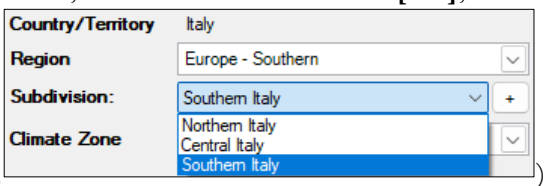
A. For the entire inventory, enter in the **Waste Type Manager**:

- ✓ user-specific values for parameters *DOC and DOCf,* of IPCC default waste types, if any,
  Note: where users apply IPCC default values only, this step does not apply.
- ✓ user-specific waste types, and associated values of parameters[34] *DOC* and *DOCf,* if any.
  Note: where users apply IPCC default values only, this step does not apply.

B. For the entire inventory, manage in worksheet **Parameters [4.A]** subdivisions (see **I.3 Reporting of Subdivisions**) by:

- ✓ renaming[35] the default subdivision *Unspecified*, if so decided,
- ✓ entering additional subdivisions, if any.
  Note: where users do not disaggregate the inventory in subdivisions, this step does not apply.

C. For each subdivision, in worksheet **Parameters [4.A]**, as selected from the dropdown menu in the field *Subdivision* (e.g.,



), users:

- ✓ select *Region*[36],
- ✓ select *Climate zone*[37],
- ✓ select *Starting year*[38], from which to enter the time series of AD,
- ✓ select *Delay time (months)*, keep the IPCC default[39] or select an alternative value,
- ✓ select *Fraction of Methane in developed gas (F)*[40], keep the IPCC default or select an alternative value.

Then, in worksheet **Parameter** of category 4.A, in TAB *Waste type Parameters*, which is accessed by clicking Waste Type Parameters for selected Subdivision… button of selected subdivision (see Waste Type Parameters for selected Subdivision…) users:

- ✓ Uncheck[41] the waste types that do not apply to the NGHGI for that subdivision. **Note** this shall be done for the single one default *Subdivision* even if no additional Subdivisions are entered by users.
- ✓ Where any of the parameters *DOC, DOCf, k* have a value in the selected *Subdivision* that is different than the value listed in TAB *Waste types Parameters for selected subdivision*, then enter it by overwriting the value present (see Waste Type Parameters for selected Subdivision…) or just enter it where the cell is blank.
- ✓ *Parameters for HWP (Municipal waste) and HWP (Industrial waste)* , are relevant only if estimates are prepared with *Bulk Industrial Waste* or *Bulk Municipal Waste*. In both cases, users select the value for the fraction (percentage) of bulk waste that is *garden*[42], *paper*, *wood*.

  This information is critical to allow the *Software* to compile data in worksheet **Harvested Wood Products** worksheet of category 4.A. Values for *garden*, *paper*, *wood* fractions of *Bulk Municipal Waste* are contained in Table 2A.2 (NEW) although they are not present in the *Software*; thus if users wish to use these values, they will have to enter them in the *Software*.

[34] Although the following parameters *dm*, *CF* and *FCF*, do not apply to the 4.A category, and thus are discussed in this Guidebook for category 4.C only, users may wish to populate values for those too.
[35] If only one subdivision is used, users may leave the *Unspecified* name or rename it (e.g., "Total National"). The name of one of the Regions or other sub-aggregation variables can be applied to subdivisions.
[36] This field is used by the *Software* to select the IPCC defaults for MSW generation and treatment. Thus, if users enter waste generation data instead of applying IPCC equations to calculate those, *Region*'s selection is not applicable.
[37] This field is used by the *Software* to select the IPCC defaults for methane generation rate (k) and half-life ($t_{1/2}$). If users enter user-specific values for those parameters, Climate zone's selection is not applicable.
[38] It is good practice to use disposal data for at least 50 years as this time frame provides an acceptably accurate result for most typical disposal practices and conditions.
[39] While the IPCC default value is 6 months, users may revise it; however, it is *good practice* to choose a delay time of between zero and six months.
[40] This is the fraction of CH_4 in the gas emitted in anaerobic conditions from an SWDS.
[41] Recall that all waste types listed in the **Waste Type Manager** are checked by default in each Subdivision.
[42] This applies to Municipal Solid Waste only.

Activity Data input

The *2006 IPCC Guidelines*, Chapter 2 contains information about the compilation of AD on waste generation composition and management, and Section 3.2.2 provides guidance on AD to estimate CH_4 emissions from SWDS.

The AD to be entered for EACH SUBDIVISION[43] for subcategories 4.A.1, 4.A.2, 4.A.3 consists of:

I. waste generation of each waste category, and its composition as bulk waste or by waste types,

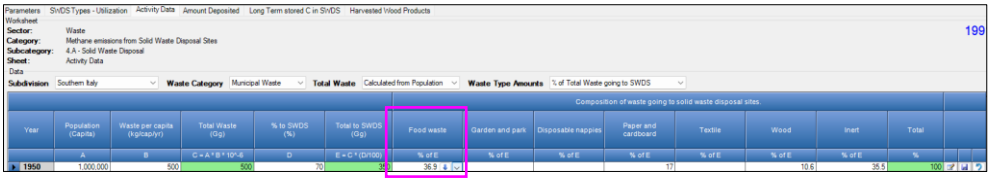
II. fraction of each waste category disposed to each SWDS type.

NOTE: AD for subcategories 4.A.1, 4.A.2, 4.A.3 are entered or calculated altogether in worksheets of category 4.A.

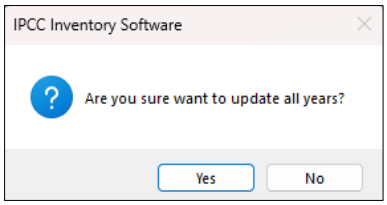
RECALL: AD are all annual, i.e. represent a calendar year or a fiscal year activity.

NOTE: all worksheets where users can enter values have a unique feature: the icon on the right-hand side of each cell of the first row. By clicking on it, the *Software* copies the value entered in the cell in the first row to the entire time series of cells in the column.

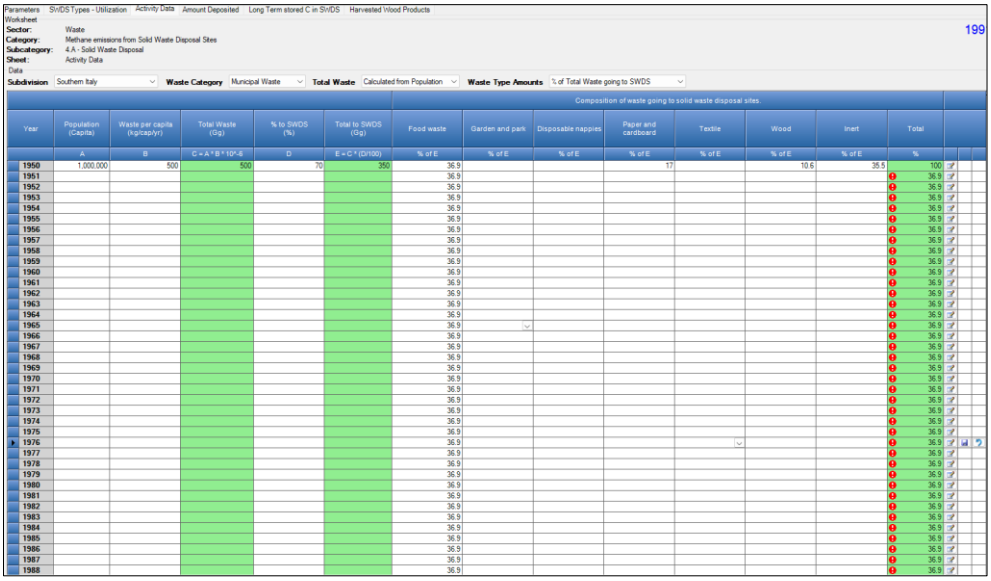
For instance, a value for fraction (percentage) of *Food waste* to *Municipal waste* is entered in column |Food waste| of worksheet **Activity Data**, for the year 1950:



If the user wishes to keep such a fraction constant across its entire time series, and therefore wants to copy the value to the entire time series, click the icon[44] on the right-hand side of the cell. The *Software* will open the following dialog-box to prompt users on the request to copy the value to the entire time series.



Clicking *Yes* copies the value to the whole timeseries, as shown in the figure below:



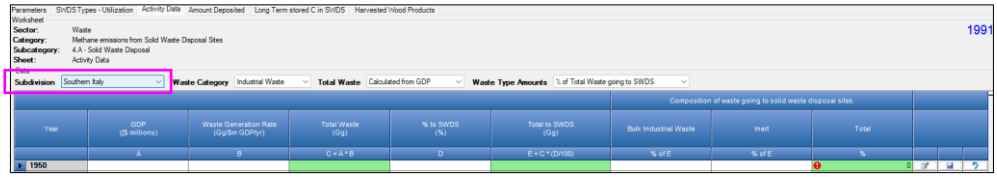
[43] Either to each subdivision, where multiple subdivisions have been entered, or to the unique subdivision, when no additional subdivisions have been entered.

[44] Note that the icon appears only when the mouse is pointer is placed over the cell.

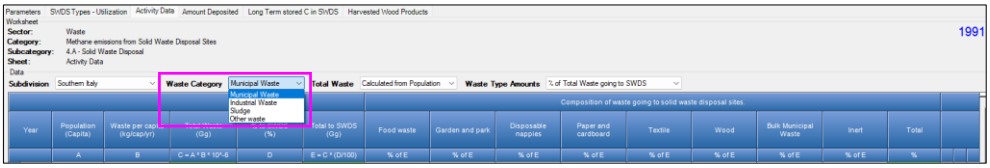
I. Waste generation for bulk waste or waste components

First step is setting the variables listed in the upper ribbon of worksheet **Activity Data**, category 4.A, for each of the 4 waste categories: *Industrial waste*, *Municipal waste*, *Sludge*, *Other waste*:

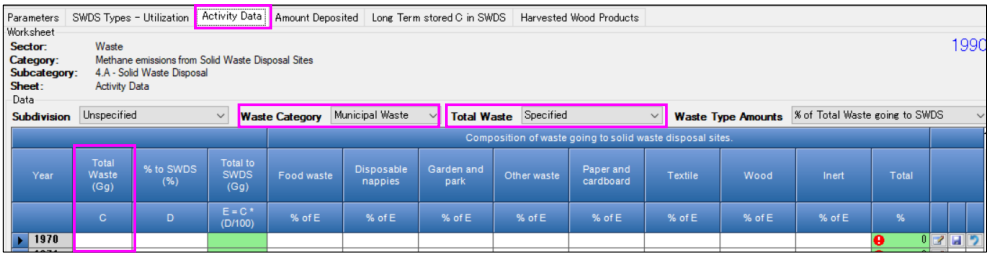
1. Select from the dropdown menu the *Subdivision* for which enter data.



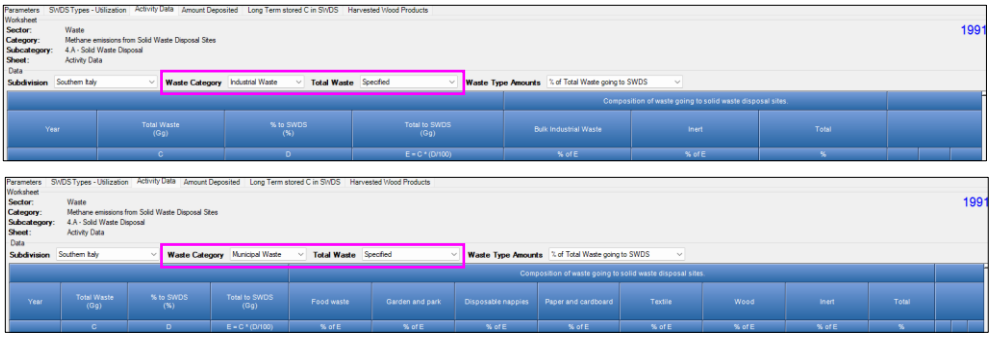
2. Select from the dropdown menu the *Waste category* for which enter data.



3. For *Industrial waste* and *Municipal waste* categories, *Total waste* can either be calculated through IPCC equations or entered in the relevant column, while for *Sludge*, *Other waste*, categories AD are to be entered in column |Total to SWDS|.



✓ If users, select from the dropdown menu the approach *Specified*, then users enter AD[45] in column |Total to SWDS|, and the worksheet **Activity Data** has the following columns to enter data:



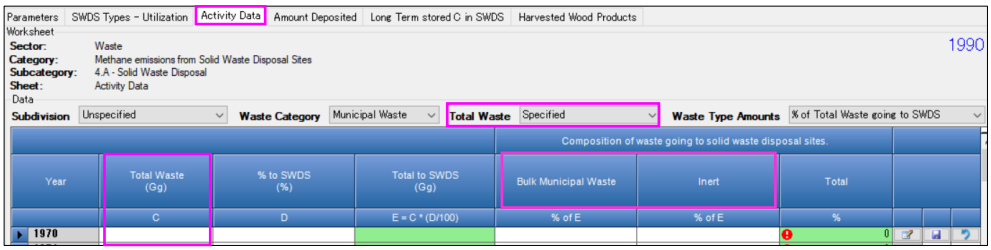
- *Total waste (Gg)*, where the total solid waste generated in the year, for the relevant category, is entered.
- *% to SWDS*, where the percentage of the total solid waste of the relevant category generated in the year that is disposed in landfills is entered.
- *Total to SWDS (Gg)*, calculated by the *Software* by multiplying *Total waste* by *% to SWDS*.
- Columns for the *Composition of waste going to SWDS*:
  - A column for each waste type checked for the relevant waste category in TAB **Waste Type Parameters**.

[45] Total amount (Gg) of waste generated of the relevant waste category.

Example: *Waste components* selected in **Waste Type Parameters** and *Total waste* is *Calculated from population*

- A column for a generic *Inert* type of waste, which sum up all waste types that have a zero (0) *DOCf* in TAB **Waste Type Parameters**.

Example: *Bulk waste* checked in **Waste Type Parameters** and *Total waste* is *Specified*



➢ *Total* (either *Gg* or *%*) (see point 4 hereafter).

Similarly, for the composition of waste deposited in SWDS, worksheet **Amount deposited** contains either 2 columns -i.e. *Bulk waste* and *Inert*- or a column for each waste type checked for the relevant waste category in TAB **Waste Type Parameters**.

The same logic also applies for the composition of waste deposited in SWDS in worksheet **Long term stored C in SWDS**, which contains either a single column for *Bulk waste* or a column for each waste type checked, for the relevant waste category in TAB **Waste Type Parameters**, that has a non-zero value for *DOCf*.

✓ If users select from the dropdown menu the approach *Calculated from population* for *Total waste* in *Municipal waste* category, then AD are calculated in column |Total to SWDS| by the *Software*; thus, worksheet **Activity Data** has 2 additional columns -i.e. column *A* (*Population*) and column *B* (*Waste per capita*)- where one enters data to calculate the *Total solid waste produced* in column *C*.

Example: *Waste components* selected in **Waste Type Parameters** and *Total waste* is *Calculated from population*

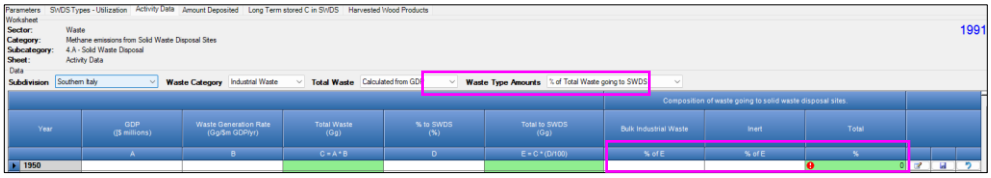
✓ If users select from the dropdown menu the approach *Calculated from GDP* for *Total waste* in *Industrial waste* category, then worksheet **Activity Data** has 2 additional columns -i.e. columns *A* (*GDP*) and *B* (*Waste Generation Rate*)- where to enter data to calculate in column *C* the Total solid waste produced.

Example: *Bulk waste* selected in **Waste Type Parameters** and *Total waste* is *Calculated from GDP*

4. Select from the dropdown menu *Waste Type Amounts* to express AD of each waste type as an absolute quantity (*Gg*) -i.e. *Specified*- or as a fraction (percentage) of the waste category absolute quantity -i.e. *% of Total Waste going to SWDS*. Furthermore.

✓ If users select *% of Total Waste going to SWDS*, then column |Total| sums up the contribution (percentage) of each waste type and reports an error alarm, marked by , if the result does not correspond to 100%.

Example: *Bulk waste* selected in **Waste Type Parameters** and *Waste Type amount* is *% of Total Waste going to SWDS*



✓ If users select *Specified*, then column |Total| sums up the contribution (Gg) of each waste type and reports an error alarm, marked by , if the result is not equal to the value[46] contained in column |Total to SWDS|.

Example: *Waste components* selected in TAB **Waste Type Parameters** and *Waste Type amount* is *Specified*

[46] Either entered or calculated.

Second step, in worksheet **Activity Data** of category 4.A, users **enter** for **each waste category** in **each subdivision** the following AD:

Note: users enter in every worksheet the entire time series of data, regardless of the inventory year active[47] in the *Software*.

Waste category: **Municipal waste**

1. Column |A|: enter the total population of the subdivision (i.e. number of persons) that generates the amount of waste of the relevant waste category.
   Note: this step does not apply if the Total waste in column |C| is entered instead of calculated.
2. Column |B|: select the default[48] value for average amount of *Waste per capita* (kg/capita/year) generated in a year by a person from the drop-down menu, or enter a user-specific value.
   Note: this step does not apply if the Total waste in column C is entered instead of calculated.
   Note: 2019 Refinement Table Annex 2A.1(Updated) provides updated values.
3. Column |C|: either the *Software* calculates[49], or users enter, the *Total waste (Gg)* generated in a year.
4. Column |D|: select the default[48] value of the percentage of waste disposed to landfills *% to SWDS* from the drop-down menu or enter a user-specific value.
   Note: 2019 Refinement Table Annex 2A.1(Updated) provides updated values.
5. Columns |Composition of waste going to SWDSs|: depending on the selection made for *Waste Type Amounts*:
   - If *% of Total Waste going to SWDS* has been selected, users select the default value of the contribution (percentage) of the relevant type to the waste category total amount that has been disposed from the drop-down menu or enter a user-specific value.
     Note: 2019 Refinement Table Annex 2A.1(Updated) provides country-specific values.

     Accordingly, in column |Total (%)| the *Software* sums up all percentage values entered for waste types and checks whether 100% is the resulting value.
   - If *Specified* has been selected, users enter the amount, in Gg, of the relevant waste type disposed in the year in each column.

     Accordingly, in column |Total (Gg)| the *Software* sums up all values entered for waste types and checks whether the resulting value matches the value in column |Total to SWDS (Gg)|.

     Recall, if *bulk waste* type has been selected in TAB **Waste Type Parameters** and *bulk waste* data contains the inert fraction of waste, users SHALL enter a zero (0) value in column |Inert|.

Waste category: **Industrial waste**

1. Column |A|: enter the total Gross Domestic Product (GDP) of the subdivision in millions of USD.
   Note: this step does not apply if the Total waste in column C is entered instead of calculated.
2. Column |B|: enter *Waste Generation Rate* (Gg/M$ GDP/year) generated in a year per million of USD.
   Note: this step does not apply if the Total waste in column C is entered instead of calculated.
3. Column |C|: either the *Software* calculates[50], or users enter, the *Total waste (Gg)* generated in a year.
   Note: 2006 IPCC Guidelines in table 2.2, Volume5, provide values of industrial waste generated by some sectors in a limited number of countries.
4. Column |D|: select the default value of the percentage[51] of solid waste disposed to landfills *% to SWDS* from the drop-down menu or enter a user-specific value.
5. Columns |Composition of waste going to SWDSs|: depending on the selection made for *Waste Type Amounts*:
   a. If *% of Total Waste going to SWDS* has been selected, in each column enter the contribution (percentage) of the relevant waste type to the total amount disposed in SWDS.

      Accordingly, in column |Total (%)| the *Software* sums up all the percentage values entered for individual waste types and checks whether this is 100%, displaying an error alarm ( ) if not.
   b. If *Specified* has been selected, users enter in each column the amount disposed in the year, in Gg, of the relevant waste type.

      Accordingly, in column |Total (Gg)| the *Software* sums up all values entered for waste types and checks whether the resulting value matches the value in column |Total to SWDS (Gg)|.

[47] I.e., the year shown in the right upper-hand side of the window.
[48] See Table 2A.1.
[49] Depending on the approach for *Total waste* selected in the upper ribbon of the worksheet **Activity Data.**
[50] Depending on the approach for *Total waste* selected in the upper ribbon of the worksheet **Activity Data.**
[51] When country-specific data on industrial waste management are not available from other sources, the management can be assumed to follow the same pattern as management of MSW.

Recall, if *bulk waste* type has been selected in TAB **Waste Type Parameters** and *bulk waste* data contains the inert fraction of waste, users SHALL enter a zero (0) value in column |Inert|.

Waste categories: **Sludge** & **Other waste**

1. Column |C|: enter *Total waste (Gg)* generated in a year.
   *Note: for both waste categories -**Sludge** & **Other Waste**- IPCC does not provide a methodology to estimate the annual total waste generated.*
2. Column |D|: enter the percentage of solid waste disposed to landfills *% to SWDS*.
3. Columns |Composition of waste going to SWDSs|: depending on the selection made for *Waste Type Amounts*:
   a. If *% of Total Waste going to SWDS* has been selected, enter in each column the contribution (percentage) of the relevant type to the waste category total amount that has been disposed.

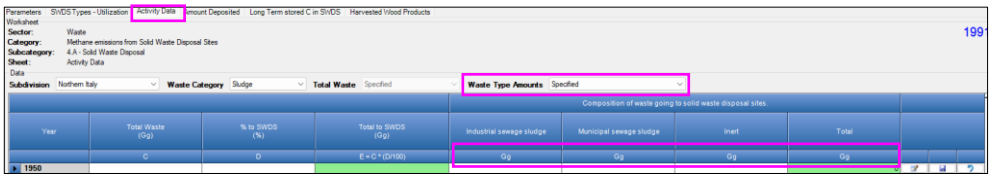
      Accordingly, in column |Total (%)| the *Software* sums up all percentage values entered for waste types and checks whether 100% is the resulting value.

Example: *Waste components* selected in TAB **Waste Type Parameters** and *Waste Type amount* is *% of Total Waste going to SWDS*

a. If *Specified* has been selected, enter in each column the amount, in Gg, of the relevant waste type disposed in the year.

   Accordingly, in column |Total (Gg)| the *Software* sums up all values entered for waste types and checks whether the resulting value matches the value in column |Total to SWDS (Gg)|.

   Example: *Waste components* selected in TAB **Waste Type Parameters** and *Waste Type amount* is *Specified*



Note: neither of these categories have a default inert waste type pre-compiled in the **Waste Manager**. Users shall therefore compile the relevant column with a time series of 0 (zero) values, unless a user-specific inert waste type of has been added in the **Waste Manager**.

II. Waste disposal to SWDS types

In worksheet **SWDS Types - Utilization**, category 4.A, in **each Subdivision** for each of the 4 waste categories: *Industrial waste*, *Municipal waste*, *Sludge*, *Other waste*, AD are entered as follows:

Note: users enter, in every worksheet, the entire time series of data, regardless of the active inventory year[52] in the *Software*.

1. Select the *Subdivision* for which to enter data from the dropdown menu.

2. Select the *Waste category* for which to enter data from the dropdown menu.

3. In each *SWDS-Type* column[53], enter the percentage of the annual amount[54] of the *Waste category* that is disposed in that SWDS type.

   Note: in column |Distribution Check – Total (%)| the *Software* sums up values entered in all SWDS-specific columns and reports an error alarm, with the symbol , if the sum does not correspond to 100%.

[52] I.e., the year shown in the right upper-hand side of the window.
[53] In 4.A.1: Managed – Anaerobic, Managed poorly – semi-Anaerobic, Managed well – semi-Anaerobic, Managed poorly – Active Aeration, Managed well – Active Aeration.
In 4.A.2: Unmanaged – Shallow; Unmanaged – Deep.
In 4.A.3: Uncategorised.
[54] I.e., the amount for the relevant year contained in column |Total to SWDS (Gg)|.

Emission Factor input

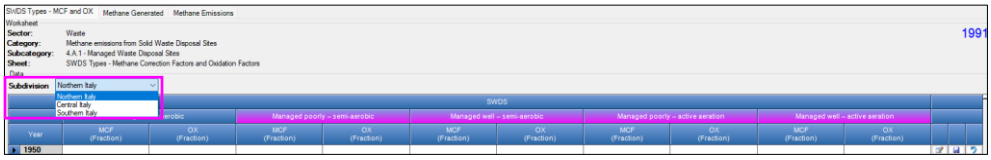
The IPCC model requires 2 additional parameters to estimate CH_4 emissions from SWDSs:

- ✓ Methane Correction Factor (MCF)[55], see Section 3.2.3 and Table 3.1 (Updated)
- ✓ Oxidation Factor (OX), see Section 3.2.3

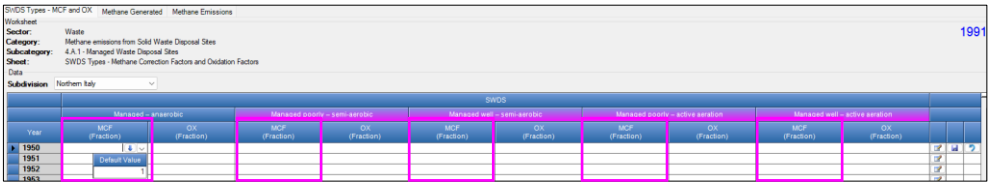
Both are entered in subcategory-specific -i.e. 4.A.1, 4.A.2, 4.A.3- worksheets **SWDS Types – MCF & OX** for each SWDS type, as it follows:

Note: users enter in every worksheet the entire time series of data, regardless of the inventory year active[56] in the *Software*.

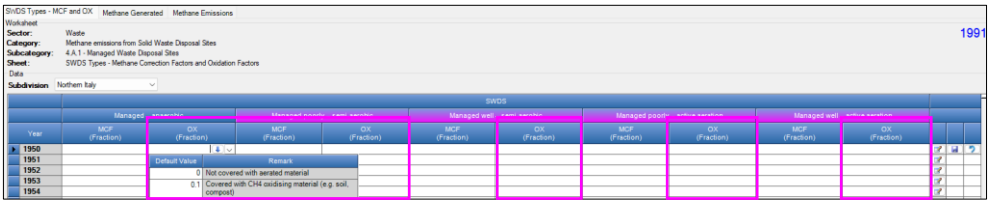
1. Select the *Subdivision* in the relevant box in the upper ribbon of the worksheet.



2. In each SWDS-type column |MCF|, select the IPCC default value or enter a user-specific one.



3. In each SWDS-type column |OX|, select the IPCC default value or enter a user-specific one.



Note: the heading of each SWDS-type column contains a question mark "**?**" . Rolling the mouse over it opens a bubble that contains the description of that type of SWDS.

Note: types of SWDS in magenta[57] have been added to IPCC default types in the *2019 Refinement*; this means that those where not part of the *2006 IPCC Guidelines* SWDS types.

[55] The part of the waste that will decompose under aerobic conditions (prior to the conditions becoming anaerobic) in the SWDS, which is interpreted with the methane correction factor (MCF).
[56] I.e., the year shown in the right upper-hand side of the window.
[57] Managed poorly - semi-Aerobic; Managed well - semi-Aerobic; Managed poor - Active Aeration; Managed well - Active Aeration.

Results

The *Software* calculates a series of **intermediate results** used to estimate:

In category 4.A

1. Solid Waste amount disposed annually, disaggregated by *subdivision/waste-category/waste-type.*
2. Organic C contained in Solid Waste disposed annually, as well as cumulated across the time series, that does not decompose, disaggregated by *subdivision/waste-category/waste-type.*
3. Organic C contained in HWP Solid Waste disposed annually, as well as cumulated across the time series, that does not decompose, disaggregated by *subdivision/waste-category/waste-type.*

In sub-categories 4.A.1, 4.A.2, 4.A.3

4. *CH_4 generated* from each *waste type* of each *waste category* in each *SWDS type* in each *Subdivision.*
5. *CH_4 oxidised* in each *SWDS type* in each *Subdivision.*

Note: in all worksheets, **grey cells** show either **data directly transferred** or **values calculated from data contained in other worksheets**, while **green cells** contain **calculated values**.

Note: *in every worksheet*, the *Software* calculates the entire time series of data, regardless of the active inventory year[58] in the *Software*.

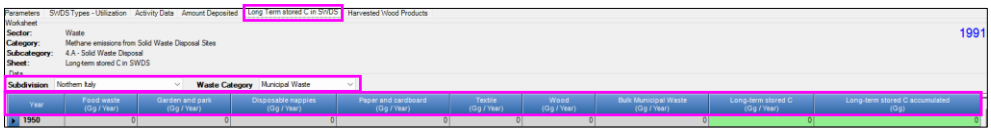
1. **Amount deposited – 4.A**:

For each *Subdivision* and *Waste category*, as selected in the upper ribbon, the *Software* calculates[59] in column |Total to SWDS|, the total amount of waste of the relevant category that has been disposed in the relevant subdivision in each year of the time series.

Data in grey cells are:

- either directly transferred from the worksheet **Activity Data** if *Waste Type Amounts* are expressed in *Gg*
- or calculated by the *Software* from data contained in the worksheet **Activity Data**: multiplying total amount of waste deposited, as contained in column |Total to SWDS|, by the contribution -i.e. fraction- of the relevant waste type, as contained in columns |Composition of waste going to SWDS|

2. **Long Term Stored C in SWDS – 4.A**:



For each *Subdivision* and *Waste category*, as selected in the upper ribbon, and for each year of the time series, the *Software* calculates:

- ✓ In the penultimate column, the annual amount of organic C contained in the *waste category* that will remain stored for a long time in the SWDS.
- ✓ In the last column, the cumulated[60] amount of organic C, contained in the *waste category*, that will remain stored for a long time in the SWDS.

Both these fields are information items in UNFCCC CRT.

Data in the grey cells are calculated[61] by the *Software* for the annual amount of organic[62] C contained in each *waste type* that will remain[63] stored for long time in the SWDS.

3. **Harvested Wood Products – 4.A**:

[58] I.e., the year shown in the right upper-hand side of the window.
[59] Summing up all values in the row reported for waste types.
[60] Summed up from the first year of the time series to the year, as contained in the first column of the relevant row.
[61] IPCC Equation 3A1.19.
[62] This explains why no inert types of waste are listed in columns of this worksheet.
[63] I.e., the portion of DOC that is not lost through decay.

For each *Subdivision*, as selected in the upper ribbon, and for each year of the time series, the *Software* calculates[61] in the grey cells:

- ✓ In the three columns *Long-term stored C*, the annual amount[64] of organic C, contained in each of the three HWP-specific[65] waste types, that will remain stored for long time in the SWDS.
- ✓ In the three columns *Long-term stored C accumulated*, the cumulated[60] amount of organic C, contained in each of the three HWP-specific[65] waste types, that will remain stored for long time in the SWDS.

4. **Methane Generated – 4.A.1, 4.A.2, 4.A.3**

For each *Subdivision/SWDS type/Waste category/Waste type*, as selected in the upper ribbon, and for each year of the time series, the *Software* calculates:

- ✓ Column |D|: annual amount of decomposable DOC deposited.
- ✓ Column |B|: decomposable DOC deposited in the year that did not decompose.
- ✓ Column |C|: decomposable DOC deposited in the year that decomposed.
- ✓ Column |H|: cumulated[60] decomposable DOC.
- ✓ Column |E|: total decomposed DOC in the year.
- ✓ Column |Q|: *CH_4 generated.*

5. **Methane Emissions – 4.A.1, 4.A.2, 4.A.3**

For each *Subdivision/SWDS type*, as selected in the upper ribbon, and for each year of the time series, the *Software*:

- ✓ Transfers in the *waste category* columns the amount of CH_4 generated by each waste category as calculated in worksheet **Methane generated.**
- ✓ Calculates in column |E| *Total Methane Generated.*
- ✓ Transfers in column |H| the *Oxidation factor* from worksheet **SWDS Types – MCF & OX**, and applying it to the *Total Methane Generated.*
- ✓ Calculates in column |I| *Methane Oxidised.*

To get the **Results**, as CH_4 emissions, in worksheet **Methane Emissions** of each of the sub-categories 4.A.1, 4.A.2 and 4.A.3, users select in the upper ribbon the *Subdivision* and the *SWDS type* for which the results are required and then in:

- ✓ Column |F|: enters the annual amount of CH_4 generated that is flared at the SWDSs of the selected type.
- ✓ Column |G|: enters the annual amount of CH_4 generated that is captured and used for energy production.

Finally, the *Software* calculates in column |J| the CH_4 emissions for each *Subdivision/SWDS-type*, as the CH_4 generated minus the quantity naturally oxidised within the landfill and the quantity recovered, either flared or used for energy production.

This process is then repeated for each relevant *Subdivision/SWDS-type* combination.

Note: *in every worksheet*, the *Software* calculates the entire time series of data, regardless of the active inventory year in the *Software*; similarly, users enter data for the entire time series regardless of the active inventory year.

[64] The HWP data for the wood waste type should correspond to variable 1B, ΔCHWP SWDS DC, i.e., the annual amount of HWP disposed (Chapter 12, Volume 4), although limited to the fraction of C that does not decay i.e., *HWP*MCF*(1-DOCf)*.

[65] Garden (which includes *Garden & park waste type* from *municipal solid waste category*), Wood (which includes *Wood waste type* from *municipal solid waste category* plus *Wood & wood products waste type* from *industrial solid waste category*), Paper (which includes *Paper & cardboard waste type* from *municipal solid waste category* plus *Pulp & paper waste type* from *industrial solid waste category*).

4.B. Biological Treatment of Solid Waste

Information

Biological treatment of solid waste includes composting and anaerobic digestion of the organic fraction of solid waste.

Composting is an aerobic process, and a large fraction of DOC in the waste material is converted into CO_2.

Anaerobic digestion generates CH_4 that can be used to produce heat and/or electricity, which is included in the Energy sector. However, emissions due to unintentional leakages during the anaerobic digestion process are reported under this category.

Anaerobic sludge treatment at wastewater treatment facilities is addressed in category 4.D, Wastewater Treatment and Discharge. However, when sludge from wastewater treatment is transferred to an anaerobic digestion facility which is co-digesting sludge with solid municipal or other waste, any related CH_4 and N_2O emissions should be included under this category.

GHGs

The *Software* estimates the following GHGs for composting and anaerobic treatment of solid waste:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
	X	X				

CO_2 emissions from biological treatment of solid waste are not estimated and reported in the Waste sector since CO_2 emissions are of biogenic origin and are covered under the AFOLU sector[66].

IPCC Equations

CH_4 emissions

1. Tier 1: IPCC Tier 1 Equation 4.1
2. Tier 2: IPCC Tier 1 equation, although with user-specific EFs
3. Tier 3: IPCC Tier 1 equation based on facility or site-specific measurements (on-line or periodic)

N_2O emissions

1. Tier 1: IPCC Tier 1 Equation 4.2
2. Tier 2: IPCC Tier 1 equation, although with user-specific EFs
3. Tier 3: IPCC Tier 1 equation based on facility or site-specific measurements (on-line or periodic)

As explained in section I.2 Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

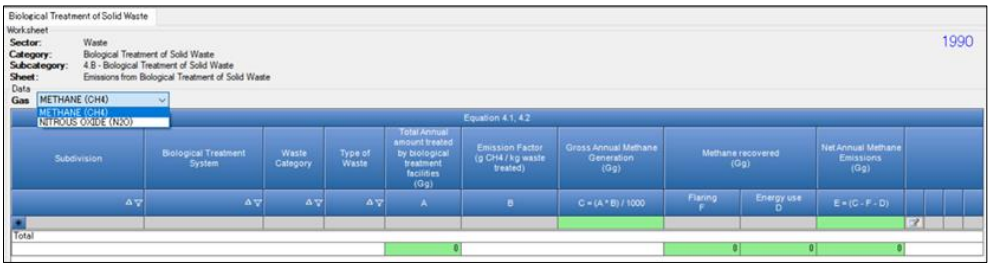
Software Worksheets

The *Software* calculates CH_4 and N_2O emissions using worksheets:

I. **Waste Type Manager**: contains parameter data for each waste type, and the selection for AD between wet[67] or dry weight.

II. **Biological Treatment of Solid Waste**, contains, for each subdivision/biological treatment system/waste category/type of waste, amount of waste treated by biological treatment facilities, EFs, CH_4 recovered, if any, and calculates GHG emissions.

In the upper part of the worksheet **Biological Treatment of Solid Waste**, users select the GHG for which to enter data.



[66] CO_2 emissions of perennial biomass are reported as C stock losses, while CO_2 emissions of annual biomass are not reported given that the CO_2 removals that have originated that biomass are not reported too. This is because annual biomass is assumed to conclude its cycle within a year (i.e., both CO_2 removals and subsequent CO_2 emissions occurring within a time-period of 1 year).

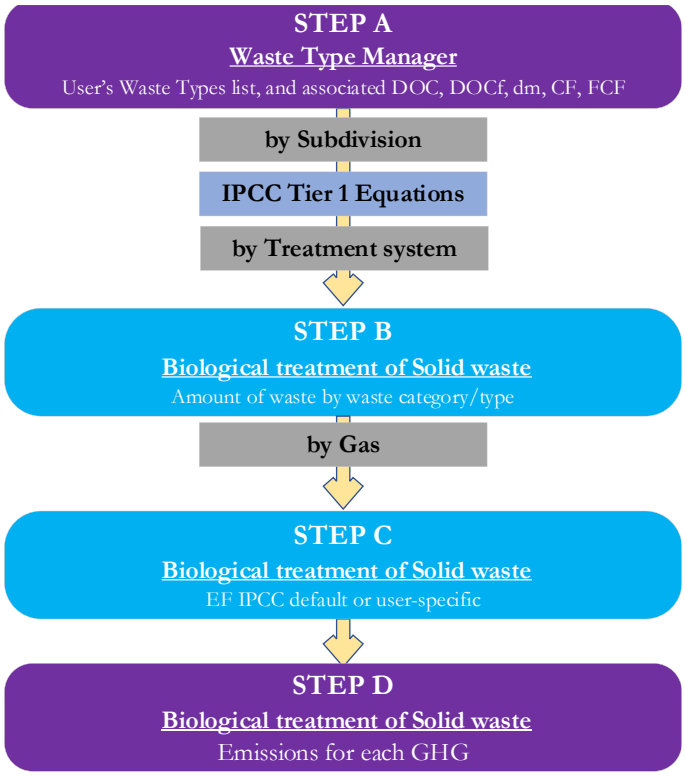
[67] The UNFCCC NGHGI requires wet weights.

User's work Flowchart

Consistent with the key category analysis, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[68] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, users apply steps described in the following flowchart:

Biological Treatment of Solid Waste – Flowchart



Step A: **Waste Type Manager**, users (1) enter values for parameters for which an IPCC default value is not precompiled, or (2) replace the value precompiled with their own user-specific values; and (3) enter user-specific waste types, if any, and associated values for parameters.

Then, for each subdivision, if any:

Step B: worksheet **Biological Treatment of Solid Waste**, users collect and enter AD (i.e. waste category/type, and amount biologically treated) for each biological treatment system.

Step C: worksheet **Biological Treatment of Solid Waste**, for each waste category/type/biological treatment system users collect and enter associated EF for each gas.

Step D: worksheet **Biological Treatment of Solid Waste**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

[68] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented by either applying different region-specific EFs or applying one user-specific EF, as the weighted average EF across the two regions, to both regions.

Activity Data input

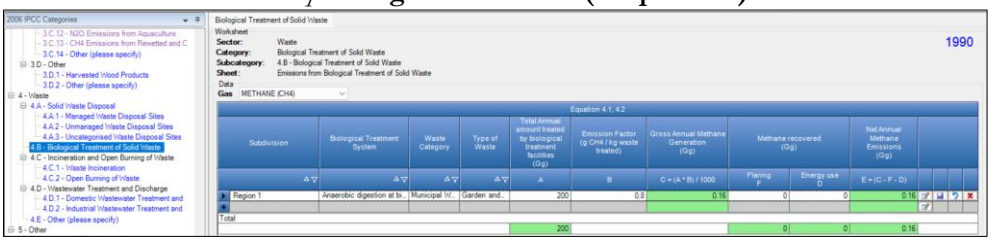
The *2006 IPCC Guidelines*, Chapter 2 contains information about the compilation of AD on waste generation composition and management. Regional default data on composting are provided in Table 2.1, and country-specific data for some countries can be found in Annex 2A.1. Guidance on collecting AD for biological treatment of solid waste is found in Section 4.1.2.

As a **starting step**, users enter in the **Waste Type Manager** all user-specific waste categories and waste types to be reported in the NGHGI; and for each waste type listed in the **Waste Type Manager** revise, where needed, pre-compiled values for *Dry Matter Content (dm)*, *Total Carbon in Dry Matter (CF)*[69], *Fossil Carbon in Total Carbon (FCF)*[70].

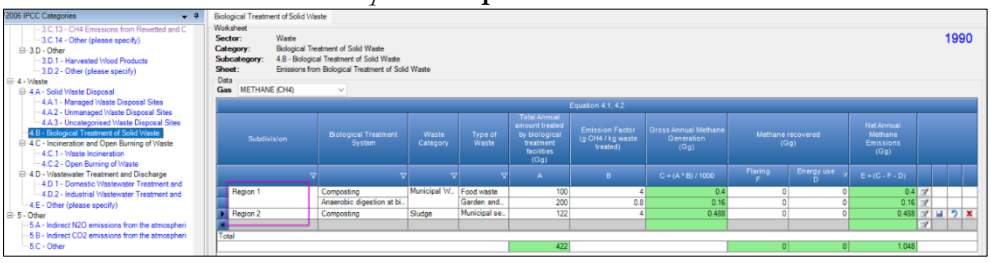
Recall: the **Waste Type Manager** is where one selects the condition of waste AD, i.e. *wet vs dry weight*. This selection affects all three source-categories 4.A., 4.B, 4.C and it is not possible to set different waste AD conditions for different source-categories, e.g., wet weight for category 4.A and dry weight for category 4.B. If users have waste data on a dry-basis and wish to enter data on a wet-basis, the wet weight can be calculated by dividing the dry weight by the *dm* content of that waste type.

Second, users compile the worksheet **Biological Treatment of Solid Waste** either with a single row of data (per treatment and waste type) for the entire category or with subnational aggregations. A univocal name/code is entered in column |Subdivision| per subdivision. If there is only one subdivision (e.g., one row per treatment type) then this can be completed with "unspecified" as selected from the dropdown menu.

Example: **Single subdivision (unspecified)**



Example: **Multiple Subdivisions**



For each subdivision data are entered in worksheet **Biological Treatment of Solid Waste** as follows:

1. Column |Biological Treatment System|: select type of biological treatment (*composting* or *anaerobic digestion*) from the drop-down menu, one treatment system in each row.
2. Column |Waste category|: select a category of waste (e.g., *municipal solid waste*, *sludge*) biologically treated from drop-down menu.
3. Column |Type of waste|: select a type of waste (e.g., *food waste*, *garden and park waste*) biologically treated from drop-down menu.
   *Note: waste types in the dropdown menu are those listed in the **Waste Type Manager**.*
4. Column |A|: enter the corresponding amount of waste biologically treated, in Gg.
   *Note: the condition of the waste entered (wet weight or dry weight) should be consistent with the selection made in the **Waste Type Manager** given that the Software will select the IPCC default value for the relevant waste condition selected in the **Waste Type Manager** (either wet waste or dry waste).*

Note: as the category/type and amount of waste should be consistent for the calculation of both CH_4 and N_2O, *the Software* transfers the AD entered in the worksheet of one gas (e.g., CH_4) to the worksheet of the other (e.g., N_2O).

Note: data entry must be completed one row at a time.

[69] Fraction of C in dry matter.
[70] Fraction of fossil C in total C.

Emission Factor input

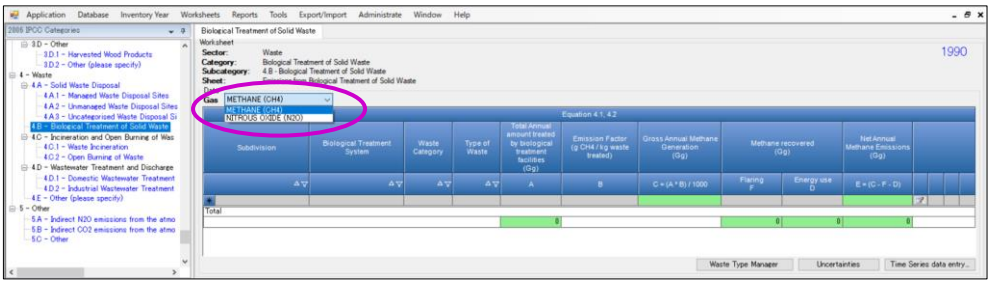
N_2O and CH_4 EFs for biological treatment of solid waste, on both a wet and a dry basis, are in Table 4.1.

Note: the EF to apply depends on the waste conditions, either dry weight or wet weight.

In worksheet **Biological Treatment of Solid Waste**:

1. Select "Methane (CH_4)" or "Nitrous Oxide (N_2O) in the "Gas" bar at the top, to enter data for each GHG

Example: **Methane emissions**



2. Column |B|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in g CH_4/kg waste treated or g N_2O/kg waste treated.

This then needs to be repeated for the second gas.

Results

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emissions from all subdivisions are reported in worksheet **Biological Treatment of Solid Waste**.

Specifically:

- **CH_4 emissions**

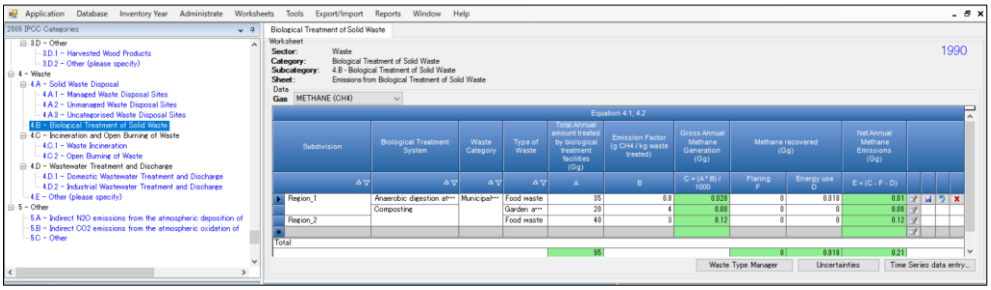
Anaerobic digestion of solid waste is usually associated with CH_4 recovery. Therefore, where data are available, the amount of CH_4 recovered is to be subtracted from the *gross annual methane production* calculated in Column |C|. Thus, to calculate actual CH_4 emissions:

1. Column |D|: enter amount of CH_4 recovered for energy use, in Gg.
2. Column |F|: enter amount of CH_4 recovered as flaring, in Gg.

Note: IPCC default CH_4 EF value for anaerobic digestion already accounts for CH_4 recovery. Thus, when the IPCC default value is applied the value "0" is to be entered in both columns.

3. Column |E|: CH_4 emissions are calculated, in Gg.

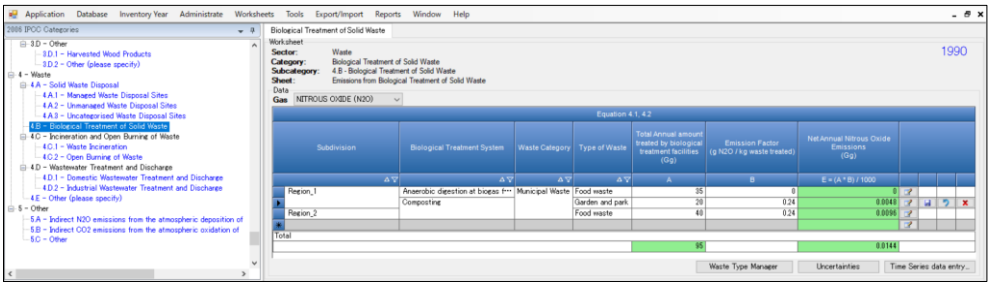
Example: **Worksheet for CH_4**



- **N_2O emissions**

1. Column |E|: N_2O emissions are calculated, in Gg.

Example: **Worksheet for N_2O**



4.C. Incineration and Open Burning of Waste

Information

Thermal treatments of waste are classified into incineration and open burning of waste.

The *2019 Refinement* extends treatments to pyrolysis, gasification, plasma. To those treatment types the same methodological approach designed for incineration applies; thus, users can prepare estimates of those in worksheet **Waste Incineration**, while applying the IPCC default EFs for CH_4 [Table 5.3A(NEW)] and N_2O [Table 5.4A(NEW)] provided by the *2019 Refinement* for MSW pyrolysis-melting and for MSW gasification-melting.

Note: IPCC Tier 1 Equation requires data in wet weight and converts wet weight in dry weight by applying the dry matter content. Where users use dry weight data when calculating CO_2 emissions *dm* is to be set to 1.

Recall: selection to instruct the *Software* about the condition of waste AD -i.e. *wet vs dry weight*- is made in the **Waste Type Manager**. This selection affects all three source-categories 4.A., 4.B, 4.C and it is not possible to set a different waste data condition for different categories, e.g., wet weight for category 4.A and dry weight for category 4.B. If users have waste data on a dry-basis and wish to enter data on a wet-basis, the wet weight can be calculated by dividing the dry weight by the *dm* content of that waste type.

GHG

The *Software* estimates the following GHGs for incineration and open burning of waste:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

CO_2 emissions from organic carbon are not estimated and reported in the Waste sector since CO_2 emissions are of biogenic origin and are covered under the AFOLU sector[71].

[71] CO_2 emissions of perennial biomass are reported as C stock losses, while CO_2 emissions of annual biomass are not reported given that the CO_2 removals that have originated that biomass are not reported too. This is because annual biomass is assumed to conclude its cycle within a year (i.e., both CO_2 removals and subsequent CO_2 emissions occurring within a time-period of 1 year).

4.C.1. Waste Incineration

Waste incineration is the activity of combustion of solid and liquid waste in controlled incineration facilities without energy recovery.

IPCC Equations

GHG emissions from waste incineration are estimated by applying the following equations of the *2006 IPCC Guidelines*.

- CO_2 emissions (excluding from incineration of *fossil liquid waste*):
  - ✓ Tier 1: Equations 5.1 & 5.2.
  - ✓ Tier 2a: Tier 1 equation, although with user-specific AD on waste and for MSW on its composition in waste types.
  - ✓ Tier 2b: Tier 1 equation, although with user-specific AD on waste, and for MSW on its composition, as well as user-specific values for *dm*, *CF*, and possibly for *FCF* and *OF*.
  - ✓ Tier 3: Emissions are estimated based on plant-specific measurement data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.
- CO_2 emissions from incineration of fossil liquid waste[72]:
  - ✓ Tier 1: IPCC Tier 1 Equation 5.3.
  - ✓ Tier 2: IPCC Tier 1 equation, although with user-specific carbon content and oxidation factor.
  - ✓ Tier 3: Emissions are estimated based on plant-specific measurement data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.

Table 5.1 provides an overview on tier levels at which default values or country-specific data are to be applied for calculating CO_2 emissions.

- CH_4 emissions:
  - ✓ Tier 1: Equation 5.4.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on waste, and for MSW on its composition, as well as user-specific EF.
  - ✓ Tier 3: Emissions are estimated based on plant-specific measurement data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.
- N_2O emissions:
  - ✓ Tier 1: Equation 5.5.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on waste, and for MSW on its composition, as well as user-specific EF.
  - ✓ Tier 3: Equation 5.6.

As explained in **I.2 Use of multiple tiers for reporting**, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Note: for the purposes of interoperability with the UNFCCC ETF Reporting Tool, the *Software* calculates estimates of CO_2, CH_4 and N_2O emissions from incineration of waste disaggregated by the origin of waste i.e. *biogenic vs fossil* origin. In calculation worksheets, columns needed for such disaggregation are listed under the element **Information for UNFCCC CRT** and separated by a black vertical line from columns needed to implement the IPCC equation.

[72] N_2O emissions are assumed negligible, otherwise to be calculated in worksheet *Waste incineration*. In such a case, parameters for CO_2 emissions estimate for the fossil liquid waste type are to be set to 0 to avoid double counting.

Software Worksheets

The *Software* calculates CO_2, CH_4 and N_2O emissions from waste incineration using the following worksheets:

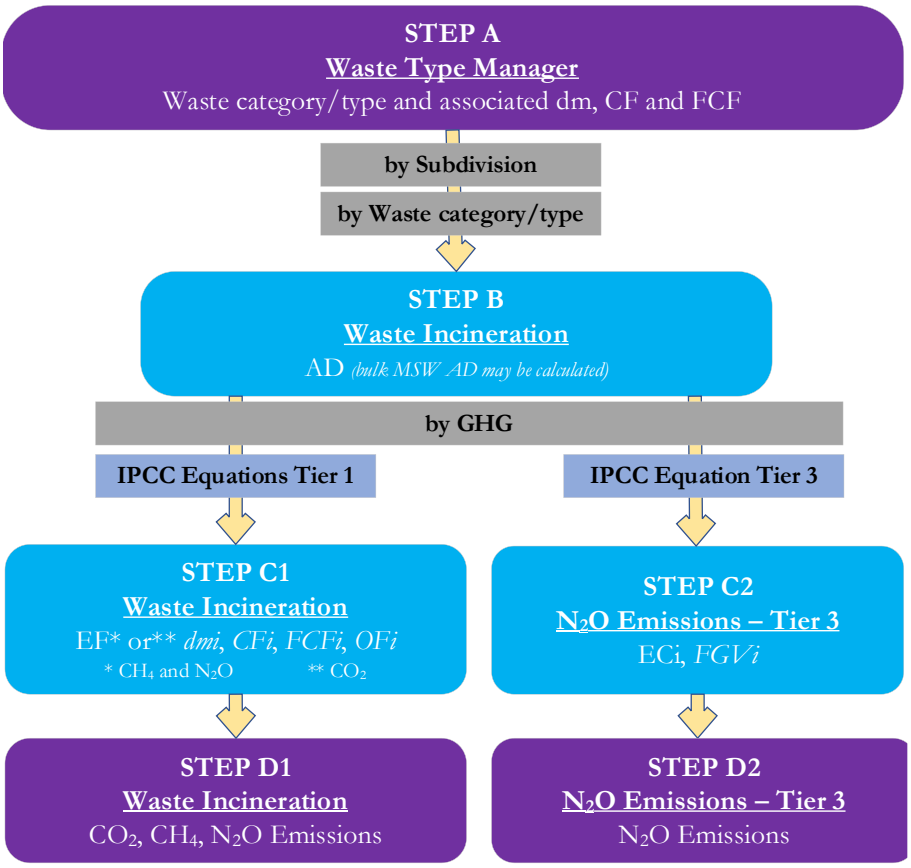
- ✓ **Waste Type Manager**: contains parameter data for each waste type, and the selection for AD between wet[73] or dry weight.
- ✓ **Waste incineration:** contains for each subdivision/waste category/type of waste the amount of waste incinerated and the relevant CO_2, CH_4 and N_2O EFs and calculates associated GHG emissions.
- ✓ **Fossil liquid incineration:** contains for each subdivision and type of fossil liquid waste[74] -i.e. *solvents*, *lubricants*, *waste oil*- the total amount of fossil liquid waste incinerated, the carbon content of the waste and the oxidation factor, and calculates associated GHG emissions. Unless fossil liquid waste is included in other types of waste (e.g., *bulk industrial waste*, *hazardous waste*), emissions from incineration of fossil liquid waste need to be estimated in this calculation worksheet.
- ✓ **N_2O emissions from incineration of waste-Tier 3:** calculates for each subdivision/waste category/type of waste N_2O emissions from incineration of waste based on site-specific data on flue gas concentrations.

[73] The UNFCCC NGHGI requires wet weights.
[74] Where data allow users to disaggregate this component from other waste types.

User's work Flowchart

Consistent with the key category analysis and the decision trees of the *2006 IPCC Guidelines*, Figure 5.1 (CO_2) and Figure 5.2 (CH_4 and N_2O), GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[75] EFs and/or measurement data.

Waste Incineration - solid waste - flowchart



Step A, **Waste Type Manager**, users (1) enter values for parameters for which an IPCC default value is not precompiled, or (2) replace the value precompiled with their own user-specific values; and (3) enter user-specific waste types, if any, and associated values for parameters.

Then, for each subdivision, if any:

Step B, in worksheet **Waste incineration**, users:

- ✓ first select[76] *Carbon Dioxide (CO_2)*, in the *Gas* toggle, in the heading of the TAB,
- ✓ then enter AD.

Step C1, in worksheet **Waste incineration**, users:

- ✓ for CO_2, may re-enter[77] values for *dm*, *CF*, *FCF* and select or enter the value for *OF*,
- ✓ for CH_4 & N_2O users elect or enter the EF values; although for N_2O this step is limited to Tier 1 and Tier 2 estimates, while for Tier 3 estimates Step C2 applies instead.

Step C2, in worksheet **N_2O Emissions from Incineration of waste – Tier 3**[78], users enter values for *FGVi* (Flue gas volume generated) and *ECi* (N_2O concentration in flue gas).

Step D1, in worksheet **Waste incineration**, for each row of data and for each GHG, the *Software* calculates emissions in mass units (Gg). In addition, total emissions of each GHG are calculated.

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[75] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the user-specific EF, as the weighted average EF across the two regions.

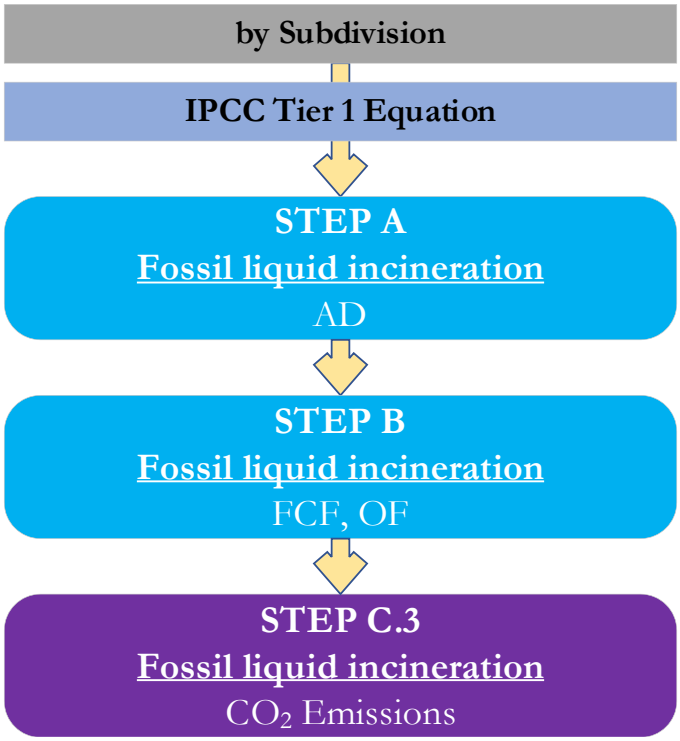
[76] Activity Data shall be entered in the worksheet with CO_2 gas selected. Those AD are then used by the *Software* to calculate emissions from all three GHGs, including in worksheet *N_2O Emissions from Incineration of waste – Tier 3*.

[77] When users select the waste type in the dropdown menu values for *dm*, *CF*, *FCF* are automatically filled in by the *Software*, with the values included in the **Waste Type Manager**.

[78] To access this worksheet users tick the checkbox *N_2O Tier 3* in the worksheet **Waste incineration** where the gas selected is N_2O.

Step D2, in worksheet **N_2O Emissions from Incineration of waste – Tier 3**, for each row of data, the *Software* calculates N_2O emissions in mass units (Gg). In addition, total N_2O emissions are calculated.

Waste Incineration - fossil liquid - flowchart



For each subdivision, if any:

Step B, in worksheet **Fossil liquid incineration**, users select or enter *waste type* and enter *waste amount*.

Step C, in worksheet **Fossil liquid incineration**, users may enter user-specific values for *CL* (fossil carbon content) and for *OX* (oxidation factor).

Step D, in worksheet **Fossil liquid incineration**, for each row of data, the *Software* calculates CO_2 emissions in mass units (Gg). In addition, total CO_2 emissions are calculated.

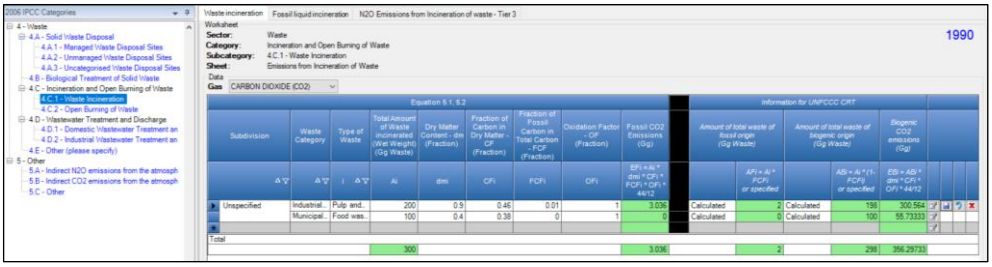
Activity Data input

The *2006 IPCC Guidelines*, Chapter 2 contains information about the compilation of AD on waste generation composition and management. Regional default data on incineration are provided in Table 2.1, and country-specific data for some countries can be found in Annex 2A.1. Further, guidance on collecting AD for incineration is found in Section 5.3.

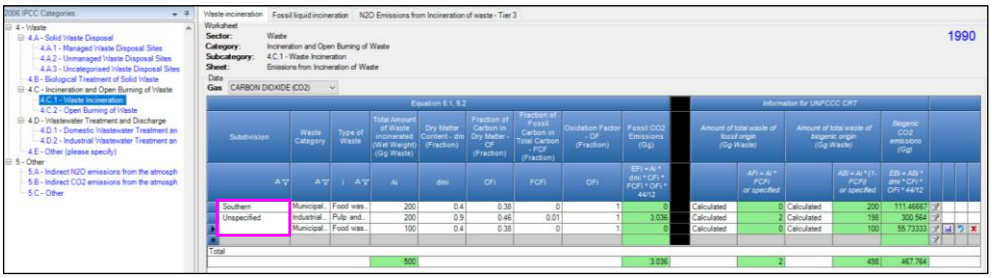
As a **starting step**, users enter in the **Waste Type Manager** all user-specific waste categories and waste types to be reported in the NGHGI; and for each waste type listed in the **Waste Type Manager** revise, where needed, pre-compiled values for *Dry Matter Content (dm)*, *Total Carbon in Dry Matter (CF)*[79], *Fossil Carbon in Total Carbon (FCF)*[80].

Second, users compile the worksheet **Waste incineration** or **Fossil liquid incineration** either with a single row of data (per waste type) for the entire category or with subnational aggregations. A univocal name/code entered is entered in column |Subdivision| for each subdivision. If there is only one subdivision (i.e., one row per waste type) then "unspecified" as selected from the dropdown menu can be used.

Example: **Single subdivision (unspecified)**



Example: **Multiple subdivisions**



For each subdivision data are entered in worksheet **Waste incineration** or **Fossil liquid incineration** as it follows:

➢ **Waste incineration**

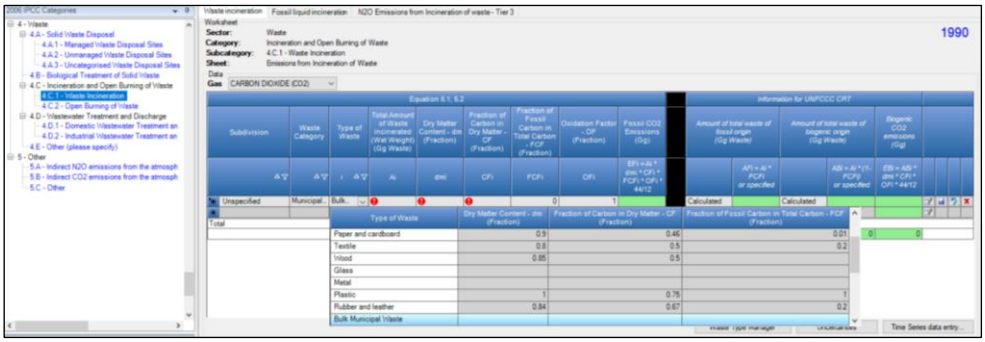
Note: AD to estimate emissions from each GHG shall be entered only once in worksheet **Waste incineration** when *Carbon Dioxide (CO_2)* is selected in the *Gas* toggle. When CH_4 or N_2O are selected, AD cannot be entered. The *Software* automatically uses AD entered for CO_2 as the AD to calculate emissions of *Methane (CH_4)* and *Nitrous Oxide (N_2O)* in the calculation worksheet when the relevant GHG is selected in the *Gas* toggle; including, where needed, in the worksheet **N_2O Emissions from Incineration of waste – Tier 3**.

In worksheet **Waste incineration**, **first** select *Carbon Dioxide (CO_2)* in the *Gas* toggle and then:

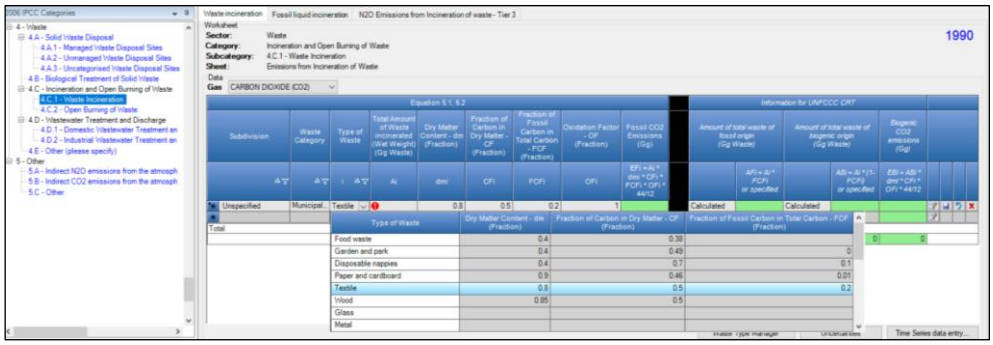
1. Column |Waste category|: select category of waste -*municipal waste*, *industrial waste*, *sludge, other waste*- from the dropdown menu.
2. Column |Type of waste|: select type of waste from dropdown menu. If data are not available by waste type (food, garden and park, plastic, rubber and leather, etc) then select *Bulk Municipal Waste* (Equation 5.1), otherwise enter each waste type, one per row (Equation 5.2).
   *Note: waste types in the dropdown menu are those listed in the **Waste Type Manager**.*

[79] Fraction of C in dry matter.
[80] Fraction of fossil C in total C.

Example: **Bulk Municipal Waste option**



Example: **Selection of waste type**

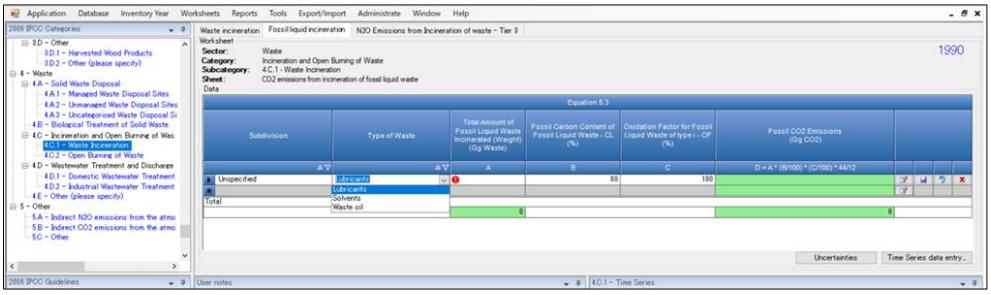


3. Column |Ai|: enter *total amount of waste incinerated*, in Gg.

➢ **Fossil liquid incineration**

In worksheet **Fossil liquid incineration**:

1. Column |Type of waste|: select the type of waste from the dropdown menu -i.e. *Solvents*, *Lubricants*, *Waste oil*- or enter a user-specific type.



2. Column |A|: enter *total amount of fossil liquid incinerated*, in Gg.

Note: data entry is completed one row at a time for both **Waste incineration** and **Fossil liquid incineration** worksheets

Emission Factor input

Guidance on choice of EFs and parameters for estimation of GHG emissions from waste incineration is provided in Section 5.4.1 (CO_2), Section 5.4.2 (CH_4) and Section 5.4.3 (N_2O) of the *2006 IPCC Guidelines*. Updated guidance for each GHG is provided in the corresponding Section of the *2019 Refinement*.

EFs are to be entered for each of the GHG, as selected in the toggle, as it follows:

CARBON DIOXIDE (CO_2)

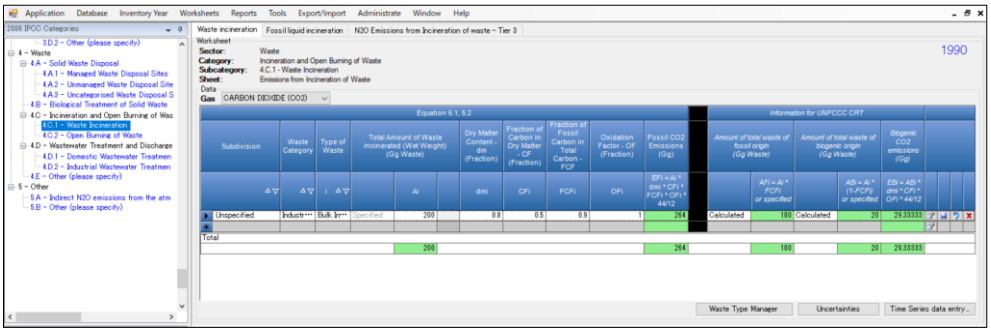
➢ **Waste incineration**

In worksheet **Waste incineration**, when *Carbon Dioxide (CO_2)* in the *Gas* toggle is selected:

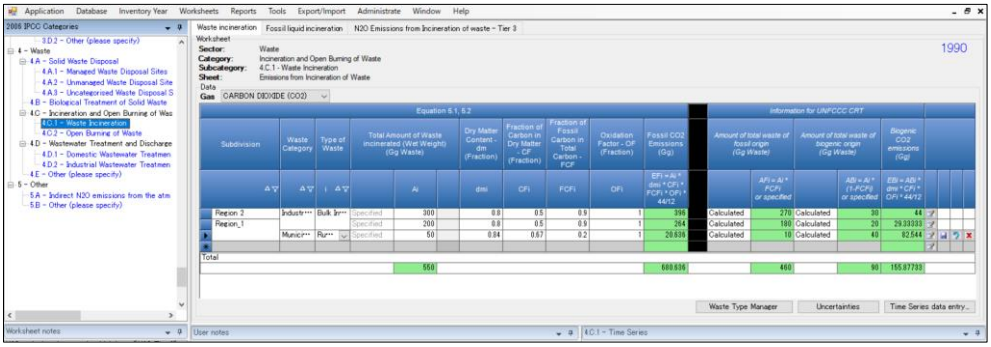
1. Column |dmi|: the *Software* precompiles[81] *dm* with the value contained in the **Waste Type Manager** for the relevant waste type. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).

   Note: where users enter waste weight in a **dry-weight basis**, the value of **1 is to be entered as *dm*** to maintain accuracy of estimates.
2. Column |CFi|: the *Software* precompiles[81] *CF* with the value contained in the **Waste Type Manager** for the relevant waste type. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).
3. Column |FCFi|: the *Software* precompiles[81] *FCF* with the value contained in the **Waste Type Manager** for the relevant waste type. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value; a fraction (value between 0 and 1).
4. Column |OFi|: the *Software* precompiles[81] *OF*[82] with the value 1 -i.e. 100% oxidation of carbon to CO_2. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).

Example: **Single subdivision**



Example: **Multiple subdivisions**



➢ **Fossil liquid incineration**

In worksheet **Fossil liquid incineration**:

1. Column |B|: the *Software* precompiles *FCF*[83] with the IPCC default value, i.e. 80%. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a percentage (value between 1 and 100).
2. Column |C|: the *Software* precompiles *OF*[82] with the IPCC default value, i.e. 100%. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a percentage (value between 1 and 100).

[81] Of course, only if a value for the relevant parameter of the relevant waste type is contained in the waste type manager.
[82] Oxidation factor.
[83] Fossil carbon content of fossil liquid waste.

METHANE (CH_4)

➢ **Waste incineration**

In worksheet **Waste incineration**, when *Methane (CH_4)* in the *Gas* toggle is selected:

1. Column |EFi|: select from the drop-down menu the relevant IPCC default EF or enter user-specific EF (e.g., country-specific) in kg CH_4/Gg wet weight.

➢ **Fossil liquid incineration**

2006 IPCC Guidelines do not provide methodological guidance to estimate CH_4 emissions from Fossil liquid incineration. Users that wish to report those can use **Waste incineration** worksheet, although in such a case the waste type needs to be added in the **Waste Type Manager**.

NITROUS DIOXIDE (N_2O)

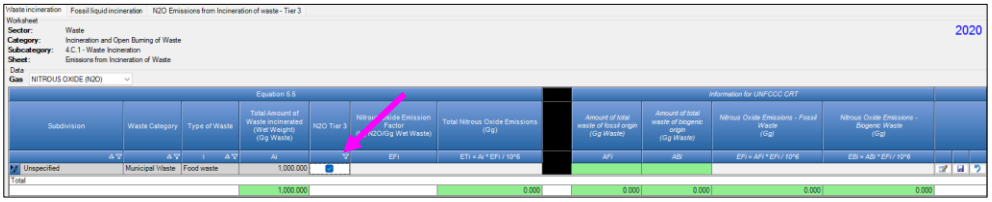
➢ **Waste incineration**

In worksheet **Waste incineration**, when *Nitrous Oxide (N_2O)* in the *Gas* toggle is selected:

First users select whether to apply the IPCC Tier 1 Equation[84] or, where data available allows, to apply IPCC Tier 3 Equation. To do so:

1. Column |N_2O Tier 3|: if users wish to apply the IPCC Tier 3 equation, then check the box, otherwise leave it unchecked. If checked all cells on the right-hand side are greyed out and AD are copied by the *Software* into worksheet **N_2O Emissions from Incineration of waste – Tier 3**.

Example: **Selection of Tier 3 for estimation of N_2O emissions**



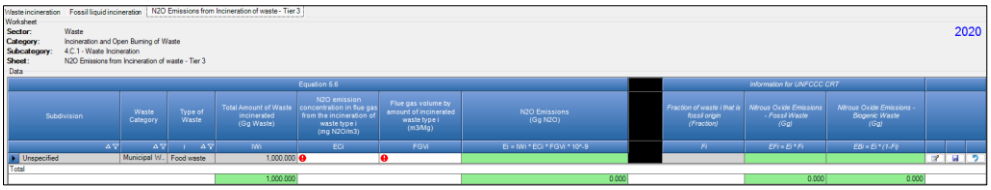
Then,

➢ if the checkbox in column |N_2O Tier 3| is left unchecked:

2. Column |EFi|: select, from the drop-down menu, the relevant IPCC default EFs or enter user-specific EFs (e.g., country-specific) in kg N_2O/Gg wet weight.
   Note: IPCC default values are for waste reported on a wet weight basis; thus, where users enter AD on a dry weight basis IPCC default values shall not be selected, and a user-specific value shall instead be entered.

➢ Otherwise, if the checkbox in column |N_2O Tier 3| is checked, in worksheet **N_2O Emissions from Incineration of waste – Tier 3**:

2. Column |ECi|: enter a user-specific value of N_2O concentration in flue gas, in mg N_2O/m^3 of flue gas.
3. Column |FGVi|: enter a user-specific value of flue gas generated by incineration, in m^3/Mg of waste incinerated.



➢ **Fossil liquid incineration**

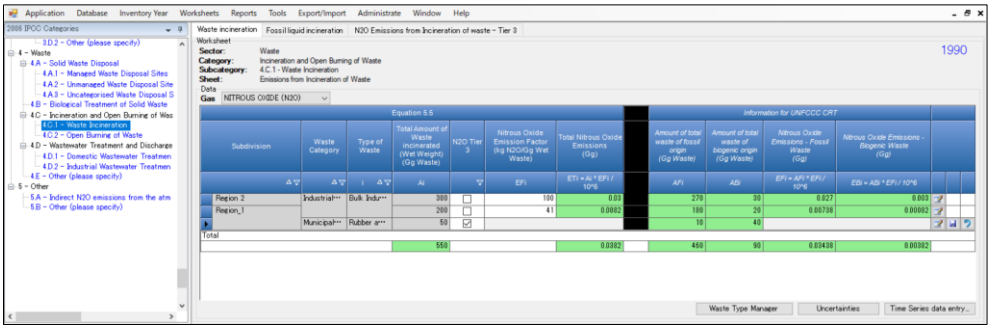
2006 IPCC Guidelines methodological guidance assumes N_2O emissions to be negligible. Users that wish to report those can use **Waste incineration** worksheet, although in such a case the waste type needs to be added in the **Waste Type Manager**.

[84] To prepare estimates according to NGHGI Tier 1 or Tier 2.

Results

In worksheet **Waste incineration**, for each row of data the *Software* calculates in mass units, Gg, CO_2 emissions from incineration of solid waste of fossil origin, in column |EFi|, and CH_4 and N_2O emissions from incineration of total waste (fossil and biogenic), in column |ETi|, as well as total emission as the sum of all emissions from incineration of all waste categories and waste types listed in all subdivisions.

Furthermore, **for purposes of UNFCCC CRT reporting**, the *Software* also calculates:



1. Column |AFi|: amount of waste of fossil origin, *Calculated* as total waste multiplied by the *FCF* value entered in the **Waste Type Manager** for the relevant waste type.
2. Column |ABi|: amount of waste of biogenic origin *Calculated* as total waste multiplied by *1-FCF*.

   Note: users may instead enter a user-specific value for both amounts -i.e. waste of fossil and of biogenic origin-. To do so, in both columns |AFi| & |ABi| users:

   a. first select *Carbon Dioxide (CO_2)* in the *Gas* toggle, although the following applies to CH_4 and N_2O too,

   b. then select *Specified* to replace the default selection *Calculated*.

   Accordingly, the *Software* makes the cells editable, removing the green[85] colour of the cells.

   Recall, the two components of *total amount of waste* -i.e. fossil *vs* biogenic waste- shall sum up to the value contained in column |Ai|. Thus, where users have data to enter for amount of fossil and/or biogenic waste, both amounts shall be entered and the sum of the two shall correspond to the value contained in Column |Ai|.
3. Column |EFi|: emissions of fossil origin, in Gg; for CH_4 and N_2O only, given that CO_2 emissions of fossil origin are already calculated.
4. Column |EBi|: emissions of biogenic origin, in Gg; for CO_2, CH_4, N_2O.

In worksheet **Fossil liquid incineration**, for each row of data the *Software* calculates in mass units, Gg, CO_2 emissions from incineration of fossil liquid waste, in column |Fossil CO_2 emissions|, as well as total emission as the sum of all emissions from incineration of all waste types listed in all subdivisions.

In worksheet **N_2O Emissions from Incineration of waste – Tier 3**, for each row of data the *Software* calculates in mass units, Gg, N_2O emissions from incineration of fossil liquid waste, in column |Fossil CO_2 emissions|, as well as total emission as the sum of all emissions from incineration of all waste types listed in all subdivisions.

[85] Green colour indicates cells where the Software calculates the value contained in.

4.C.2. Open Burning of Waste

Open burning of waste is the activity of combustion of solid waste in open-air or in open dumps. It also can include uncontrolled incineration devices.

IPCC Equations

GHG emissions from open burning are estimated by applying the following equations of the *2006 IPCC Guidelines*.

- CO_2 emissions:
  - ✓ Tier 1: Equations 5.1 & 5.2.
  - ✓ Tier 2a[86]: Tier 1 equation, although with user-specific AD on waste and for MSW on its composition in waste types.
  - ✓ Tier 2b[87]: Tier 1 equation, although with user-specific AD on waste, and for MSW on its composition, as well as user-specific values for *dm*, *CF*, and possibly for *FCF* and *OF*.
  - ✓ Tier 3: no IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.

Table 5.1 provides an overview on tier levels at which default values or country-specific data are to be applied for calculating CO_2 emissions.

- CH_4 emissions:
  - ✓ Tier 1: Equation 5.4.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on waste, and for MSW on its composition, as well as user-specific EF.
  - ✓ Tier 3: no IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.
- N_2O emissions:
  - ✓ Tier 1: Equation 5.5.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on waste, and for MSW on its composition, as well as user-specific EF.
  - ✓ Tier 3: no IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.

As explained in **I.2 Use of multiple tiers for reporting**, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Note: for the purposes of interoperability with the UNFCCC ETF Reporting Tool, the *Software* calculates estimates of CO_2, CH_4 and N_2O emissions from open burning disaggregated by the origin of waste i.e. *biogenic vs fossil* origin. In the calculation worksheets, columns needed for such disaggregation are listed under the element **Information for UNFCCC CRT** and are separated by a black vertical line from columns needed to implement the IPCC equation.

Software Worksheets

The *Software* calculates CO_2, CH_4 and N_2O emissions from open burning using the following worksheets:

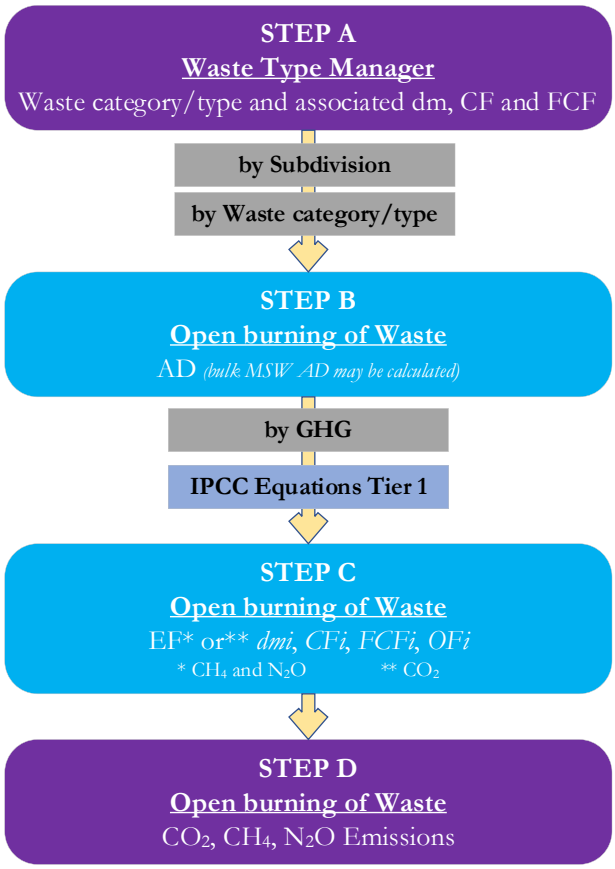
- ✓ **Waste Type Manager**: contains parameter data for each waste type, and the selection for AD between wet[88] or dry weight.
- ✓ **Open burning of waste:** contains for each subdivision/waste category/type of waste the amount of waste burnt and the relevant CO_2, CH_4 and N_2O EFs and calculates associated GHG emissions.

[86] Tier 2a method for open burning of waste could incorporate annual surveys on the amounts and the composition of waste burned by households, authorities and companies responsible for the waste management.
[87] Tier 2b method for open burning of waste could incorporate annual and detailed surveys on the amounts and the composition of waste burned by households, authorities and companies responsible for the waste management described in Tier 2a, with a combined measurement programme for emission factors related to the practices of open burning in the country.
[88] The UNFCCC NGHGI requires wet weights.

User's work Flowchart

Consistent with the key category analysis and the decision trees of the *2006 IPCC Guidelines*, Figure 5.1 (CO_2) and Figure 5.2 (CH_4 and N_2O), GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[89] EFs and/or measurement data.

Open burning of Waste - solid waste - flowchart



Step A, in **Waste Type Manager**, users (1) enter values for parameters for which an IPCC default value is not precompiled, or (2) replace the value precompiled with their own user-specific values; and (3) enter user-specific waste types, if any, and associated values for parameters.

Then, for each subdivision, if any:

Step B, in worksheet **Open burning of waste**, users:

- ✓ first select[90] *Carbon Dioxide (CO_2)*, in the *Gas* toggle, in the heading of the TAB,
- ✓ then enter AD.

Step C, in worksheet **Open burning of waste**, users:

- ✓ for CO_2, may re-enter[91] values for *dm*, *CF*, *FCF* and select or enter the value for *OF,*
- ✓ for CH_4 & N_2O users elect or enter the EF values.

Step D, in worksheet **Open burning of waste**, for each row of data and for each GHG, the *Software* calculates emissions in mass units (Gg). In addition, total emissions of each GHG are calculated.

[89] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented by either applying different region-specific EFs or applying the user-specific EF, as the weighted average EF across the two regions, to both regions.

[90] Activity Data shall be entered in the worksheet with CO_2 gas selected. Those AD are then used by the *Sofwtare* to calculate emissions from all three GHGs, including in worksheet *N_2O Emissions from Incineration of waste – Tier 3.*

[91] When users select the waste type in the dropdown menu, *dm*, *CF*, *FCF* values are automatically filled in by the *Software*, with the values in the **Waste Type Manager**.

Activity Data input

The *2006 IPCC Guidelines*, Chapter 2 contains information about the compilation of AD on waste generation composition and management. Regional default data on incineration are provided in Table 2.1, and country-specific data for some countries can be found in Annex 2A.1. Further, guidance on collecting AD for open burning is found in Section 5.3.

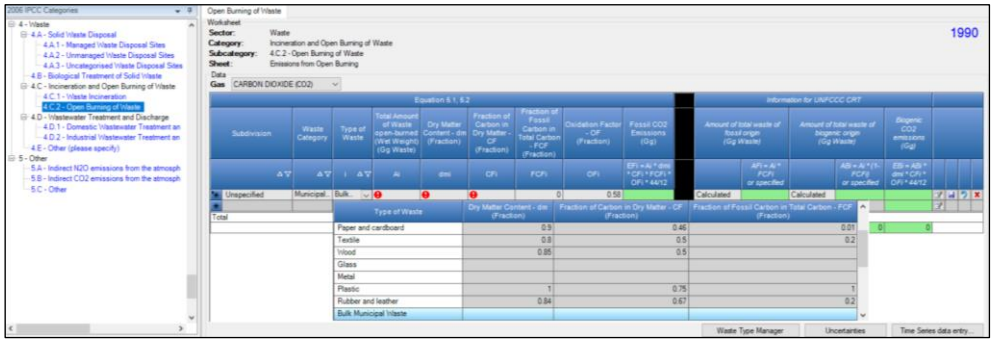
As a **starting step**, users enter in the **Waste Type Manager** all user-specific waste categories and waste types to be reported in the NGHGI; and for each waste type listed in the **Waste Type Manager** revise, where needed, pre-compiled values for *Dry Matter Content (dm)*, *Total Carbon in Dry Matter (CF)*[92], *Fossil Carbon in Total Carbon (FCF)*[93].

Second, users compile the worksheet **Open Burning of Waste** either with a single row of data for the entire category (per waste type) or with subnational aggregations. A univocal name/code is entered in column |Subdivision| per subdivision. If one subdivision (i.e. a single row of data) is used per waste type then "unspecified", as selected from the dropdown menu, can be used.

Note: AD to estimate emissions from each GHG shall be entered only once in worksheet **Open Burning of Waste,** when *Carbon Dioxide (CO_2)* is selected in the *Gas* toggle. When CH_4 or N_2O are selected, AD cannot be entered. The *Software* automatically uses AD entered for CO_2 as the AD to calculate emissions of *Methane (CH_4)* and *Nitrous Oxide (N_2O)* in the calculation worksheet when the relevant GHG is selected in the *Gas* toggle.

In worksheet **Open Burning of Waste** select *Carbon Dioxide (CO_2)* in the *Gas* toggle and then:

1. Column |Waste category|: select category of waste -*municipal waste*, *industrial waste*, *sludge, other waste*- from the dropdown menu.
2. Column |Type of waste|: select the type of waste from the dropdown menu. If data are not available by waste type (food, garden and park, plastic, rubber and leather, etc) then select *Bulk Municipal Waste* (Equation 5.1), otherwise enter each waste type, one per row (Equation 5.2).
   *Note: waste types in the dropdown menu are those listed in the **Waste Type Manager**.*



3. Column |Ai|: enter *total amount of waste open burned*, in Gg.

[92] Fraction of C in dry matter.
[93] Fraction of fossil C in total C.

Emission Factor input

Guidance on choice of EFs and parameters for estimation of GHG emissions from open burning of waste is provided in Section 5.4.1 (CO_2), Section 5.4.2 (CH_4) and Section 5.4.3 (N_2O) of the *2006 IPCC Guidelines*. Updated guidance for each GHG is provided in the corresponding Section of the *2019 Refinement*.

Emission factors are to be entered for each of the GHG, as selected in the toggle, as it follows:

CARBON DIOXIDE (CO_2)

In worksheet **Open Burning of Waste**, when *Carbon Dioxide (CO_2)* in the *Gas* toggle is selected:

4. Column |dmi|: the *Software* precompiles[94] *dm* with the value contained in the **Waste Type Manager** for the relevant waste type. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).

   Note: where users enter waste weight in a **dry-weight basis**, the value of **1 is to be entered as *dm*** to maintain accuracy of estimates.

5. Column |CFi|: the *Software* precompiles[81] *CF* with the value contained in the **Waste Type Manager** for the relevant waste type. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).

6. Column |FCFi|: the *Software* precompiles[81] *FCF* with the value contained in the **Waste Type Manager** for the relevant waste type. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).

7. Column |OFi|: the *Software* precompiles[81] *OF*[95] with the value 0.58 -i.e. 58% of carbon oxidised to CO_2. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).

METHANE (CH_4)

In worksheet **Open Burning of Waste**, when *Methane (CH_4)* in the *Gas* toggle is selected:

4. Column |EFi|: select from the drop-down menu the relevant IPCC default EF or enter user-specific EF (e.g., country-specific) in kg CH_4/Gg wet weight.
   Note: IPCC default values are for waste reported on a wet weight basis; thus, where users enter AD on a dry weight basis IPCC default values shall not be selected, and a user-specific value shall instead be entered.

NITROUS OXIDE (N_2O)

In worksheet **Open Burning of Waste**, when *Nitrous Oxide (N_4O)* in the *Gas* toggle is selected:

4. Column |dmi|: the *Software* precompiles[96] *dm* with the value contained in the **Waste Type Manager** for the relevant waste type. Nevertheless, users can overwrite the values with a user-specific (e.g., subdivision-specific) value, a fraction (value between 0 and 1).

   Note: where users enter waste weight in a **dry-weight basis**, the value of **1 is to be entered as *dm*** to maintain accuracy of estimates.

5. Column |EFi|: select from the drop-down menu the relevant IPCC default EF or enter user-specific EF (e.g., country-specific) in kg N_2O/Gg dry weight.

Results

In worksheet **Open Burning of Waste**, for each row of data, the *Software* calculates in mass units, Gg, CO_2 emissions from open burning of solid waste of fossil origin in column |EFi|, and CH_4 and N_2O emissions from incineration of total waste (fossil and biogenic) in column |ETi|. Total emission as the sum of all emissions from open burning of all waste categories and waste types listed in all subdivisions is also calculated.

Furthermore, as explained in **4.C.1. Waste Incineration**, **for purposes of UNFCCC CRT reporting**, the *Software* also calculates CO_2 emissions from biogenic carbon as well as disaggregating CH_4 and N_2O emissions into fossil and biogenic components.

[94] Of course, only if a value for the relevant parameter of the relevant waste type is contained in the waste type manager.
[95] Oxidation factor.
[96] Of course, only if a value for the relevant parameter of the relevant waste type is contained in the waste type manager.

4.D. Wastewater Treatment and Discharge

Information

Wastewater treatments and discharges are classified into *Domestic* and *Industrial* wastewater.

The *Wetlands Supplement* extends wastewater treatment to *Constructed Wetlands*.[97]

Figure 6.2 of the *Wetlands Supplement* represents the different pathways for wastewater treatment and discharge. It is *good practice* to draw a diagram like Figure 6.2 to consider treatment and discharge systems and pathways including *collected* and *uncollected* as well as *treated* and *untreated*, for both *Domestic* and *Industrial* wastewaters.

GHG

The *Software* estimates the following GHGs for wastewater treatment and discharge:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
	X	X				

CO_2 emissions from organic carbon are not estimated and reported in the Waste sector since CO_2 emissions are of biogenic origin and are covered under the AFOLU sector[98].

N_2O emissions can occur as direct emissions from advanced treatment plants, and indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea.

[97] Including Constructed Wetlands (CWs) and Semi-Natural Treatment Wetlands (SNTWs).

[98] CO_2 emissions of perennial biomass are reported as C stock losses, while CO_2 emissions of annual biomass are not reported given that the CO_2 removals that have originated from that biomass are also not reported. This is because annual biomass is assumed to conclude its cycle within a year (i.e., both CO_2 removals and subsequent CO_2 emissions occurring within a time-period of 1 year).

4.D.1. Domestic Wastewater Treatment and Discharge

Domestic wastewater treatment and discharge is the activity of treatment and discharge of wastewater from household use. According to the IPCC guidelines, treatment and discharge of commercial wastewater are reported as part of domestic wastewater.

Hereafter information is reported aggregated for each GHG:

I. **METHANE (CH4)** emissions

II. **NITROUS OXIDE (N2O)** emissions (direct and indirect)

Note for both GHGs, domestic wastewater treated in Constructed Wetlands is reported in separate worksheet and so care should be taken to **separate AD** between ***all types of treatment and discharge pathways*** and **Constructed Wetlands**.

Note users need to ensure consistency of data/information used to estimate in different worksheets CH_4 and N_2O emissions.

METHANE (CH_4)

IPCC Equations

CH_4 emissions from Domestic Wastewater Treatment and Discharge are estimated by applying the following equations of the *2006 IPCC Guidelines* and its *Wetlands Supplement*.

- CH_4 emissions (excluding treatment in *Constructed Wetlands*)
  - ✓ Tier 1: Equations 6.1, 6.2 and 6.3.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on wastewater and user-specific EF.
  - ✓ Tier 3: emissions are estimated based on treatment system-specific data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.
- CH_4 emissions from treatment in *Constructed Wetlands*
  - ✓ Tier 1: Equations 6.1, 6.2 and 6.3 of the *Wetlands Supplement*.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on wastewater and user-specific EF.
  - ✓ Tier 3: emissions are estimated based on treatment system-specific data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.

Software Worksheets

The *Software* calculates CH_4 and N_2O emissions from Domestic Wastewater Treatment and Discharge using the following worksheets:

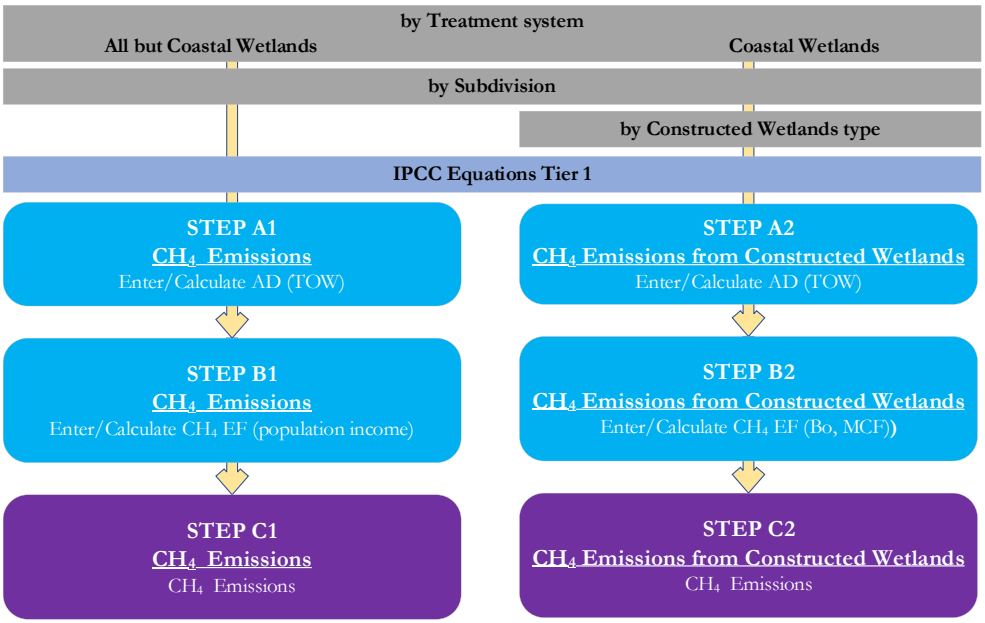
- ✓ **CH_4 emissions**: contains for each subdivision the amount of organically degradable matter in treated[99] wastewater, as calculated or entered directly, as well as the CH_4 EF and calculates associated CH_4 emissions.
- ✓ **CH_4 emissions from constructed wetlands**: contains for each subdivision the amount of organically degradable matter in wastewater, as calculated or entered directly, as well as the CH_4 EF, as calculated or entered directly, and calculates associated CH_4 emissions.

[99] Excluding Constructed Wetlands treatments.

User's work Flowchart

Consistent with the key category analysis and the decision tree, Figure 6.2 of the *2006 IPCC Guidelines* and Figure 6.3 of the *Wetlands Supplement* worksheets, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[100] EFs and/or measurement data.

Domestic Wastewater Treatment and Discharge – CH_4 – Flowchart



Using a different worksheet according to the treatment system (i.e. non-Constructed Wetlands *vs* Constructed Wetlands), for each subdivision, if any:

Step A1, in worksheet **CH_4 Emissions**, users enter either *Total Organics in Wastewater* (TOW) or *Population*, *Biochemical Oxygen Demand* (BOD) and *correction factor for industrial BOD* to calculate *TOW*.

Step A2, in worksheet **CH_4 Emissions from Constructed Wetlands**, users enter either *Total Organics in Wastewater* (TOW) or *Population*, *Biochemical Oxygen Demand* and *correction factor for industrial BOD* to calculate *TOW*.

Step B1, in worksheet **CH_4 Emissions**, users either enter *Weighted Emission Factor* (WEF) or enter *Population*, as stratified by *income* level and *type of treatment and discharge pathway,* and the associated *EF*. The *EF* may alternatively be calculated from *maximum methane producing capacity* (B_0) and *Methane Correction Factor* (*MCF*)- and calculate the *WEF*.

Step B2, in worksheet **CH_4 Emissions from Constructed Wetlands**, for each type of Constructed Wetlands, users enter either *EF* or *maximum methane producing capacity* (B_0) and *Methane Correction Factor* (*MCF*) and the *Software* calculates the *EF*.

Step C1, in worksheet **CH_4 Emissions**, for each row of data users enter *Sludge removed*, if any, as well as *CH_4 flared* and *CH_4 recovered for energy use* then the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

Step C2, in worksheet **CH_4 Emissions from Constructed Wetlands**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

[100] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity Data input

The AD for this source category is the amount of organically degradable material in the wastewater (TOW). This parameter is a function of human population and it can be calculated from the biochemical oxygen demand (kg BOD/year) to oxidise the organic matter (Equations 6.3 and 6.3).

WORKSHEET **CH_4 Emissions**

Table 6.4 provides BOD values in domestic wastewater for selected regions and countries. Section 6.2.2.3 provides guidance on data needs and where to find and how to apply data.

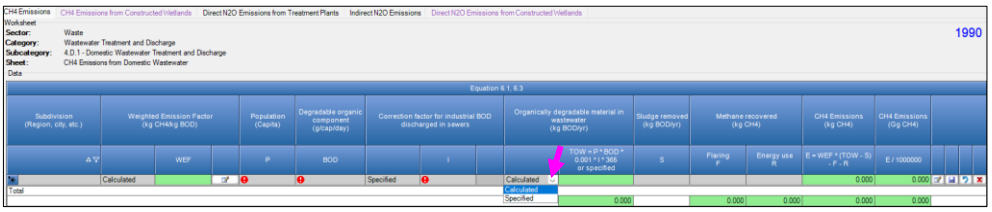
Users compile the worksheet **CH_4 Emissions** either with a single row of data for the entire category or with subnational aggregations. For each subdivision a univocal name/code is entered in column |Subdivision|. If a single row of data is used (i.e., one subdivision) for the entire category then "unspecified", as selected from the dropdown menu, can be used.

For each subdivision in column |Subdivision| data are entered as it follows:

The *Software* provides two options for AD, **TOW**, in the dropdown menu in column |Organic degradable material in wastewater (kg BOD/yr)|: *Calculated* or *Specified*.

So, as a **first step**:

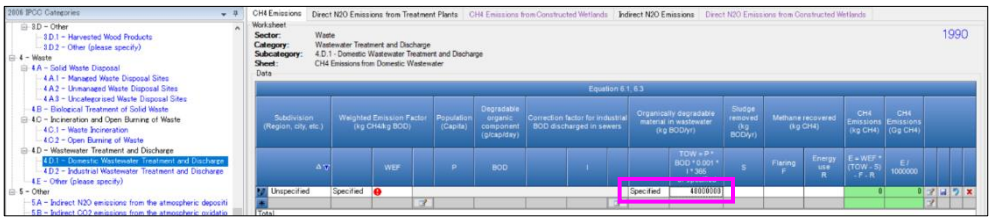
1. Column |Organic degradable material in wastewater|: users select:
   - ✓ either *Specified*, if user-specific data (e.g., country-specific data) on *TOW* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.3.



Once selected, users follow one of the following two paths:

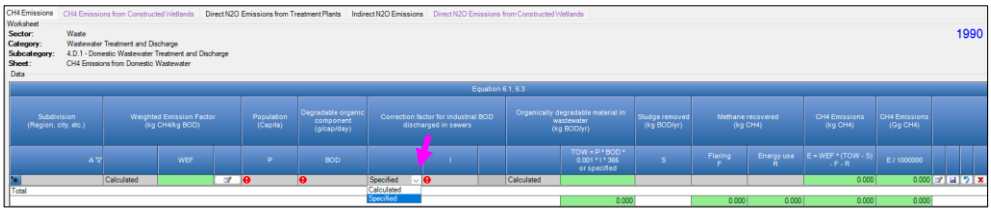
A. **TOW** *Specified*

2. Column |TOW|: enter TOW, in kg of degradable organic matter per year.



B. **TOW** *Calculated*

2. Column |P|: enter population, capita.
3. Column |BOD|: select the relevant IPCC default EF from the drop-down menu or enter user-specific EF, in grams of degradable organic matter per capita per day.
4. Column |Correction factor for industrial BOD discharged into sewers (I)|: users select:
   - ✓ either *Specified*, if user-specific data (e.g., country-specific data) are available,
   - ✓ otherwise *Calculated*, which implements Equations 6.1 and 6.2.



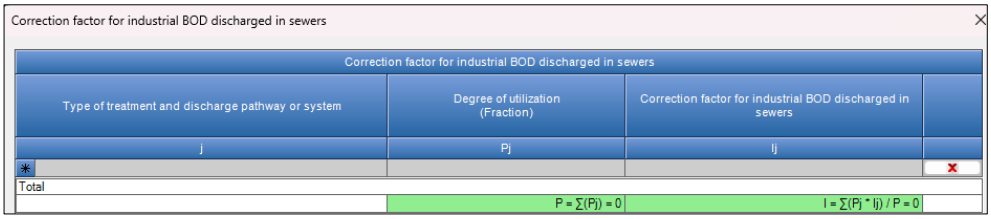
Once selected, users follow one of the following two paths:

A. **I** *Specified*

5. Column |I|: enter correction factor for co-discharge, dimensionless.

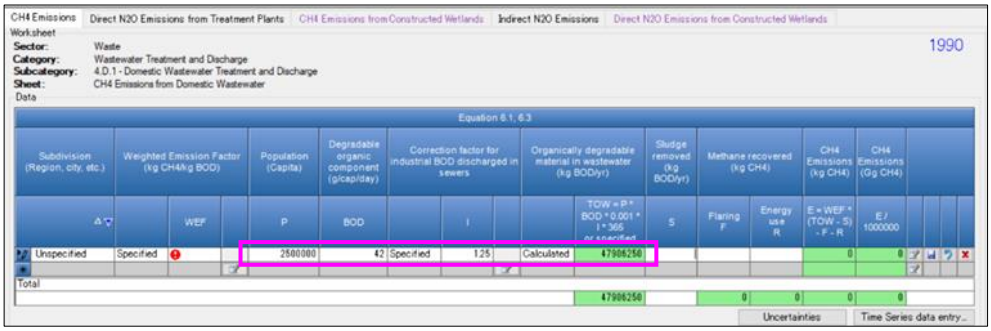
B. **I** *Calculated*

5. Column |I|: click the *Edit* mark on the right-hand side, opening the sub-worksheet below.



6. Column |j|: select the relevant type of treatment and discharge pathway from the drop-down menu or enter a user-specific type.
7. Column |Pj|: enter the degree of utilization, in the relevant subdivision, of the relevant type of treatment and discharge pathway, a fraction between 0 and 1.
8. Column |Ij|: select the IPCC default correction factor from the drop-down menu or enter a user-specific, a value from 1 onward.
   Note: 1.25 means that co-discharged organic matter from industrial sources equals to 25% of that discharged by domestic sources.
   Note: 1 means that co-discharge in uncollected type of treatment and discharge pathway is not relevant for this category.

Note: the weighted average is calculated automatically in the green cell at the bottom of column |Ij|.



As a **final step**:

9. Column |S|: users enter the amount of sludge removed, kg of degradable organic matter per year, if any.

WORKSHEET CH_4 Emissions from Constructed Wetlands

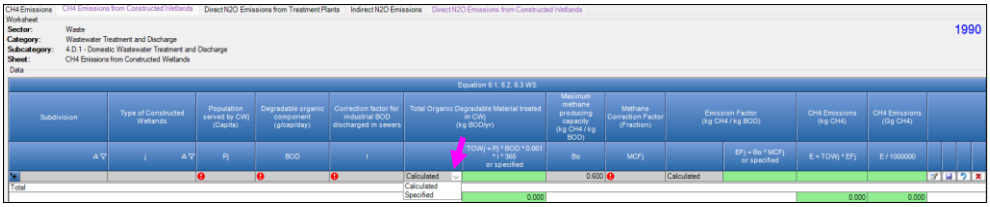
Users compile the worksheet **CH_4 Emissions from Constructed Wetlands** either with a single row of data for the entire category or with subnational aggregations. For each subdivision a univocal name/code is entered in column |Subdivision|. If a single row of data is entered for the entire category then "unspecified", as selected from the dropdown menu, can be used.

For each subdivision in column |Subdivision| data are entered as it follows:

The *Software* provides two options for AD, TOW, in the dropdown menu in column |Organic degradable material treated in CWj (kg BOD/yr)|: *Calculated* or *Specified*.

So, as a **first step**:

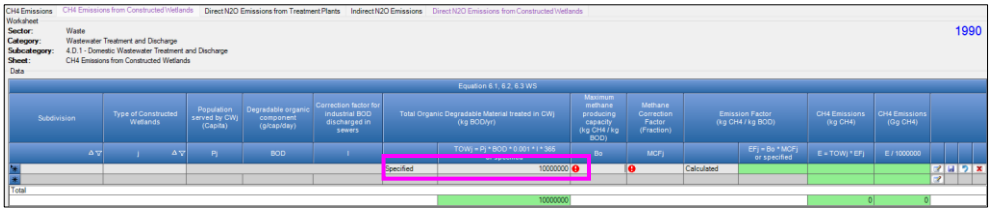
1. Column |Organic degradable material treated in CWj|: users select:
   - ✓ either S*pecified*, if user-specific data (e.g., country-specific data) on *TOW* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.3.



Once selected, users follow one of the following two paths:

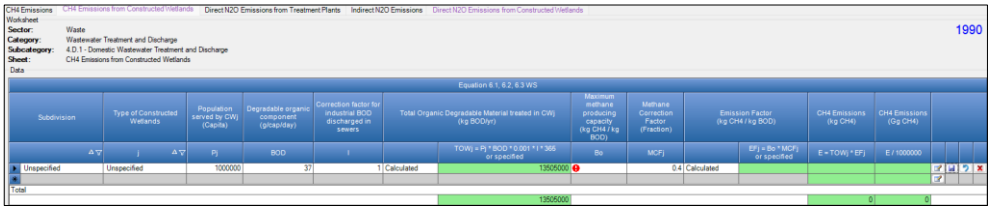
A. **TOW** *Specified*

2. Column |TOW|: enter TOW, in kg of degradable organic matter per year.



B. **TOW** *Calculated*

2. Column |j|: select the relevant Type of Constructed Wetlands (CWj) from the drop-down menu or enter a user-specific type.
3. Column |Pj|: enter the population served by the relevant CWj, capita.
4. Column |BOD|: select the relevant IPCC default EF from the drop-down menu or enter a user-specific EF, in grams of degradable organic matter per capita per day.
5. Column |Correction factor for industrial BOD discharged into sewers (I)|: select the relevant IPCC default from the drop-down menu or enter a user-specific value.
   Note: 1.25 means that co-discharged organic matter from industrial sources equals to 25% of that discharged by domestic sources.
   Note: 1 means that co-discharge in uncollected type of treatment and discharge pathway is not relevant for this category.



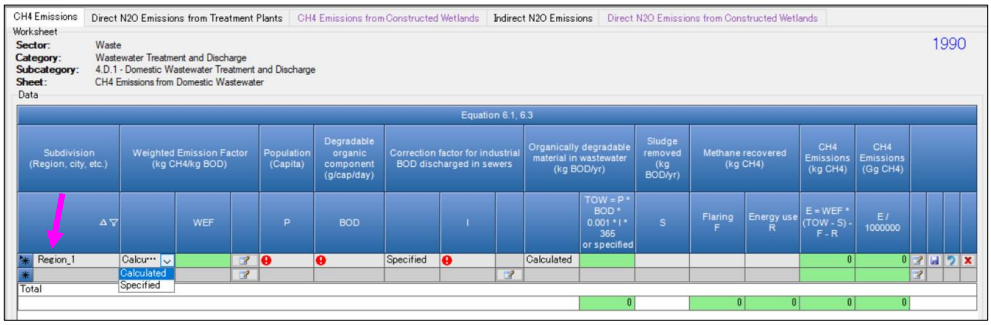
Emission Factor input

WORKSHEET **CH_4 Emissions**

The *Software* provides two options to deal with the weighted emission factor, **WEF**, in the dropdown menu in column |Weighted Emission Factor (kg CH_4/kg BOD)|: *Calculated* or *Specified.*

So, as a **first step**:

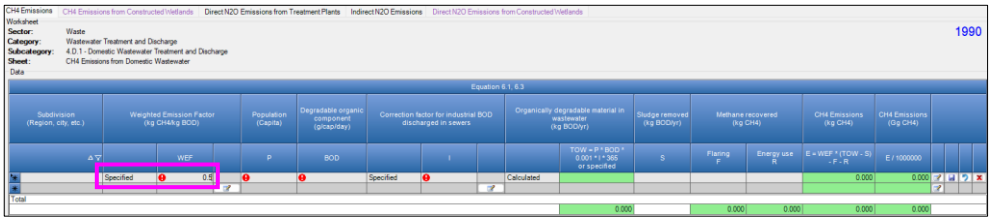
1. Column |Weighted Emission Factor (kg CH_4/kg BOD)|: users select:
   - ✓ either S*pecified*, if user-specific (e.g., country-specific) *WEF(s)* are available,
   - ✓ otherwise *Calculated*, which implements Equations 6.1 and 6.2.



Once selected, users follow one of the following two paths:

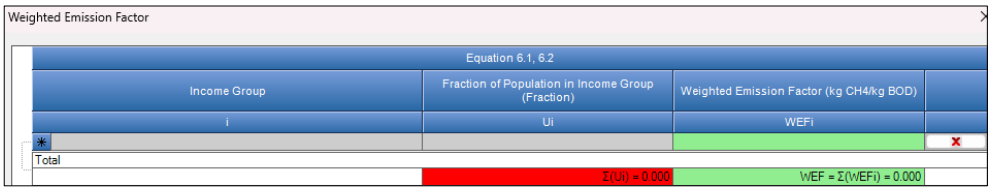
A. **WEF** *Specified*

2. Column |WEF|: enter the WEF, in kg of CH_4 emissions per kg of degradable organic matter.

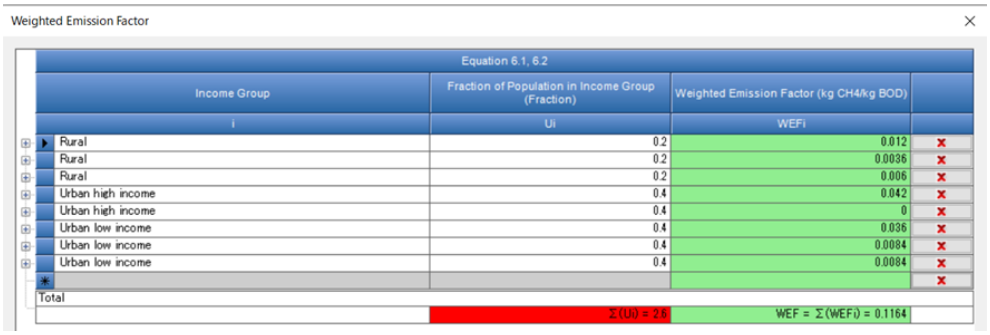


B. **WEF** *Calculated*

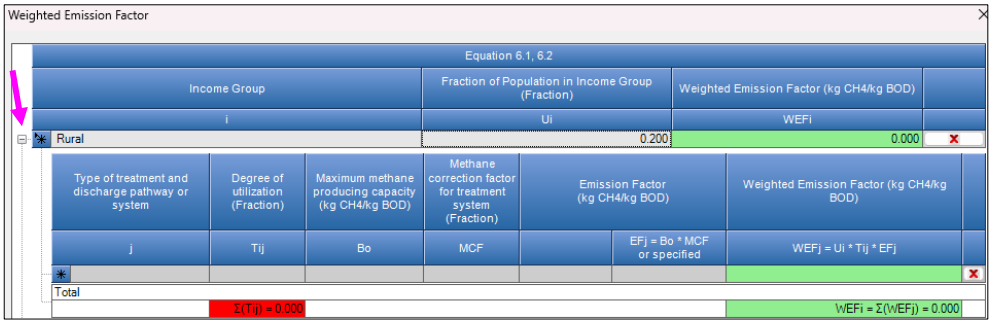
2. Column |WEF|: click the *Edit* mark on the right-hand side, opening the sub-worksheet below.



3. Column |i|: select the income group (rural, urban high income and urban low income) from the drop-down menu or enter user-specific group.
4. Column |Ui|: enter the fraction of population in the group I, a fraction between 0 and 1.
   Note: in the last cell of column |Ui| the Software sum up the fractions entered in the column. Fractions shall sum up to 1, otherwise the Software shows a red background colour in the cell to signal the error.

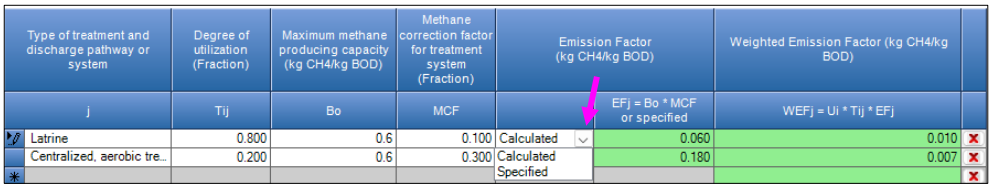


Once *i* and *Ui* are entered, a symbol ⊞ will be shown on the left-hand side of each row. Users click on it to open an additional table of variables to be entered for the calculation of WEF.



5. Column |j|: select from the drop-down menu the relevant type of treatment and discharge pathway or enter a user-specific type.
6. Column |Tij|: enter the degree of utilization, in the group of population *i*, of the relevant type of treatment and discharge pathway, a fraction between 0 and 1.
   Note: Table 6.5 provides the fraction of population for each income group and the associated degree of utilization of types of treatment and discharge pathway for some countries.
   Note: in the last cell of column |Ui| the Software sum up the fractions entered in the column. Fractions shall sum up to 1, otherwise the Software shows a red background colour in the cell to signal the error.

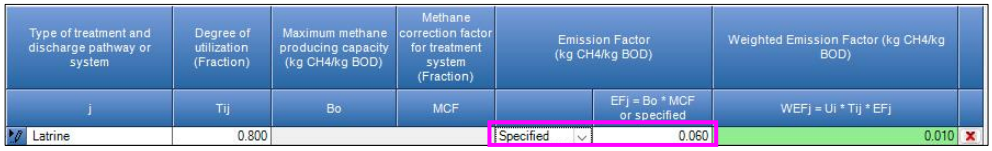
   The *Software* provides two options for EF in the dropdown menu in column | Emission Factor (kg CH_4/kg BOD)|: *Calculated* or *Specified*. To enter the data for the EF:
7. Column |Emission Factor (kg CH_4/kg BOD)|: users select:
   - ✓ either *Specified*, if user-specific (e.g., country-specific) *EF(s)* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.2.



Once selected, users follow one of the following two paths:

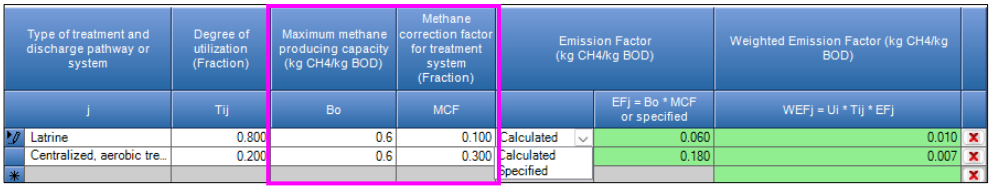
A. **EF** *Specified*

8. Column |EF|: enter EF, in kg of CH_4 emissions per kg of degradable organic matter.



B. **EF** *Calculated*

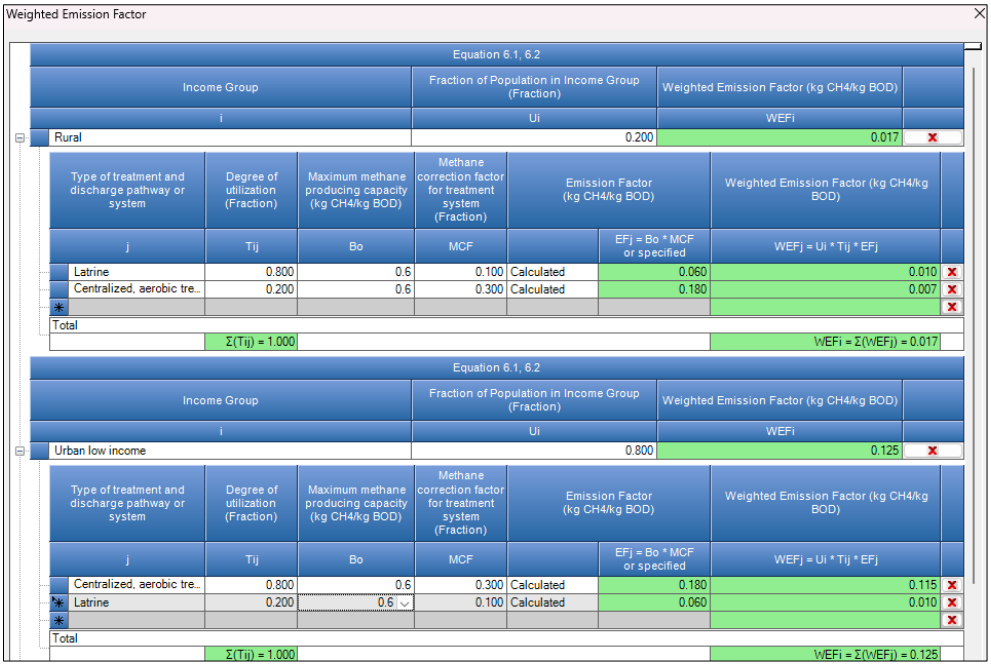
8. Column |B_0|: the *Software* precompile *maximum methane producing capacity* with the IPCC default value of 0.6; users can overwrite the value with a user-specific value, in kg CH_4/kg BOD.
   Note: for domestic wastewater, a COD-based value of Bo can be converted into a BOD-based value by multiplying it with a factor of 2.4
9. Column |MCF|: once users select one of the IPCC default types of treatment and discharge pathways from the dropdown menu, the *Software* automatically compiles the IPCC default *methane correction factor* in this column. Users can overwrite this value with a user-specific one. Where a user-specific type of treatment and discharge pathway has been entered in column |*j*|, users enter a user-specific value, a fraction between 0 and 1.



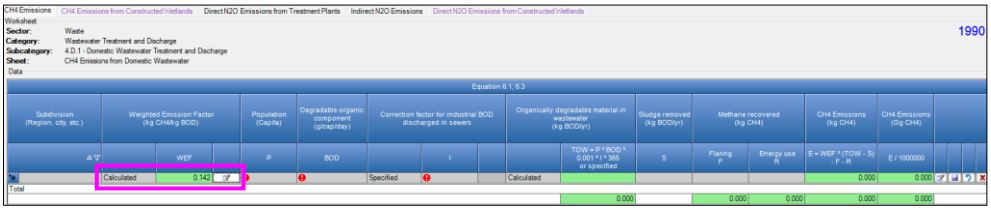
Note the calculation of **WEF** is implemented at three levels:

I. First, *WEFj* is calculated per each type of treatment and discharge pathway *j* used by a relevant group of population.

II. Second, *WEFi* is calculated per each population group *i*.



III. Third, *WEF* is calculated per each subdivision.

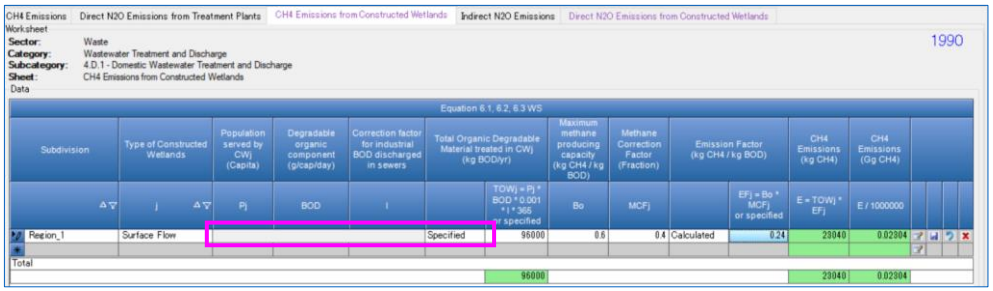


WORKSHEET **CH_4 Emissions from Constructed Wetlands**

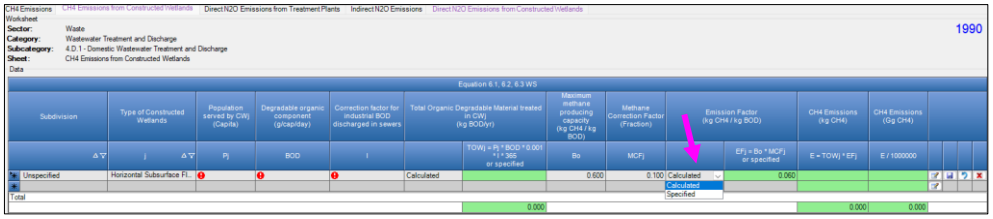
The EF for wastewater treatment in CW is a function of the maximum CH_4 producing potential, B_o and the MCF (Equation 6.2 of the *Wetlands Supplement*).

The *Software* provides two options for the EF in the dropdown menu in column |Emission Factor (kg CH_4/kg BOD)|: *Calculated* or *Specified*. To enter the EF:

1. Column |Emission Factor (kg CH_4/kg BOD)|: users select:
   - ✓ either *Specified*, if user-specific (e.g., country-specific) *EF(s)* are available,



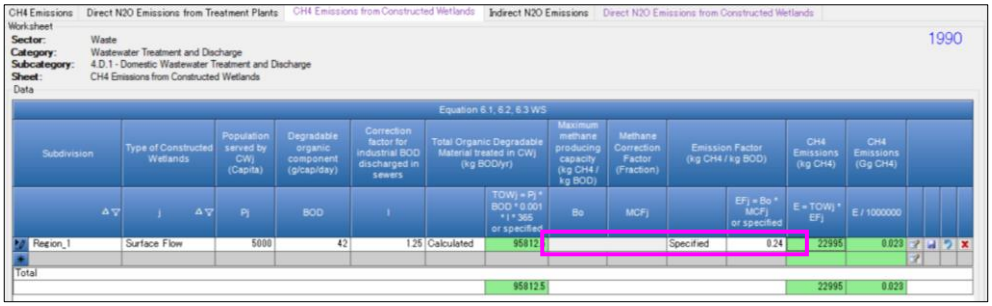
   - ✓ otherwise *Calculated*, which implements Equation 6.2.



Once selected, users follow one of the following two paths:

A. **EF** *Specified*

2. Column |EF|: enter the EF, in kg of CH_4 emissions per kg of degradable organic matter.



B. **EF** *Calculated*

2. Column |B_0|: once users select one of the IPCC default types of constructed wetlands from the dropdown menu, the *Software* automatically compiles the IPCC default *maximum methane producing capacity* in this column. Users can overwrite it with a user-specific value. Where a user-specific type constructed wetlands has been entered in users enter a user-specific value, in kg CH_4/kg BOD.
3. Column |MCFj|: once users select one of the IPCC default types of constructed wetlands from the dropdown menu, the *Software* automatically compiles the IPCC default *methane correction factor* in this column. Users can overwrite it with a user-specific value. Where a user-specific type constructed wetlands has been entered in column |*j*|, users enter a user-specific value, a fraction between 0 and 1.

Results

WORKSHEET CH_4 Emissions

To get **Results**, as CH_4 emissions for each *Subdivision*, users:

- ✓ Column |F|: enter the annual amount of CH_4 generated that is flared at the treatment site.
- ✓ Column |R|: enter the annual amount of CH_4 generated that is captured and used for energy production.

Finally, the *Software* calculates in column |CH_4 emissions| the CH_4 emissions in mass units, Gg, for each *Subdivision*, as the CH_4 generated minus the quantity recovered, either flared or used for energy production, as well as total CH_4 emission.

WORKSHEET CH_4 Emissions from Constructed Wetlands

For each row of data, the *Software* calculates in mass units, Gg, CH_4 emissions in column |CH_4 emissions| as well as total CH_4 emissions.

NITROUS OXIDE (N_2O)

IPCC Equations

GHG emissions from Domestic Wastewater Treatment and Discharge are estimated by applying the following equations of the *2006 IPCC Guidelines* and its *Wetlands Supplement*.

- Direct N_2O emissions (excluding treatment in *Constructed Wetlands*)
  - ✓ Tiers 1 & 2 & 3: none.

    However, equation 6.9. is provided in Box 6.1 of the IPCC Guidelines together with an EF calculated for the Northern United States. This equation is not qualified as a methodological tier level, although users can apply it where direct N_2O emissions from advanced centralized wastewater treatment plants with controlled nitrification and denitrification steps are to be estimated. As such, Equation 6.9 is implemented in the *Software* as well as the EF value given in Box 6.1, which, although provided in the *Software*, is NOT qualified as an IPCC default EF.
- Indirect N_2O emissions (including treatment in *Constructed Wetlands*)
  - ✓ Tier 1: Equations 6.7 & 6.8.
  - ✓ Tier 2: Tier 1 equations, although with a user-specific EF.
  - ✓ Tier 3: no IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.
- N_2O emissions from treatment in *Constructed Wetlands*
  - ✓ Tier 1: Equations 6.5 and 6.6 of the *Wetlands Supplement*.
  - ✓ Tier 2: Tier 1 equations, although with a user-specific EF.
  - ✓ Tier 3: no IPCC Tier 3 Equation is provided in the *Wetlands Supplement*.

Software Worksheets

The *Software* calculates N_2O emissions from domestic wastewater treatment and discharge using the following worksheets:

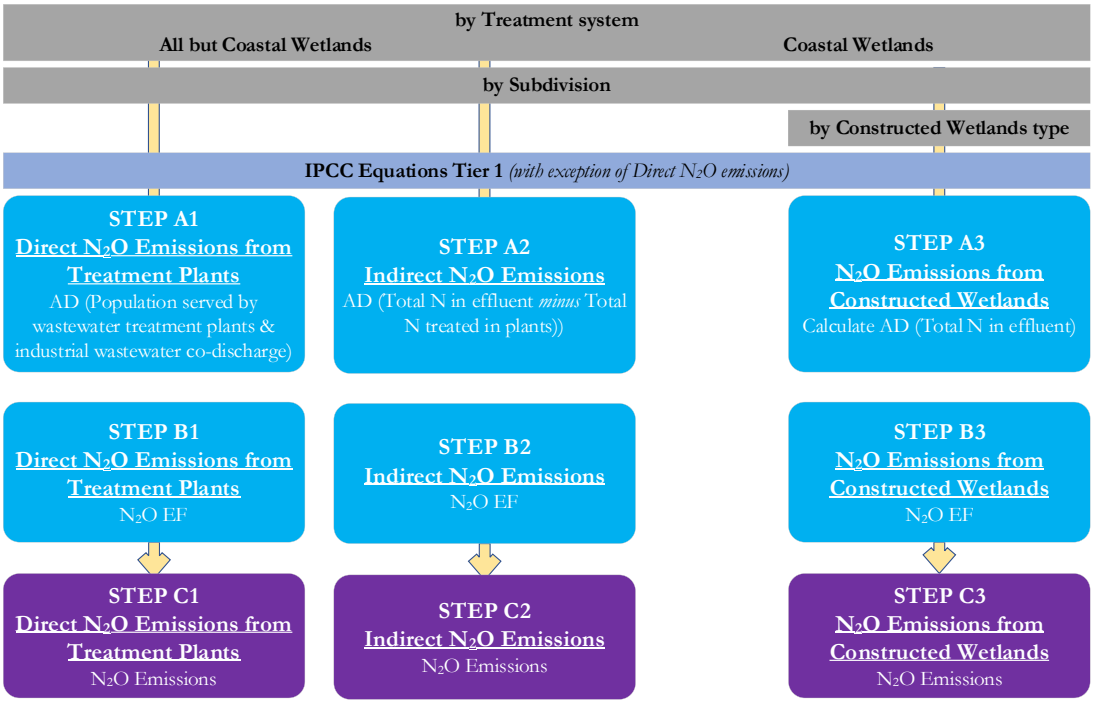
- ✓ **Direct N_2O emissions**: contains, for each subdivision, the amount of population that uses advanced treatment plants[99] as well as the N_2O EF and calculates associated N_2O emissions.
- ✓ **N_2O emissions from constructed wetlands**: calculates, for each subdivision, the amount of nitrogen in effluents to constructed wetlands as well as the N_2O EF and calculates associated N_2O emissions.
- ✓ **Indirect N_2O Emissions**: calculates, for each subdivision, the amount of nitrogen in effluents from treatment plants[101], subtracts the N treated in wastewater plants, contains the N_2O EF, and calculates associated N_2O emissions.

[101] Including from Constructed Wetlands.

User's work Flowchart

Consistent with the key category analysis and the decision tree Figure 6.4 of the *Wetlands Supplement* worksheets, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[102] EFs and/or measurement data.

Domestic Wastewater Treatment and Discharge – N_2O – Flowchart



Using different worksheets according to the treatment system (i.e. non-Constructed Wetlands *vs* Constructed Wetlands), for each subdivision, if any:

Step A1, in worksheet **Direct N_2O Emissions from Treatment Plants**, users enter *Population served by treatment plants* and *fraction of industrial co-discharged proteins*.

Step A2, in worksheet **Indirect N_2O Emissions**, users enter *Population*, *per capita protein consumption*, *fraction of N in proteins*, *fraction of proteins discharged not consumed*, and *fraction of industrial proteins co-discharged*, *N removed with Sludge* to calculate *Total Nitrogen in effluent*.

Step A3, in worksheet **N_2O Emissions from Constructed Wetlands**, users enter *Population*, *per capita protein consumption*, *fraction of N in proteins*, *fraction of proteins discharged not consumed*, *fraction of industrial proteins co-discharged*, and *N removed with Sludge* to calculate *Total Nitrogen in effluent*.

Step B1, in worksheet **Direct N_2O Emissions from Treatment Plants**, users enter *EF*.

Step B2, in worksheet **Indirect N_2O Emissions**, users enter *EF*.

Step B3, in worksheet **N_2O Emissions from Constructed Wetlands**, for each type of Constructed Wetlands, users enter *EF*.

Step C1, in worksheet **Direct N_2O Emissions from Treatment Plants**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

Step C2, in worksheet **Indirect N_2O Emissions**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

Step C3, in worksheet **N_2O Emissions from Constructed Wetlands**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

[102] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity Data input

N_2O emissions from wastewater depends on the amount of N in wastewaters.

Users compile the worksheet **Direct N_2O Emissions from Treatment Plants** or **Indirect N_2O Emissions** or **N_2O Emissions from Constructed Wetlands** either with a single row of data for the entire category or with subnational aggregations. A univocal name/code is entered in column |Subdivision| for each subdivision. If only one subdivision (i.e., a single row of data for the whole category) is entered then "unspecified", as selected from the dropdown menu, can be used.

Then, **for each subdivision** in column |Subdivision| users:

WORKSHEET **Direct N_2O emissions from treatment plants**

1. Column |A|: enter *Population* in the subdivision, capita.
2. Column |B|: enter *Degree of utilization of modern, centralized wastewater treatment plants*, a fraction between 0 and 1.
3. Column |C|: can enter a user-specific value by overwriting the IPCC default value precompiled -i.e. 1.25- for the *fraction of industrial proteins co-discharged*, kg of total N discharged / kg N in domestic wastewater.

WORKSHEET **Indirect N_2O emissions**

1. Column |A|: enter *Population* in the subdivision, capita.
2. Column |B|: enter *per capita protein consumption*, in kg protein per capita per day.

   Note if national statistics on protein consumed or protein supply are not available, *Food Balance Sheets* of FAOSTAT (https://www.fao.org/faostat/en/#data/FBS) can be used as AD on per capita *protein supply quantity*. This information represents the total amount of protein available to the population but must be adjusted to reflect the fraction of protein consumed (FPC), according to Equation 6.10a of the *2019 Refinement*. Default regional values of FPC are listed in Table 6.10a.
3. Column |C|: automatically completed with the IPCC default value for the *fraction of Nitrogen in protein* -i.e. 0.16-. This can be overwritten with a user-specific value.
4. Column |D|: select the IPCC default value for the *fraction of non-consumed proteins disposed in sewer system* from the drop-down menu or enter a user-specific, kg of N in domestic wastewater / kg N in consumed proteins.
5. Column |E|: automatically completed with the IPCC default value -i.e. 1.25- for the *fraction of industrial proteins co-discharged*, kg of total N discharged / kg N in domestic wastewater. This can be overwritten with a user-specific value.
6. Column |F|: enter the amount of *N removed with sludge*, if any, kg N.
7. Column |H|: the *Software* automatically compiles the amount of N emitted as direct N_2O emissions from treatment plants from data entered in worksheet **Direct N_2O emissions from treatment plants**, kg N/year.
8. Column G: the *Software* automatically calculates the amount of N contained in effluent water as the total N discharged minus the amount removed as sludge and already directly emitted as N_2O from treatment plants.

WORKSHEET **N_2O emissions from Constructed Wetlands**

1. Column |Type of constructed wetlands|: select the type of CWs from the drop-down menu or enter a user-specific type.
2. Column |A|: enter *Population* served by the relevant type of CWs, capita.
3. Column |B|: enter *per capita protein consumption*, in kg protein per capita per day.
4. Column |C|: automatically completed with the IPCC default value for the *fraction of Nitrogen in protein* -i.e. 0.16-. This can be overwritten with a user-specific value.
5. Column |D|: select the IPCC default value for the *fraction of non-consumed proteins disposed in sewer system* from the drop-down menu or enter a user-specific value, kg of N in domestic wastewater / kg N in consumed proteins.
6. Column |E|: automatically completed with the IPCC default value -i.e. 1.25- for the *fraction of industrial proteins co-discharged*, kg of total N discharged / kg N in domestic wastewater . This can be overwritten with a user-specific value.
7. Column |F|: enter the amount of *N removed with sludge*, if any, kg N.

Note: no guidance is provided on Sludge in the Wetlands Supplement

8. Column G: the *Software* automatically calculates the amount of N contained in effluent water as the total N discharged minus the amount removed as sludge.

Emission Factor input

WORKSHEET **Direct N_2O emissions from treatment plants**

1. Column |D|: automatically completed with the IPCC default EF value -i.e. 0.0032-, in kg N_2O/person/year. This can be overwritten with a user-specific value.

WORKSHEET **Indirect N_2O emissions**

1. Column |I|: automatically completed with the IPCC default EF value -i.e. 0.005-, in kg N_2O-N/kg N. This can be overwritten with a user-specific value.

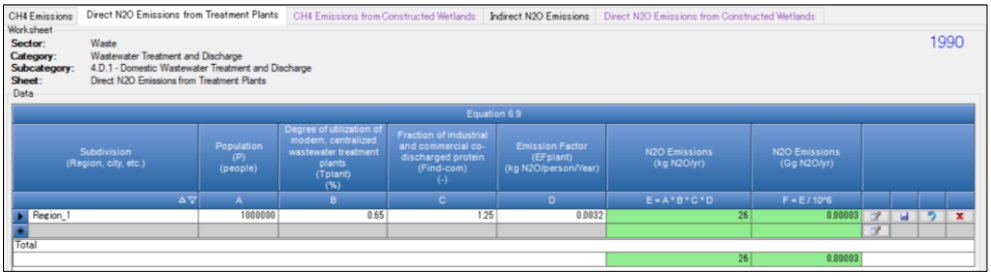
WORKSHEET **N_2O emissions from Constructed Wetlands**

1. Column |H|: once users select one of the IPCC default types of constructed wetlands from the dropdown menu, the *Software* automatically compiles the IPCC default *EF* in this column; users can overwrite it with a user-specific value. Where a user-specific type constructed wetlands has been entered in column |*Type of constructed wetlands*|, users enter a user-specific value, in kg N_2O-N/kg N.

Results

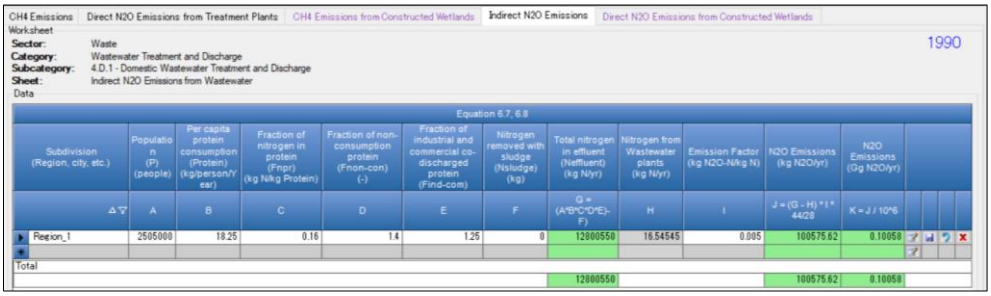
WORKSHEET Direct N_2O emissions from treatment plants

For each row of data, the *Software* calculates in mass units, Gg, direct N_2O emissions in column |F| as well as total N_2O emissions.



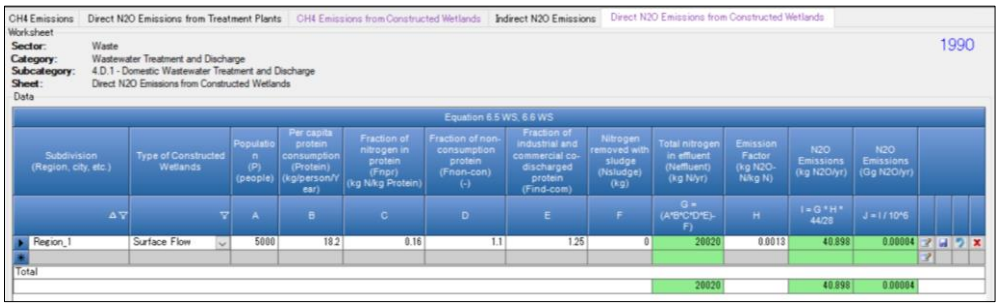
WORKSHEET Indirect N_2O emissions

For each row of data, the *Software* calculates in mass units, Gg, indirect N_2O emissions in column |K| as well as total N_2O emissions.



WORKSHEET N_2O emissions from Constructed Wetlands

For each row of data, the *Software* calculates in mass units, Gg, N_2O emissions in column |J| as well as total N_2O emissions.



4.D.2. Industrial Wastewater Treatment and Discharge

Industrial wastewater treatment and discharge is the activity of treatment and discharge of wastewater from household use.

Hereafter, information is reported aggregated for each GHG:

I. **METHANE (CH4)** emissions
II. **NITROUS OXIDE (N2O)** emissions (direct and indirect)

Note for both GHGs, industrial wastewater treated in Constructed Wetlands is reported in separate worksheet and so care should be taken to **separate AD** between ***all types of treatment and discharge pathways*** and **Constructed Wetlands**.

Note users need to ensure consistency of data/information used to estimate in different worksheets CH_4 and N_2O emissions.

METHBNE (CH_4)

IPCC Equations

CH_4 emissions from Industrial Wastewater Treatment and Discharge are estimated by applying the following equations of the *2006 IPCC Guidelines* and its *Wetlands Supplement*.

- CH_4 emissions (excluding treatment in *Constructed Wetlands*)
  - ✓ Tier 1: Equations 6.4, 6.5 and 6.6.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on wastewater and user-specific EF.
  - ✓ Tier 3: emissions are estimated based on treatment system-specific data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.
- CH_4 emissions from treatment in *Constructed Wetlands*
  - ✓ Tier 1: Equations 6.1, 6.2 and 6.4 of the *Wetlands Supplement*.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on wastewater and user-specific EF.
  - ✓ Tier 3: emissions are estimated based on treatment system-specific data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.

Software Worksheets

The *Software* calculates CH_4 emissions from Industrial Wastewater Treatment and Discharge using the following worksheets:

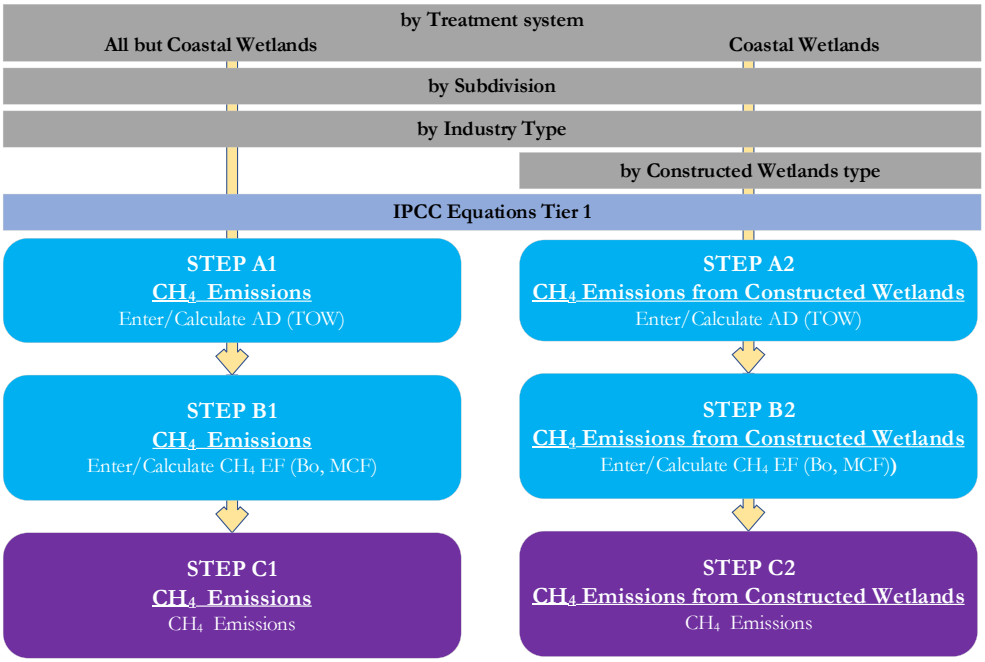
- ✓ **CH_4 emissions**: contains for each subdivision the amount of organically degradable matter in treated[103] wastewater, as calculated or entered, as well as the CH_4, as calculated or entered, EF and calculates associated CH_4 emissions.
- ✓ **CH_4 emissions from constructed wetlands**: contains for each subdivision the amount of organically degradable matter in wastewater, as calculated or entered, as well as the CH_4 EF, as calculated or entered, and calculates associated CH_4 emissions.

[103] Excluding Constructed Wetlands treatments.

User's work Flowchart

Consistent with the key category analysis and the decision tree Figure 6.2 of the *2006 IPCC Guidelines* and Figure 6.3 of the *Wetlands Supplement* worksheets, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[104] EFs and/or measurement data.

Industrial Wastewater Treatment and Discharge – CH_4 – Flowchart



Using a different worksheet according to the treatment system (i.e. non-Constructed Wetlands *vs* Constructed Wetlands), for each subdivision, if any:

Step A1, in worksheet **CH_4 Emissions**, users enter either *Total Organics in Wastewater* (TOW) or *Total Industry Product*, *Wastewater generated*, *Chemical Oxygen Demand* (COD) to calculate *TOW*.

Step A2, in worksheet **CH_4 Emissions from Constructed Wetlands**, users enter either *Total Organics in Wastewater* (TOW) or *Wastewater generated* and *Chemical Oxygen Demand* (COD) to calculate *TOW*.

Step B1, in worksheet **CH_4 Emissions**, users either enter the *Weighted Emission Factor* (WEF) or enter *type of treatment and discharge pathways, maximum methane producing capacity* (B_0), *Methane Correction Factor* (*MCF*) to calculate the *WEF*.

Step B2, in worksheet **CH_4 Emissions from Constructed Wetlands**, for each type of Constructed Wetlands, users enter either the *EF* or *maximum methane producing capacity* (B_0) and *Methane Correction Factor* (*MCF*) to calculate the *EF*.

Step C1, in worksheet **CH_4 Emissions**, for each row of data users enter *Sludge removed*, if any, as well as *CH_4 flared* and *CH_4 recovered for energy use;* then the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

Step C2, in worksheet **CH_4 Emissions from Constructed Wetlands**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

[104] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity Data input

The AD for this source category is the amount of organically degradable material in the wastewater (TOW). This parameter is a function of industrial production and associated wastewater generation and it can be calculated from the chemical oxygen demand (kg COD/year) to oxidise the organic matter (Equations 6.6 and 6.4).

WORKSHEET CH_4 Emissions

Table 6.9 provides Wastewater production and COD values in industrial wastewater for industry types. Section 6.2.3.3 provides guidance on data needs and where to find and how to apply data.

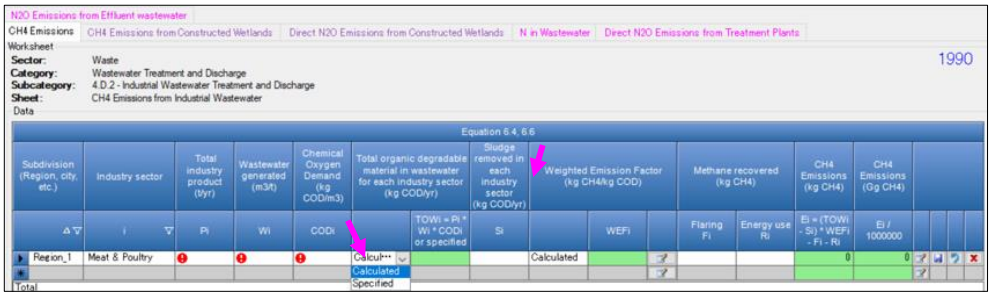
Users compile the worksheet **CH_4 Emissions** either with a single row of data for the entire category or with subnational aggregations, with a univocal name/code entered in column |Subdivision| per subdivision. If there is only one subdivision (i.e., one row of data for the category) then "unspecified", as selected from the dropdown menu can be used.

For each subdivision in column |Subdivision| data are entered as it follows:

The *Software* provides two options for AD, **TOW**, in the dropdown menu in column |Organic degradable material in wastewater (kg COD/yr)|: *Calculated* or *Specified*.

So, as a **first step**:

1. Column |Organic degradable material in wastewater|: users select:
   - ✓ either S*pecified*, if user-specific data (e.g., country-specific data) on *TOW* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.6.



Once selected, users follow one of the following two paths:

A. **TOW** *Specified*

2. Column |TOW|: enter TOW, in kg of degradable organic matter per year.

B. **TOW** *Calculated*

2. Column |i|: select from the drop-down menu the relevant IPCC default industry type or enter a user-specific value.
3. Column |Pi|: enter amount of product of industry sector i, in tons per year.
4. Column |Wi|: once users select one of the IPCC default types of industry from the dropdown menu, the *Software* automatically compiles the IPCC default *wastewater generated* in this column; users can overwrite it with a user-specific value. Where a user-specific industry type has been entered in column |*Industry sector*|, users enter a user-specific value, in m^3 per ton of industrial product.
5. Column |CODi|: once users select one of the IPCC default types of industry from the dropdown menu, the *Software* automatically compiles the IPCC default *chemical oxygen demand* in this column; users can overwrite it with a user-specific value. Where a user-specific industry type has been entered in column |*Industry sector*|, users enter a user-specific value, in kg of degradable per m^3 of wastewater.

As a **final step**:

6. Column |S|: users enter the amount of sludge removed in the relevant industry sector, in kg of degradable organic matter per year, if any.

WORKSHEET CH_4 Emissions from Constructed Wetlands

Users compile the worksheet **CH_4 Emissions from Constructed Wetlands** either with a single row of data for the entire category or with subnational aggregations, with a univocal name/code entered in column |Subdivision| per subdivision. If there is only one subdivision (i.e., a single row of data for the category) then e.g., "country "unspecified", as selected from the dropdown menu, can be used.

For each subdivision in column |Subdivision| data are entered as it follows:

The *Software* provides two options for AD, TOW, in the dropdown menu in column |Organic degradable material treated in CWj (kg COD/yr)|: *Calculated* or *Specified.*

So, as a **first step**:

1. Column |Organic degradable material treated in CWj|: users select
   - ✓ either S*pecified*, if user-specific data (e.g., country-specific data) on *TOW* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.4.

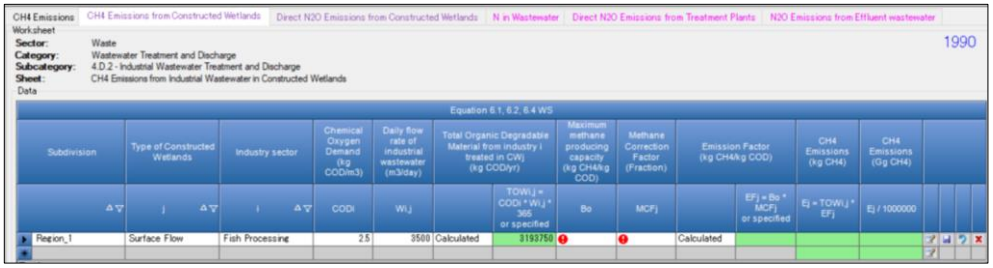
Once selected, users follow one of the following two paths:

A. **TOW** *Specified*

2. Column |TOW|: enter TOW, in kg of degradable organic matter per year.

B. **TOW** *Calculated*

2. Column |j|: select from the drop-down menu the relevant Type of Constructed Wetlands (CWj) or enter a user-specific type.
3. Column |CODi|: once users select one of the IPCC default types of industry from the dropdown menu, the *Software* automatically compiles the IPCC default *chemical oxygen demand* in this column; users can overwrite it with a user-specific value. Where a user-specific industry type has been entered in column |*Industry sector*|, users enter a user-specific value, in kg of degradable per m^3 of wastewater.
4. Column |Wi,j|: enter amount of wastewater treated in the relevant CWj,in m^3 of wastewater generated by the relevant industry type *i*.



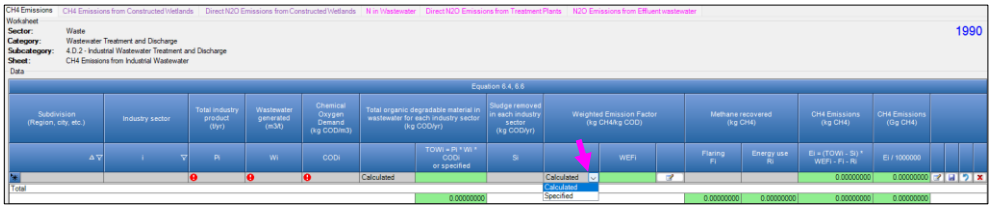
Emission Factor input

WORKSHEET **CH_4 Emissions**

The *Software* provides two options to deal with the weighted emission factor, **WEF**, in the dropdown menu in column |Weighted Emission Factor (kg CH_4/kg COD)|: *Calculated* or *Specified.*

So, as a **first step**:

1. Column |Weighted Emission Factor (kg CH_4/kg COD)|: users select
   - ✓ either S*pecified*, if user-specific (e.g., country-specific data) *WEF(s)* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.6



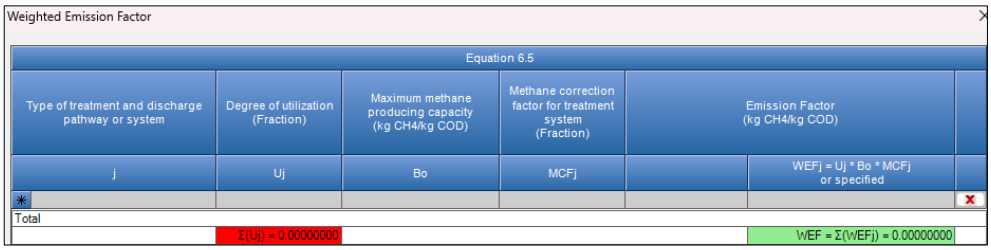
once selected, users follow one of the following two paths:

A. **WEF** *Specified*

2. Column |WEFi|: enter WEF, in kg of CH_4 emissions per kg of degradable organic matter.

B. **WEF** *Calculated*

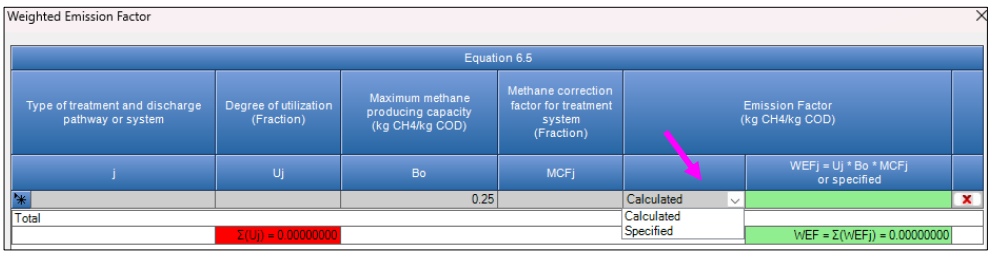
2. Column |WEFi|: click the *Edit* mark on the right-hand side. The sub-worksheet below will open.



3. Column |j|: select from the drop-down menu the relevant type of treatment and discharge pathway or enter a user-specific value.
4. Column |Uj|: enter the degree of utilization of the relevant type of treatment and discharge pathway, a fraction between 0 and 1.
   Note: in the last cell of column |Uj| the Software sums up the fractions entered in the column. Fractions shall sum up to 1, otherwise the Software shows a red background colour in the cell to signal the error.

   The *Software* provides two options for EF in the dropdown menu in column |Emission Factor (kg CH_4/kg COD)|: *Calculated* or *Specified.* To enter data for the EF:

5. Column |Emission Factor (kg CH_4/kg COD)|: users select:
   - ✓ either S*pecified*, if user-specific (e.g., country-specific) *EF(s)* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.5.



Once selected, users follow one of the following two paths:

A. **EF** *Specified*

6. Column |EF|: enter EF, in kg of CH_4 emissions per kg of degradable organic matter.

B. **EF** *Calculated*

6. Column |B_0|: once users select one of the IPCC default types of treatment and discharge pathways from the dropdown menu, the *Software* automatically compiles the IPCC default *maximum methane producing capacity* in this column; users can overwrite it with a user-specific value.

Where a user-specific type of treatment and discharge pathway has been entered in column |*j*|, users enter a user-specific value, in kg CH_4/kg COD.

7. Column |MCF|: once users select one of the IPCC default types of treatment and discharge pathways from the dropdown menu, the *Software* automatically compiles the IPCC default *methane correction factor* in this column; users can overwrite it with a user-specific value. Where a user-specific type of treatment and discharge pathway has been entered in column |*j*|, users enter a user-specific value, a fraction between 0 and 1.

Note the calculation of **WEF** is implemented at two levels:

I. First, *WEFj* is calculated per each type of treatment and discharge pathway *j* used by a relevant industry sector

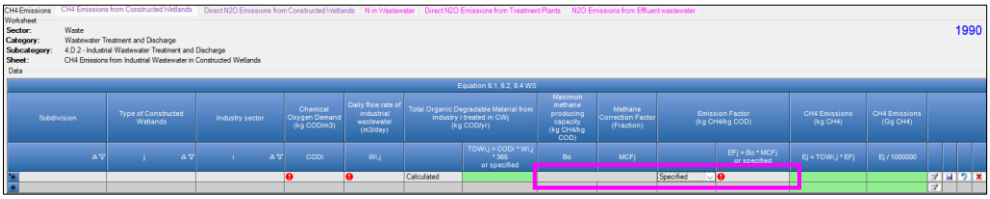
II. Second, *WEFi* is calculated per industry sector *i*.

WORKSHEET CH_4 Emissions from Constructed Wetlands

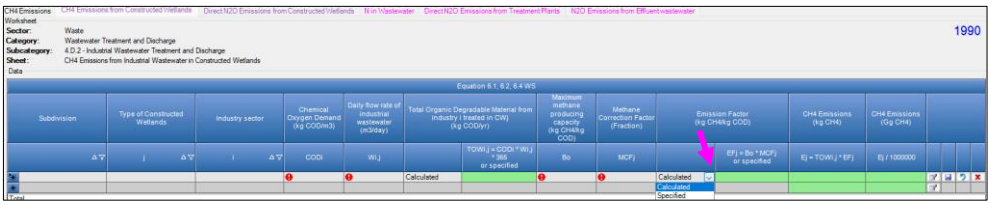
The EF for wastewater treatment in CW is a function of the maximum CH_4 producing potential, B_o and the MCF (Equation 6.2 of the *Wetlands Supplement*).

The *Software* provides two options for EF in the dropdown menu in column |Emission Factor (kg CH_4/kg COD)|: *Calculated* or *Specified*. So:

1. Column |Emission Factor (kg CH_4/kg COD)|: users select:
   - ✓ either S*pecified*, if user-specific (e.g., country-specific) *EF(s)* are available,



   - ✓ otherwise *Calculated*, which implements Equation 6.2.



Once selected, users follow one of the following two paths:

A. **EF** *Specified*

2. Column |EF|: enter EF, in kg of CH_4 emissions per kg of degradable organic matter.

B. **EF** *Calculated*

2. Column |B_0|: the *Software* precompiles *maximum methane producing capacity* with the IPCC default value of 0.25; users can overwrite the value with a user-specific value, in kg CH_4/kg COD.
3. Column |MCFj|: once users select one of the IPCC default types of constructed wetlands from the dropdown menu, the *Software* automatically compiles the IPCC default *methane correction factor* in this column; users can overwrite it with a user-specific value. Where a user-specific type constructed wetlands has been entered in column |*j*|, users enter a user-specific value, a fraction between 0 and 1.

Results

WORKSHEET **CH_4 Emissions**

For each row of data, the *Software* calculates in mass units, Gg, CH_4 emissions in column |CH_4 emissions| as well as total CH_4 emissions.

WORKSHEET **CH_4 Emissions from Constructed Wetlands**

For each row of data, the *Software* calculates in mass units, Gg, CH_4 emissions in column |CH_4 emissions| as well as total CH_4 emissions.

NITROUS OXIDE (N_2O)

IPCC Equations

N_2O emissions can occur as direct emissions from treatment plants and indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea, as well as from CWs. No methodology is provided in the *2006 IPCC Guidelines* to estimate N_2O emissions from industrial wastewater treatment and discharge. Thus, the *Software* implements methodological guidance provided in the *2019 Refinement*. Further, the *Software* implements methodological guidance provided in the *Wetlands Supplement* to estimate N_2O emissions from CWs.

- Direct N_2O emissions (excluding treatment in *Constructed Wetlands*)
  - ✓ Tier 1: Equations 6.11(New) and 6.13(New).
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on wastewater and user-specific EF.
  - ✓ Tier 3: emissions are estimated based on treatment system-specific data, no IPCC Tier 3 Equation is provided in the *2019 Refinement*.
- Indirect N_2O emissions (excluding treatment in *Constructed Wetlands*)
  - ✓ Tier 1: Equations 6.12 (New) and 6.14 (New).
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on wastewater and user-specific EF.
  - ✓ Tier 3: emissions are estimated based on treatment system-specific data. No IPCC Tier 3 Equation is provided in the *2019 Refinement*.
- N_2O emissions from treatment in *Constructed Wetlands*
  - ✓ Tier 1: Equations 6.5, 6.7 of the *Wetlands Supplement*.
  - ✓ Tier 2: Tier 1 equation, although with user-specific AD on wastewater and user-specific EF.
  - ✓ Tier 3: emissions are estimated based on treatment system-specific data. No IPCC Tier 3 Equation is provided in the *2006 IPCC Guidelines*.

Software Worksheets

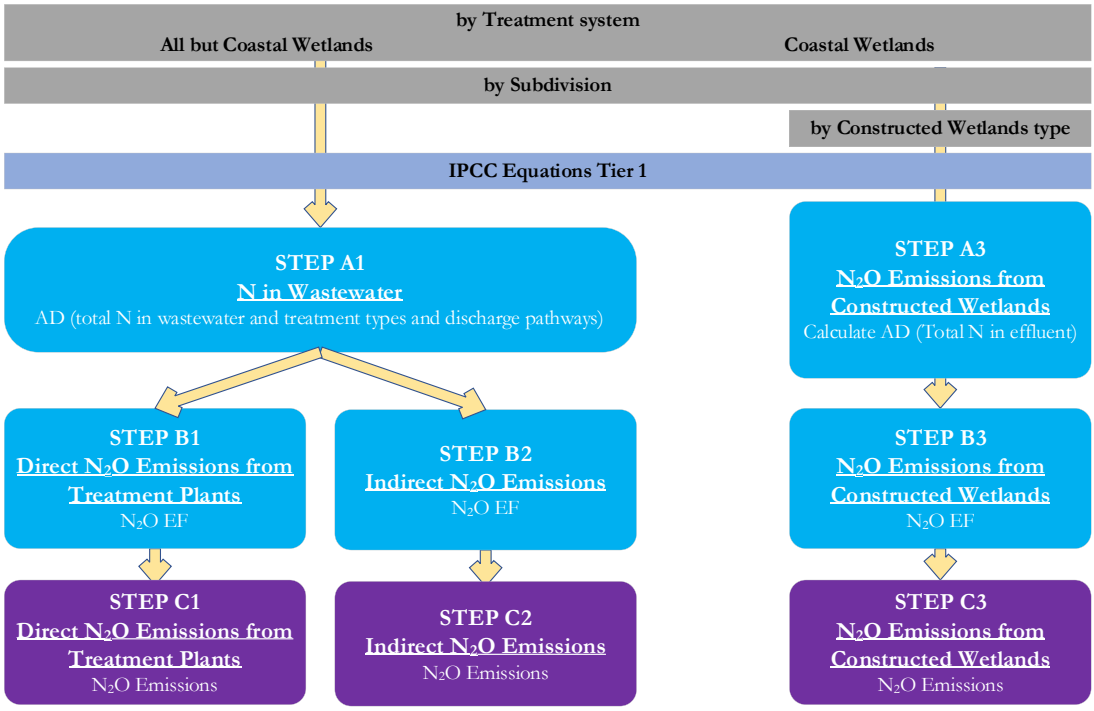
The *Software* calculates N_2O emissions from industrial wastewater treatment and discharge using the following worksheets:

- ✓ **N in Wastewater:** contains for each industry sector in each subdivision the AD -*total N in wastewater*-, as entered or calculated, as well the associated types of treatment and discharge pathways used.
- ✓ **Direct N_2O Emissions from Treatment Plants:** contains for each industry sector the N_2O EF and calculates associated direct N_2O emissions.
- ✓ **N_2O Emissions from Effluent Wastewater:** contains for each industry sector the N_2O EF and calculates associated indirect N_2O emissions.
- ✓ **N_2O emissions from constructed wetlands**: calculates for each subdivision the amount of nitrogen in effluents to constructed wetlands, contains the N_2O EF and calculates associated N_2O emissions.

User's work Flowchart

Consistent with the key category analysis and the decision trees, Figure 6.6 of the *2019 Refinement* and Figure 6.4 of the *Wetlands Supplement*, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[105] EFs and/or measurement data.

Industrial Wastewater Treatment and Discharge – N_2O – Flowchart



Using different worksheets according to the treatment system (i.e. non-Constructed Wetlands *vs* Constructed Wetlands), for each subdivision, if any:

Step A1, in worksheet **N in Wastewater**, users enter *industry product*, *wastewater generated*, *N concentration in wastewater* and types of treatment and discharge pathways for each industry sector.

Step A3, in worksheet **N_2O Emissions from Constructed Wetlands**, users enter *N concentration in wastewater*, *yearly flow rate of wastewater* -or calculate it from *industry product*, *wastewater generated*- and type of CW for each industry sector.

Step B1, in worksheet **Direct N_2O Emissions from Treatment Plants**, users enter *EF*.

Step B2, in worksheet **Indirect N_2O Emissions**, users enter *EF*.

Step B3, in worksheet **N_2O Emissions from Constructed Wetlands**, for each type of Constructed Wetlands, users enter *EF*.

Step C1, in worksheet **Direct N_2O Emissions from Treatment Plants**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

Step C2, in worksheet **Indirect N_2O Emissions**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

Step C3, in worksheet **N_2O Emissions from Constructed Wetlands**, for each row of data the *Software* calculates emissions in mass units (Gg). In addition, total emissions are calculated.

[105] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity Data input

N_2O emissions from wastewater depends on the amount of N in wastewaters.

Users compile the worksheet **N in Wastewater** or **N_2O Emissions from Constructed Wetlands** either with a single row of data for the entire category or with subnational aggregations, with a univocal name/code entered in column |Subdivision| per subdivision If only one subdivision is entered (i.e., one row of data for the category) then "unspecified" as selected from the dropdown menu can be used.

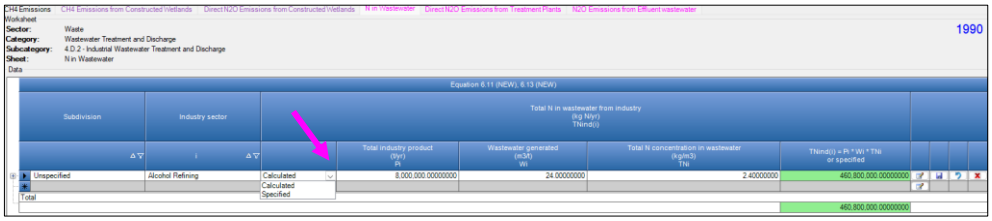
Then, **for each subdivision** in column |Subdivision| users:

WORKSHEET **N in wastewater**

1. Column |i|: select the relevant industry sector from the drop-down menu or enter a user-specific value.

The *Software* provides two options for AD in the dropdown menu in column |Total N in Wastewater from industry (kg N/yr)|: *Calculated* or *Specified*. To enter the AD:

2. Column |Total N in Wastewater from industry|: users select
   - ✓ either *Specified*, if user-specific (e.g., country-specific) *EF(s)* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.13(NEW).



Once selected, users follow one of the following two paths:

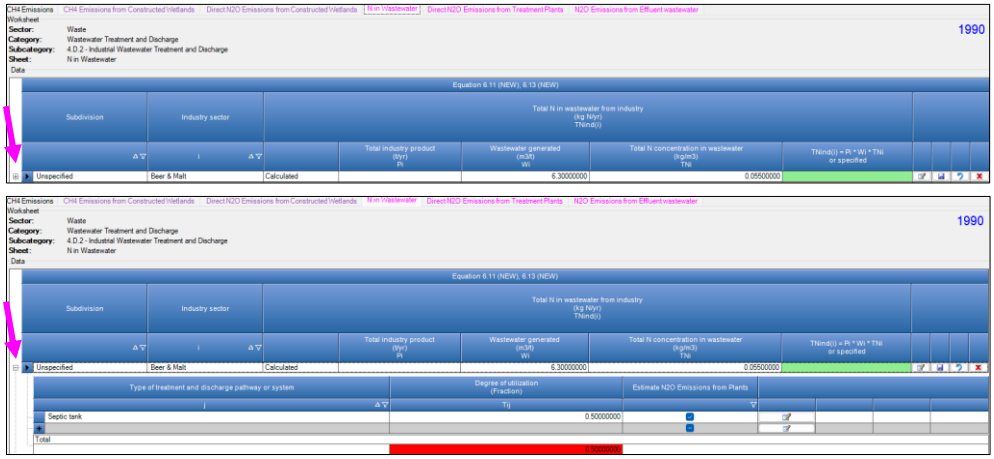
C. **AD** *Specified*

3. Column |TN(ind)|: enter AD, in kg of N in total amount of wastewater treated in the year.

D. **AD** *Calculated*

3. Column |Pi|: enter total production of the relevant industry sector *i*, in ton of products produced in the year.
4. Column |Wi|: once users select one of the IPCC default industry sectors for which an IPCC default value is available from the dropdown menu, the *Software* automatically compiles the IPCC default *wastewater generated per ton of product* in this column; users can overwrite the default with a user-specific value. Where a user-specific industry sector has been entered in column |*i*,| or there is not an IPCC default value for an IPCC industry sector, users enter a user-specific value, in m^3 of wastewater generated per ton of product.
5. Column |TNi|: once users select from one of the IPCC default industry sector for which an IPCC default value is available the dropdown menu, the *Software* automatically compiles the IPCC default *N concentration in wastewater* in this column; users can overwrite the default with a user-specific value. Where a user-specific industry sector has been entered in column |*i*,| or there is not an IPCC default value for an IPCC industry sector, users enter a user-specific value, in kg N per m^3 of wastewater generated.

Once column |*TN(ind)*| is completed, a symbol ⊞ is shown on the left-hand side. Users click on it to open an additional table of variables to be entered per line of data originally completed.



6. Column |j|: select the relevant type of treatment and discharge pathway from the drop-down menu or enter a user-specific value.
7. Column |Tij|: enter the degree of utilization, in the relevant subdivision, of the relevant type of treatment and discharge pathway, a fraction between 0 and 1.
   Note: in the last cell of column |Tij| the Software sum up the fractions entered in the column. Fractions shall sum up to 1, otherwise the Software shows a red background colour in the cell to signal the error.

In addition, although not for AD input, users in

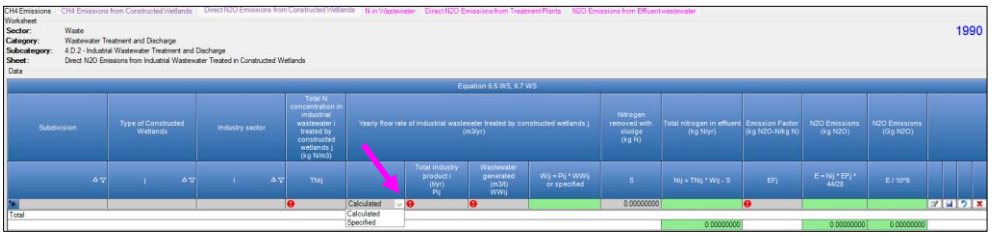
8. Column |Estimate N_2O emissions from plants|: indicate, by clicking the checkbox, whether to estimate direct N_2O emissions in the worksheet **Direct N_2O Emissions from Treatment Plants.**

WORKSHEET N_2O Emissions from Constructed Wetlands

1. Column |j|: select the relevant type of Constructed Wetlands from the drop-down menu or enter a user-specific value.
2. Column |i|: select the relevant industry sector from the drop-down menu or enter a user-specific value.
3. Column |TNij|: once users select one of the IPCC default industry sectors for which an IPCC default value is available from the dropdown menu, the *Software* automatically compiles the IPCC default *N concentration in wastewater* in this column. Users can overwrite the default with a user-specific value. Where a user-specific industry sector has been entered in column |*i*|, or there is not an IPCC default value for an IPCC industry sector, users enter a user-specific value, in kg N per m^3 of wastewater generated.

The *Software* provides two options for AD in the dropdown menu in column |Yearly flow rate of industrial wastewater treated by CWj (m^3/yr)|: *Calculated* or *Specified*. To enter the AD:

4. Column |Yearly flow rate of industrial wastewater treated by CWj|: users select
   - ✓ either S*pecified*, if user-specific (e.g., country-specific) *EF(s)* are available,
   - ✓ otherwise *Calculated*, which implements Equation 6.7.



Once selected, users follow one of the following two paths:

E. **AD** *Specified*

5. Column |TN(ind)|: enter AD, in kg of N in total amount of wastewater treated in the year.

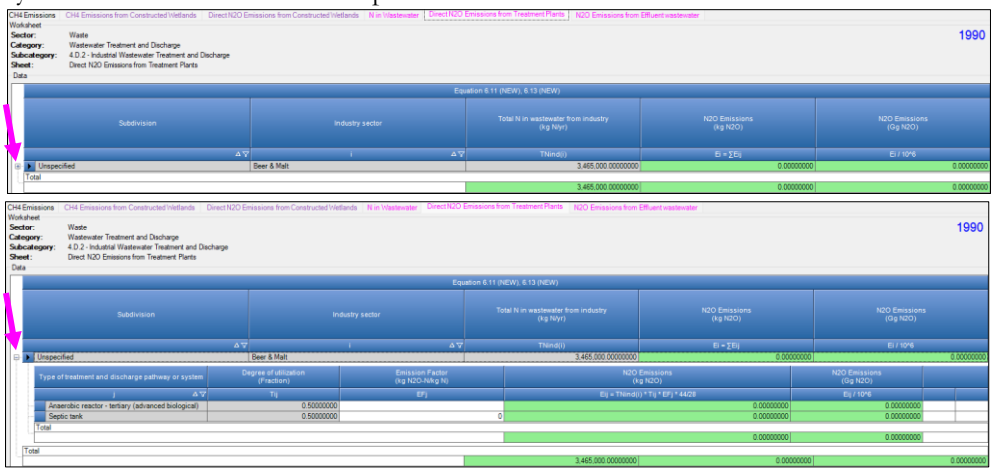
F. **AD** *Calculated*

5. Column |Pij|: enter total production of the relevant industry sector *i*, in ton of products produced in the year.
6. Column |WWij|: once users select one of the IPCC default industry sectors for which an IPCC default value is available from the dropdown menu, the *Software* automatically compiles the IPCC default *wastewater generated per ton of product* in this column. Users can overwrite the default with a user-specific value. Where a user-specific industry sector has been entered in column |*i*,| or there is not an IPCC default value for an IPCC industry sector, users enter a user-specific value, in m^3 of wastewater generated per ton of product.

Emission Factor input

WORKSHEET Direct N_2O emissions from treatment plants

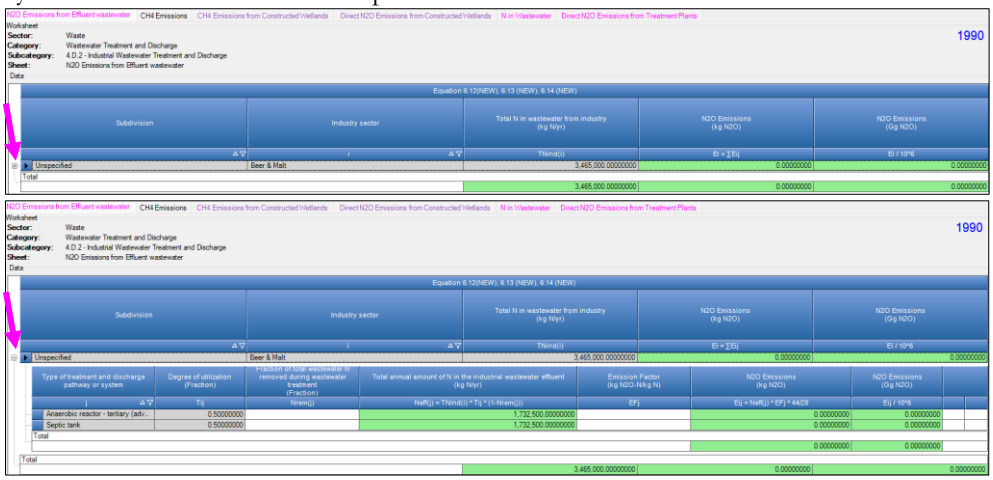
Data entered into worksheet **N in Wastewater** are compiled by the *Software* into this worksheet. Users click on the left-hand side a symbol ⊞ for each row which opens an additional table to enter EFs.



1. Column |EFj|: select the IPCC default EF from the drop-down menu or enter a user-specific value, kg N_2O-N/kg N.

WORKSHEET N_2O Emissions from Effluent wastewater

Data entered into worksheet **N in Wastewater** are compiled by the *Software* into this worksheet. Users click on the left-hand side a symbol ⊞ for each row which opens an additional table to enter EFs.



1. Column |Nrem|: select the IPCC default value for the fraction[106] of N removed at treatment plants from the drop-down menu or enter a user-specific value, a fraction between 0 and 1.
2. Column |EFj|: select the IPCC default EF from the drop-down menu or enter a user-specific value, kg N_2O-N/kg N.

WORKSHEET N_2O emissions from Constructed Wetlands

1. Column |EFj|: select the IPCC default EF from the drop-down menu or enter a user-specific value, kg N_2O-N/kg N.

[106] Note that if Direct N_2O emissions have been calculated, the value to enter here is equal to $\frac{E_i}{44/28}$ (as calculated in worksheet **N in Wastewater**) *divided by* *TNind(i)* *minus* *N in Sludge removed*, if any.

Results

WORKSHEET Direct N_2O emissions from treatment plants

For each row of data, the *Software* calculates in mass units, Gg, direct N_2O emissions in column |Ei| as well as total N_2O emissions.

WORKSHEET N_2O emissions from Effluent wastewater

For each row of data, the *Software* calculates in mass units, Gg, indirect N_2O emissions in column | Ei| as well as total N_2O emissions.

WORKSHEET N_2O emissions from Constructed Wetlands

For each row of data, the *Software* calculates in mass units, Gg, N_2O emissions in column |E| as well as total N_2O emissions.

4.E. Other

Information

GHG emissions from waste handling activities not covered elsewhere in 4A-4D categories are estimated under this category.

GHGs

In general, waste handling activities generate the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

Only CO_2 emissions of fossil origin are estimated and reported in Waste sector.

IPCC Equations

No guidance/methodology is provided in the *2006 IPCC Guidelines*.

The *Software* implements the IPCC generic equation to estimate GHG emissions: AD (i.e., amount of waste treated) multiplied by corresponding EF.

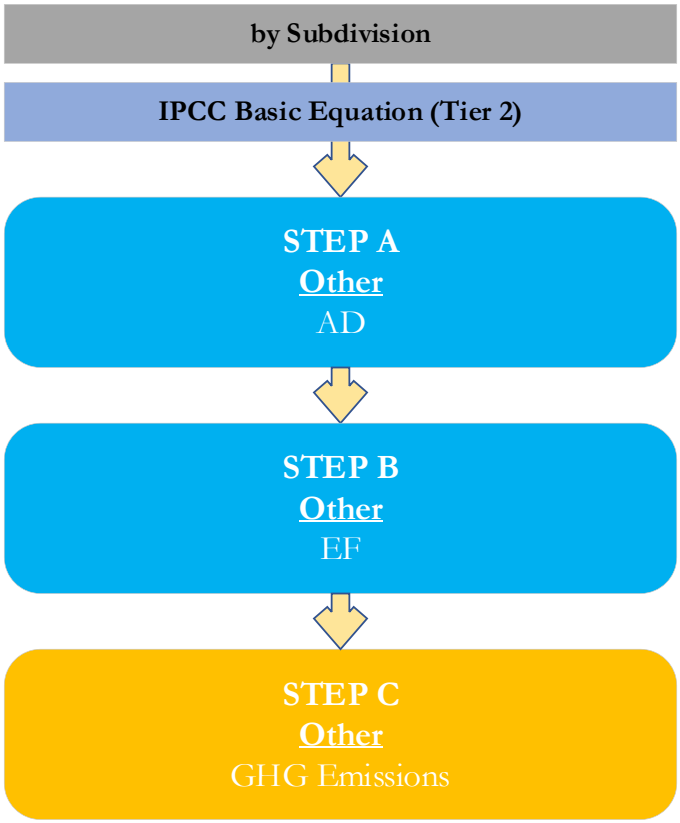
Software Worksheets

All GHGs[107] emissions are estimated in the single worksheet **Other.**

[107] CO_2 (fossil origin), CH_4 and N_2O.

User's work Flowchart

GHG estimates are calculated using a single methodological tier, i.e. Tier 2 or applying a combination of tiers according to the availability of AD and of user-specific[108] EFs and/or measurement data.



The estimation of GHG emissions involves following steps for each subdivision, if any.

Step A, in worksheet **Other**, users collect and enter data on the source and AD.

Step B, in worksheet **Other**, users collect and enter in each row the associated EF.

Step C, in worksheet **Other**, for each row of data, the *Software* calculates the emissions in mass units (Gg). In addition, total emissions are calculated.

[108] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in column |S| (e.g., "*country name*" or "*unspecified*" as selected from the dropdown menu), or with subnational aggregations, and for each of those the univocal name/code entered in column |S|.

For each subdivision in column |S|, data are entered in worksheet **Other**, row by row, as follows:

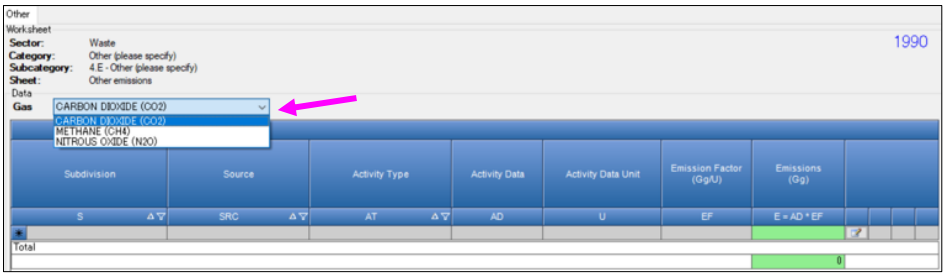
1. Column |SRC|: select one of the activities from the dropdown menu or enter a user-specific activity.

   Activities listed are:

   - ✓ *CH_4 and N_2O emissions from fossil liquid waste incineration*: if CO_2 emissions are estimated in worksheet **Fossil liquid incineration** of category 4.C, then CH_4 and N_2O emissions can be estimated here. In such a case, AD type in column |AT| is *incineration*, the AD unit column |U| is to be consistent with the EF available and the quantity in column |AD| is to correspond to the value entered in column |A| of worksheets **Fossil liquid incineration**.
   - ✓ *CH_4 and N_2O emissions from flaring at SWDS*: if CH_4 is flared in worksheet **Methane emissions** of categories 4.A, then CH_4 and N_2O emissions should be estimated here. In such a case, AD type in column |AT| is *flaring*, the AD unit column |U| is to be consistent with the EF available and the quantity in column |AD| is to correspond to the value entered in column |F| of worksheet **Methane emissions**.
   - ✓ *CH_4 and N_2O emissions from flaring at biogas facility*: if CH_4 is flared in worksheet **Biological treatment of solid waste** of category 4.B, then CH_4 and N_2O emissions should be estimated here. In such a case, AD type in column |AT| is *flaring*, the AD unit column |U| is to be consistent with the EF available and the quantity in column |AD| is to correspond to the value entered in column |F| of worksheet **Biological treatment of solid waste**.
   - ✓ *CH_4 and N_2O emissions from flaring at wastewater treatment plants*: if CH_4 is flared in worksheet **CH_4 emissions** of categories 4.D, then CH_4 and N_2O emissions should be estimated here. In such a case, AD type in column |AT| is *flaring*, the AD unit column |U| is to be consistent with the EF available and the quantity in column |AD| is to correspond to the value entered in column |F| of worksheet **CH_4 emissions**.

2. Column |AT|: enter activity type corresponding to the source selected.
3. Column |AD|: enter AD quantity.
4. Column |U|: enter Unit of AD.

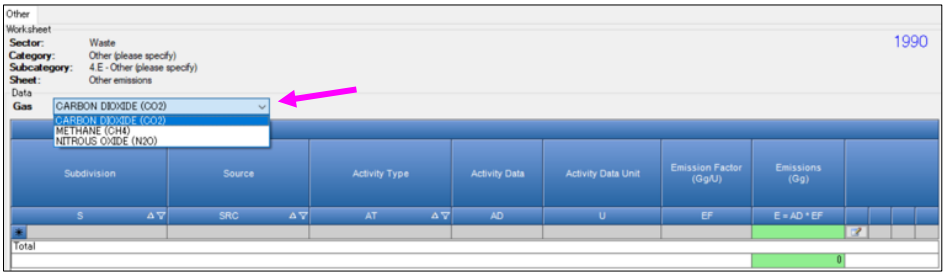
Note: AD are entered once, regardless to the selection of the GHG in the toggle, given that AD apply to the estimate of every GHG.



Emission Factor input

For each row of data entered in worksheet **Other emissions from Energy Production**, data are entered as follows:

1. Column |EF|: enter CH_4 or CO_2 or N_2O EF.
   Note: user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)"or "Nitrous Oxide (N_2O)" in the "Gas" toggle, to enter EF for each GHG one by one.



Results

Then, for each GHG, in worksheet **Other**, for each row of data the *Software* calculates in mass units, Gg, emissions in Column |E| as well as total emissions.

Annex I: Mapping between the IPCC Inventory Software and the UNFCCC ETF Reporting Tool

The *Software* enables users to calculate national GHG emissions in accordance with the *2006 IPCC Guidelines*. The methods contained in the *Software* are consistent with those required to be used by Parties in preparing a NGHGI, consistent with decision 18/CMA.1, under the Enhanced Transparency Framework (ETF) of the Paris Agreement. However, Parties to the UNFCCC have agreed to a specific format for reporting the GHG inventory information, called the common reporting tables (CRT), that differ from the IPCC reporting tables contained in volume 1, chapter 8 of the *2006 IPCC Guidelines*.

Thus, Parties to the UNFCCC, acknowledging the importance of the *Software* in aiding countries to estimate their NGHGI, have invited IPCC to work together to facilitate interoperability between the *Software* and the UNFCCC ETF Reporting Tool. Consequently, the *Software* has been upgraded to operationalize the interoperability. Specifically, users of the *Software* can estimate GHG emissions and removals for all categories and gases that are required to be reported pursuant to the CRT. Once data are entered into the *Software*, users wishing to use these data to facilitate reporting to the UNFCCC must generate a file in the *Software* (in JSON format). This file, can then subsequently, through a separate UNFCCC platform, be uploaded and further processed through the UNFCCC ETF Reporting Tool to transfer to UNFCCC their NGHGI, as compiled in the CRTs and as required under the Paris Agreement.

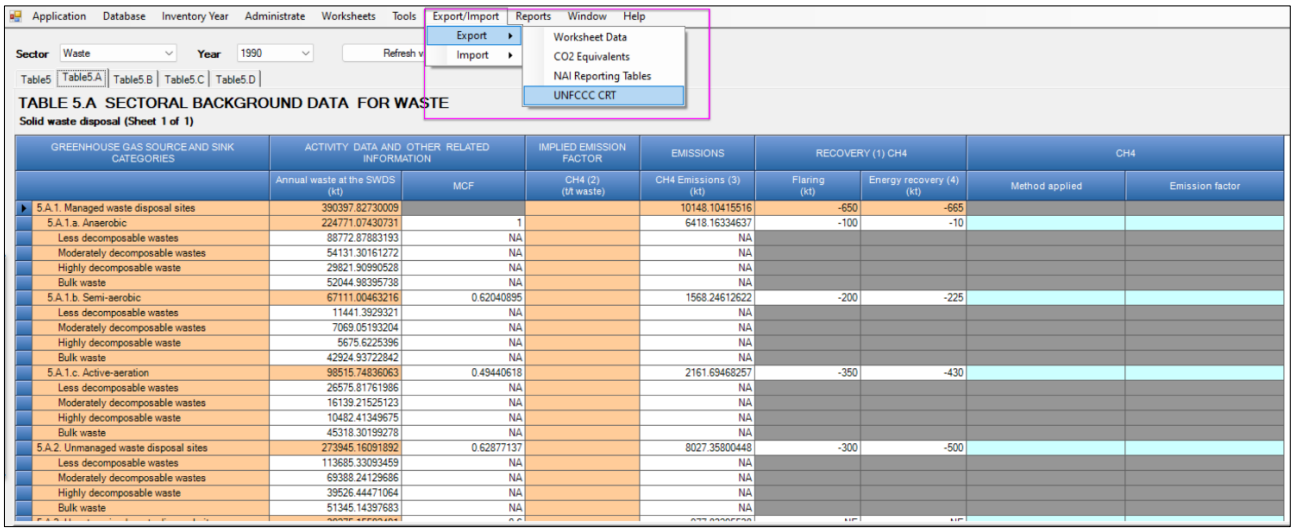
Preparing a JSON file that can be imported into the UNFCCC ETF Reporting Tool required a cell-by-cell mapping of the CRT to document where each of the AD and GHG emissions estimates contained in each worksheet of the *Software* reside in the CRT.

This annex contains detailed information to illustrate the mapping of categories and gases between the IPCC Software and the CRT. The specific information presented in this annex related to reporting of emissions from the Waste sector in the CRT is supplemental to the general information provided in the IPCC Inventory Software - UNFCCC Interoperability – CRT Export Quick Start Guide.

CRT visualization tables in the IPCC Inventory Software

The mapping between the *Software* and the CRT are visualized in the *Software* to allow the user to properly understand (thus enhancing transparency) and keep for internal use the results of the conversion of IPCC category GHG estimates into UNFCCC NGHGI categories.

To generate the visualization tables select, from the main ribbon, "Export/Import" and then "UNFCCC CRT". For complete guidance on how to produce a CRT data set and compile data from the underlying worksheets of the *Software* into the CRT data set, refer to the **IPCC Inventory Software -UNFCCC Interoperability – CRT Export Quick Start Guide**. The result of the generated tables is presented below.



GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA AND OTHER RELATED INFORMATION		IMPLIED EMISSION FACTOR	EMISSIONS	RECOVERY (1) CH4		CH4	
	Annual waste at the SWDS (kt)	MCF	CH4 (2) (t/t waste)	CH4 Emissions (3) (kt)	Flaring (kt)	Energy recovery (4) (kt)	Method applied	Emission factor
5.A.1. Managed waste disposal sites	390397.82730009			10148.10415516	-650	-665		
5.A.1.a. Anaerobic	224771.07430731	1		6418.16334637	-100	-10		
Less decomposable wastes	88772.87883193	NA		NA				
Moderately decomposable wastes	54131.30161272	NA		NA				
Highly decomposable waste	29821.90990528	NA		NA				
Bulk waste	52044.98395738	NA		NA				
5.A.1.b. Semi-aerobic	67111.00463216	0.62040895		1568.24612622	-200	-225		
Less decomposable wastes	11441.3929321	NA		NA				
Moderately decomposable wastes	7069.05193204	NA		NA				
Highly decomposable waste	5675.6225396	NA		NA				
Bulk waste	42924.93722842	NA		NA				
5.A.1.c. Active-aeration	98515.74836063	0.49440618		2161.69468257	-350	-430		
Less decomposable wastes	26575.81761986	NA		NA				
Moderately decomposable wastes	16139.21525123	NA		NA				
Highly decomposable waste	10482.41349675	NA		NA				
Bulk waste	45318.30199278	NA		NA				
5.A.2. Unmanaged waste disposal sites	273945.16091892	0.62877137		8027.35800448	-300	-500		
Less decomposable wastes	113685.33093459	NA		NA				
Moderately decomposable wastes	69388.24129686	NA		NA				
Highly decomposable waste	39526.44471064	NA		NA				
Bulk waste	51345.14397683	NA		NA				

IMPORTANT: these visualization tables have been prepared to enhance transparency and demonstrate to the user how the data entered in the *Software* are mapped to the UNFCCC CRT. The data entered in the *Software* are not automatically used to meet the UNFCCC reporting requirements. The user will still be required to formally submit the information through the UNFCCC ETF Reporting Tool, and the user is responsible for reviewing first the information compiled in the CRT visualization tables and second the information once imported into that tool.

How to read mapping tables

The mapping tables have been developed to enhance transparency of the relationship between the categories in the *Software* and the UNFCCC ETF Reporting Tool. For each cell in the CRT, the mapping tables describe the source of the data from the *Software* that is reported in that cell. The majority of cells in the CRT map from the underlying category-specific worksheets of the *Software*. In the case of short-lived climate forcer emissions, data in the sector summary tables of the CRT are mapped from the IPCC sectoral reporting table.

The specific instructions vary, depending on the nature of the category, and how many calculation worksheets from the *Software* map to that cell, but generally, the instruction is written to direct the user to:

1. The specific IPCC category in the category tree
2. The tab in that worksheet that contains the relevant information
3. The gas of interest
4. The waste category, type of waste and/or treatment pathway
5. The column that contains the relevant information, with an indication of any mathematical operation needed (e.g., SUM, MULTIPLY BY, etc)
6. Any conversions needed to ensure correct units map to the UNFCCC CRT (e.g., DIVIDE by 1,000,000 to convert kilograms to kilo tonnes)

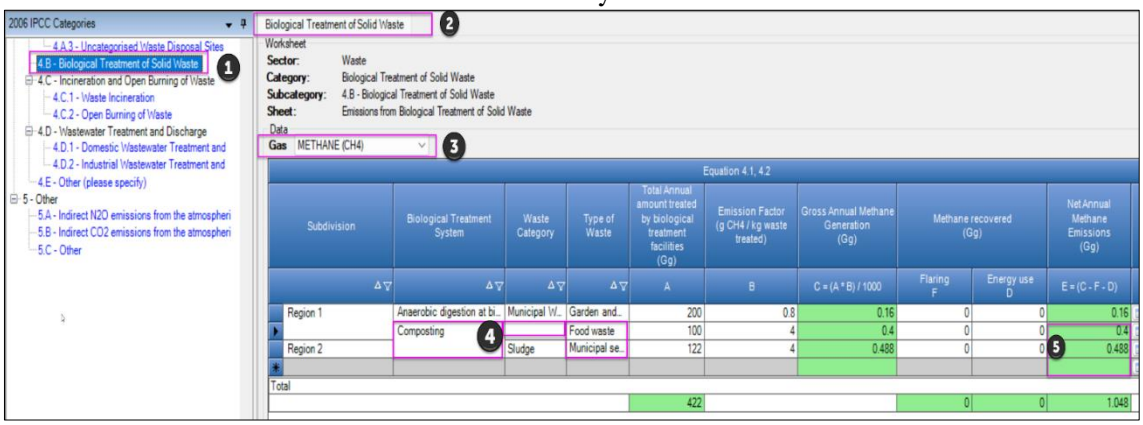
By illustration, the directions in the mapping file to report CH_4 emissions from composting of municipal solid waste in the CRT, and the corresponding location of the information in the *Software* are shown below. Generally, white cells in the CRT are mapped from the *Software*. Orange, green, or blue cells in the visualized CRT in the *Software* will be calculated by the UNFCCC ETF Reporting Tool, upon import of the JSON file.

***Example:* How to read mapping between the *Software* and the UNFCCC CRT**

UNFCCC CRT

	CH_4 (3)
5.B.1. Composting	F11 + F12
5.B.1.a. Municipal solid waste	IPCC 4.B. <Biological treatment of solid waste> <gas = methane> <Biological Treatment System = composting> <Waste Category = Municipal Waste> <Type of waste = all> SUM of values in column E

IPCC Inventory Software



The example above is a simple illustration. In some cases, multiple worksheets and even multiple categories may map to a single cell in the CRT. This would be illustrated by reference to the two key instructions "PLUS" or "AND" to denote consideration of multiple data elements from the *Software*.

The following recurrent key instructions in the mapping are:

- ✓ The sign **"SUM"** indicates a summatory of information (numerical or alphabetical) contained across the column/row to which applies.
- ✓ The sign **"-SUM"** indicates that the result of the summatory is to be reported as a negative value.
- ✓ The sign **"AND"** indicates an additional element for mapping in the cell, which pertains to the same IPCC category.

- ✓ The sign **"PLUS"** indicates an additional element for mapping in the cell, which pertains to an additional IPCC category.
- ✓ The signs **"ALLEXCEPT"** indicates all elements for mapping to be included except the listed element, because this element (e.g., category) is already included elsewhere.
- ✓ The signs **"MULTIPLY BY"** and **"WEIGHTED AVERAGE"** indicate the corresponding mathematical operation to be applied to information sourced from the *Software*.

There are two elements for the mapping of Waste sector emissions relevant to highlight for users:

1. **Wet weight and dry weight.** Users have the choice in the **I.1 Waste Type Manager** to enter AD for solid waste either on a wet weight basis or a dry weight basis. For reporting in the CRT, the user shall select *Wet Weight* in the **Waste Type Manager**. The mapping to the visualized CRT will then:
   a. CRT category 5.A (Solid Waste Disposal): maps AD in wet weight;
   b. CRT category 5.B (Biological Treatment of Solid Waste): converts the original AD on a wet weight basis to dry weight by multiplying those by the dry matter content and maps the calculated dry-weight AD;
   c. CRT table 5.C (Incineration and open burning of waste): map AD in wet weight.

   For CRT category 5.C.2 (open burning), consistent with the *2006 IPCC Guidelines*, N_2O emissions are calculated based on the dry weight of waste, nevertheless AD in CRT table 5.C is requested in wet weight. Users may report the corresponding dry weight used in the calculations in the documentation box and/or NID.
2. **Classes of decomposability.** The naming convention for classes of waste decomposability in solid waste disposal sites, and the waste types assigned to each class changed slightly between the *2006 IPCC Guidelines* and the *2019 Refinement* as shown in Table 1 below.

   According to the footnote to table 5.A of the CRT, *"(5) Less decomposable waste includes wood, engineered wood products, and tree branches (wood). Moderately decomposable waste includes paper, textile and nappies. Highly decomposable waste includes food waste and grass (garden and park waste excluding tree branches). Bulk waste can be used if the fractions of less, moderately and highly decomposable waste in MSW are not known."* Taking into account the evolution of the waste nomenclature, and the agreed table 5.A of the CRT, the classes of waste decomposability in the *Software* are as presented in Table 1 below.

Table 1. Classes of decomposability of solid waste in Software

Default Waste Types in IPCC Inventory Software	*2006 IPCC Guidelines* *2019 Refinement* (Tables 3.3 and 3.4)	*2019 Refinement* (Table 3.0 (New))	Class of decomposability in CRT 5.A
Municipal Waste			
Wood	Slowly degrading waste	Less decomposable wastes	Less decomposable wastes
Paper and cardboard	Slowly degrading waste	Moderately decomposable wastes	Moderately decomposable wastes
Textiles	Slowly degrading waste	Moderately decomposable wastes	Moderately decomposable wastes
Disposable nappies		Moderately decomposable wastes	Moderately decomposable wastes
Garden and Park	Moderately degrading waste	Highly decomposable wastes	Highly decomposable wastes
Food waste	Rapidly degrading waste	Highly decomposable wastes	Highly decomposable wastes
Bulk waste	Bulk waste	Bulk waste	Bulk waste
Inert (Glass, metal, plastic, rubber, leather)			Inert (Excluded from CRT5.A)
Industrial Waste			
Food beverages and tobacco			Highly decomposable wastes
Pulp and paper			Moderately decomposable wastes
Textile			Moderately decomposable wastes
Construction and demolition			Less decomposable wastes
Wood and wood products			Less decomposable wastes
Bulk waste			Bulk waste
Inert (solvents, plastics, rubber, petroleum products)			Inert (Excluded from CRT5.A)
Sludge			
Industrial sewage sludge	Rapidly degrading waste		Highly decomposable wastes
Municipal sewage sludge	Rapidly degrading waste		Highly decomposable wastes
Inert			Less decomposable wastes
Other			
Clinical waste			Bulk waste
Hazardous waste			Bulk waste
Inert			Inert (Excluded from CRT5.A)

Detailed mapping between the *Software* and the UNFCCC ETF Reporting Tool

The attached tables reflect the UNFCCC CRT agreed by Parties for reporting under the Paris Agreement, and the corresponding mapping instructions from the *Software*.

Table 2. Detailed mapping between the Software and the UNFCCC ETF reporting tool

Please note that the tables are accessible by clicking the ATTACH icon (paper-clip) on the left-hand side of your screen.

You will notice that notation keys are automatically populated in some cells of the visualized CRT for the waste sector. Table 3 explains the existence of notation keys for each table relevant for reporting of GHG emissions from the waste sector. If appropriate for national circumstance (e.g., a category labelled as "IE" or "NA" is really not occurring in your country "NO") you may change the type of notation key presented prior to generating the JSON file. Recall that for reporting in the CRTs, Parties should provide the necessary explanations for the use of the notation keys "NE" and "IE". Refer to the UNFCCC Interoperability- CRT Export Quick Start Guide for more information on how to change notation keys and enter notation key explanations.

Table 3. Automatic Reporting of Notation Keys in the Waste sector of the CRT

CRT Table	CRT category	Parameter/Gas	Automatic mapping	Explanation
5	5.D.3 Other	NO_X, CO, NMVOC	NO	CRT category 5.D.3 (other wastewater) does not occur in the *Software,* therefore precursor emissions from this category also do not occur.
5	5.E CH_4 and N_2O emissions from CH_4 flaring at waste facilities	CO_2	NA	According to the *2006 IPCC Guidelines* "Emissions from flaring are however not significant, as the CO_2 emissions are of biogenic origin and the CH_4 and N_2O emissions are very small, so *good practice* in the Waste sector does not require their estimation." Thus, category 5.E allows for reporting of CH_4 and N_2O emissions, while CO_2 is "NA".
5	5.E CH_4 and N_2O emissions from CH_4 flaring at waste facilities	NO_X, CO, NMVOC	IE	Precursor emissions from this category should already be included under a subcategory of CRT category 5.A (Solid waste disposal), 5.B (Biological treatment of solid waste) or 5.D (wastewater treatment and discharge).
5.A	5.A.1 (all) 5.A.2 5.A.3	MCF for each decomposability class	NA	The *2006 IPCC Guidelines* assign MCFs to the type of solid waste disposal sites (e.g., managed anaerobic, unmanaged – deep) and not to the class of decomposability of each waste type. As solid waste disposal sites contain a mixture of waste types, reporting of a single value of MCF by decomposability class is considered "Not Applicable".
5.A	5.A.1 5.A.2 5.A.3	CH_4 for each decomposability class	IE	Although the *Software* calculates CH_4 generated by each waste types in each solid waste disposal site, CH_4 emissions are not currently separated by class of decomposability of waste types. Thus, "IE" is applied at level of Decomposability class.
5.C	5.C.1.a.ii.5 5.C.1.b.ii.6	AD, CO_2, CH_4, N_2O	NO	This category reflects incineration of other biogenic and other non-biogenic sources of waste. This category is listed as "NO" because all waste from the *Software* is captured elsewhere in CRT 5.C.
5.D	5.D.3	AD, CH_4, N_2O	NO	This category includes GHG emissions from wastewater treatment other than domestic wastewater and industrial wastewater. This category is listed as "NO" because all emissions from wastewater treatment are already captured by categories 5.D.1 and 5.D.2.

Annex II: Worked Examples

This section provides some worked examples for calculating GHG emissions using a Tier 1 methodology for a few sectors. The examples cover the complete process from sourcing data to entering it into *the Software*. The examples only cover one year.

Example 1: Emissions from domestic waste water treatment and disposal for two countries (5.D.1)

Country A

Country A is a small developed nation with no national data for domestic waste water treatment and disposal. To calculate CH_4 emissions using a Tier 1 method, the data required (for which default values are not available in the 2006 Guidelines) is population. To calculate emissions from N_2O the amount of protein consumed per capita is also required.

As Country A has no national data on either of these, the inventory team sources the data from:

- ✓ World bank for population[109]. The value of 23,132 for 1990 was used.
- ✓ FAO for protein consumption[110]. There was no protein consumption data available for Country A but there was for a neighbouring country that is thought to be equivalent to Country A. The value of 111g/cap/day was used.

Default values are available in Volume 5, Chapter 6 of the 2006 Guidelines for the remaining parameters B_o, MCF, urbanisation and degree of utilisation of treatment/discharge pathway per income group. Country A does not have specific values within the guidebook but they are available for the same neighbouring country that is being used for protein consumption. The values are presented in the table below. Some expert judgement was required to assign MCFs to the treatment pathways provided with a degree of utilisation as well as whether Country A has sink garbage disposals (yes) or co-discharge of industrial wastewater (no).

Urbanisation	Fraction of population	Treatment/discharge pathway	Degree of utilisation
Rural	0.32	Septic tank	0.42
		Latrine	0
		Other	0
		Sewer[a]	0.58
		None	0
Urban high income	0.68	Septic tank	0.04
		Latrine	0
		Other	0
		Sewer[a]	0.96
		None	0
Urban low income	0	NA	NA

a the sewer was assumed to be flowing using expert judgement.

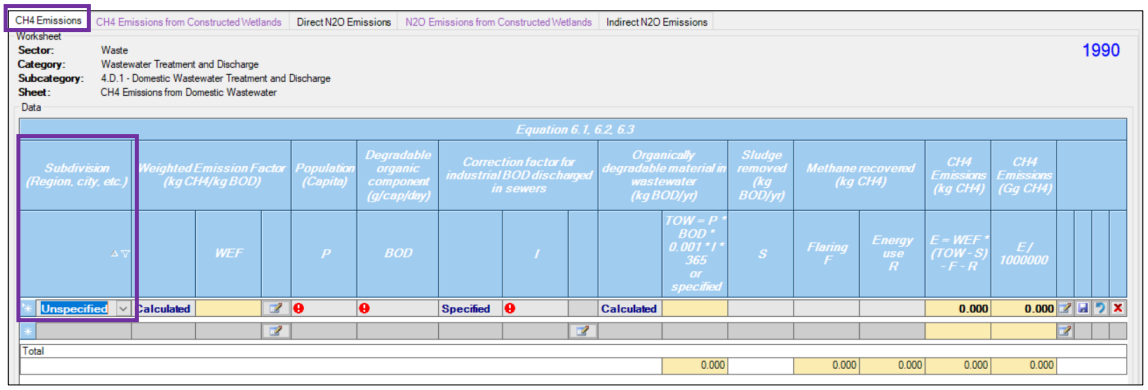
Having sourced the data needed to estimate emissions compilation could then be completed in *the Software*.

CH_4 Emissions

I. The inventory team navigated to the **CH4 Emissions** worksheet under 4.D.1 Domestic Wastewater Discharge and Treatment.

II. As emissions were being estimated for the country as a whole and a Tier 1 method was being used the |Subdivision| column was completed with "Unspecified".

[109] Population, total | Data (worldbank.org) (accessed October 2024).
[110] FOASTAT data from: http://chartsbin.com/view/1155 (accessed October 2024).

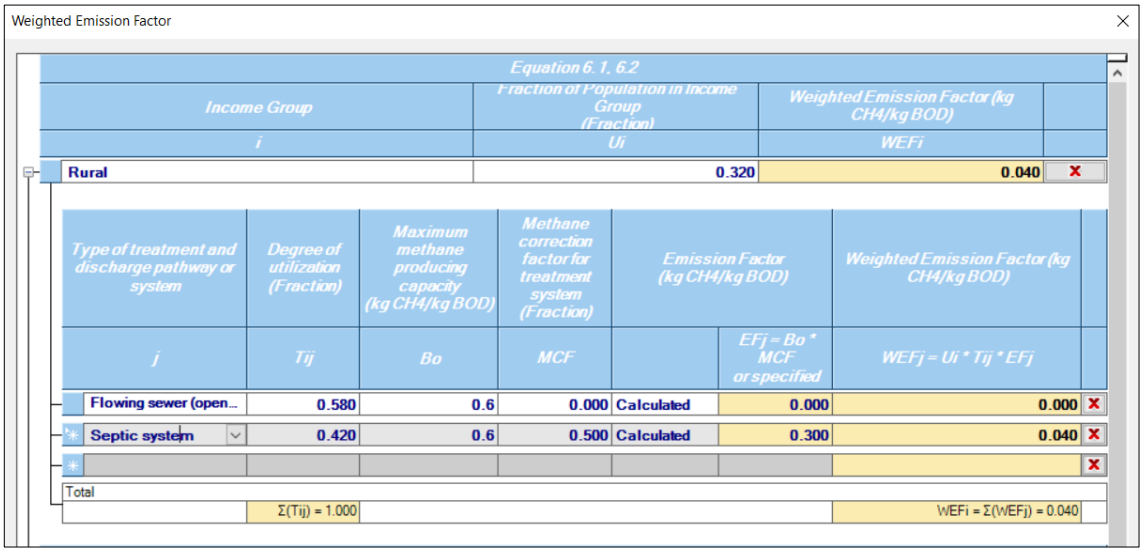


III. In the |Weighted Emission Factor| column the selection of "Calculated" was kept and the edit table button (which looks like a pencil next to a data table) was used to open up the table to enter the data required to calculate the WEFs.

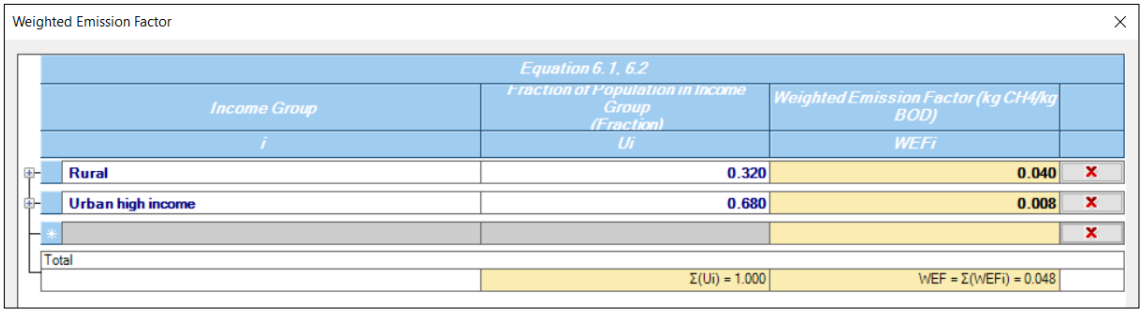
IV. Once the WEF entry window was open, first "Rural" was selected from the drop down in the first column |Income Group| and the fraction of population (in the table above) was entered in the next column.

V. To enter the treatment/discharge pathways, MCFs and B_o, the sub-table needed to be expanded by clicking the "+" to the left of the row.

VI. Once this sub-table was open, one by one the treatment/disposal pathways were selected from the dropdown in the first column and the degree of utilization entered into the second. The remaining columns were completed automatically with the default values from the 2006 Guidelines.

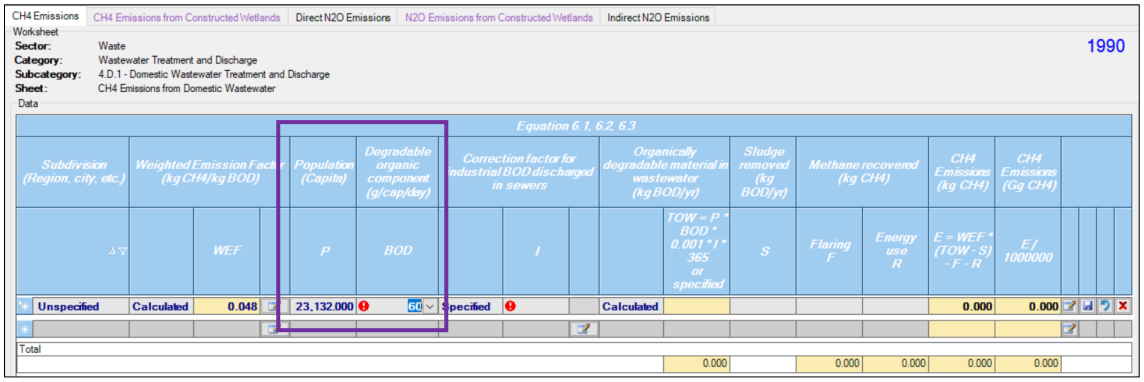


VII. The process was then repeated for urban high income to give the below. The data entry was saved (click save) completing the WEF data entry.



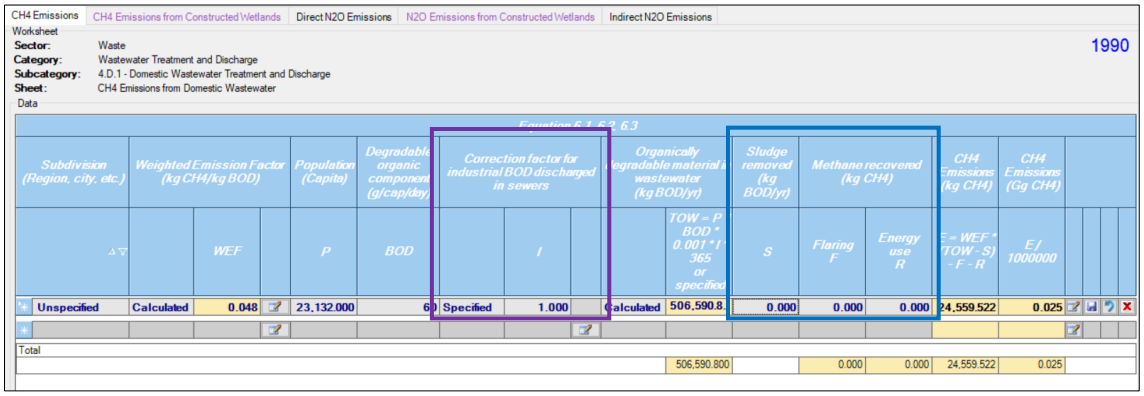
VIII. Next the population was added by the inventory team to the |Population| column.

IX. For BOD, there is no IPCC default for Country A but there is one for the neighbouring country used for other parameters so the default value for that country was selected in column |Degradable organic content|.



X. Country A does not co-discharge industrial wastewater so a value of 1 was used for column |Correction factor for industrial BOD discharged in sewers| in addition to selecting "Specified".

XI. There is no sludge removal or methane recovery so the remaining editable columns were completed with zero and *the Software* calculated the CH_4 emissions in kg and Gg.

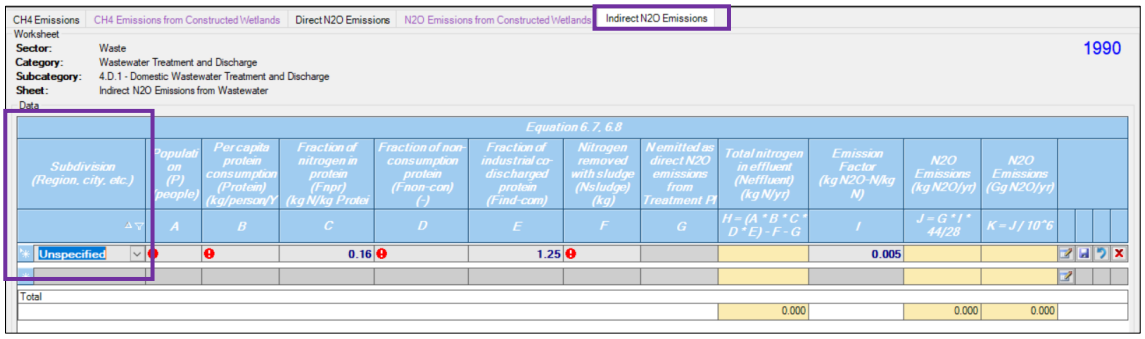


As no wastewater is treated in constructed wetlands the **CH_4 Emissions from Constructed Wetlands** worksheet is left blank.

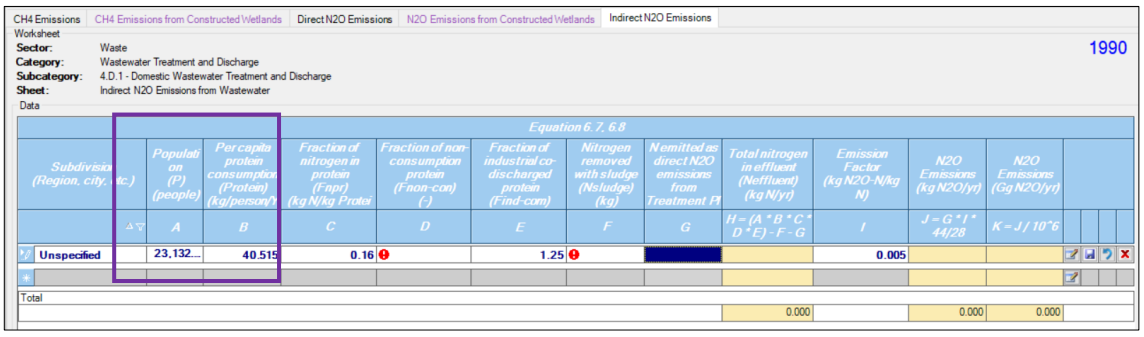
N_2O Emissions

I. The inventory team navigated to the **Indirect N_2O Emissions** worksheet.

II. As for CH_4 emissions the |Subdivision| column was completed with "Unspecified".

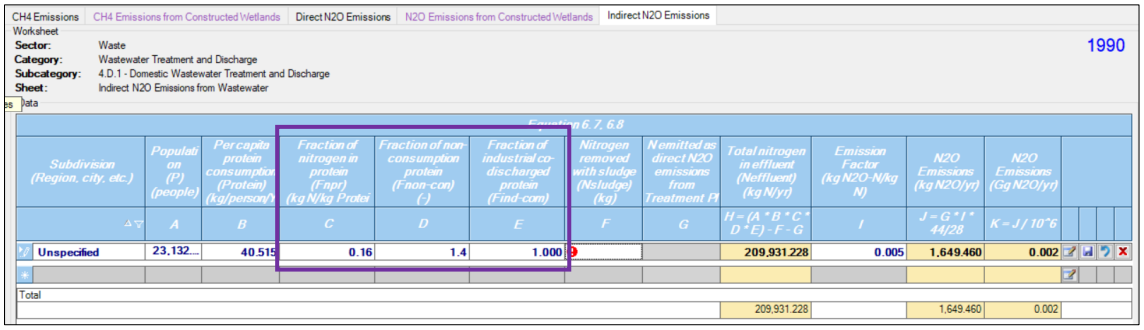


III. The population was entered in the |Population| column and protein consumption in the |Per capita protein consumption| column. The FAO protein consumption data first had to be converted from g/cap/day to kg/cap/year by multiplying by 0.001 and 365.



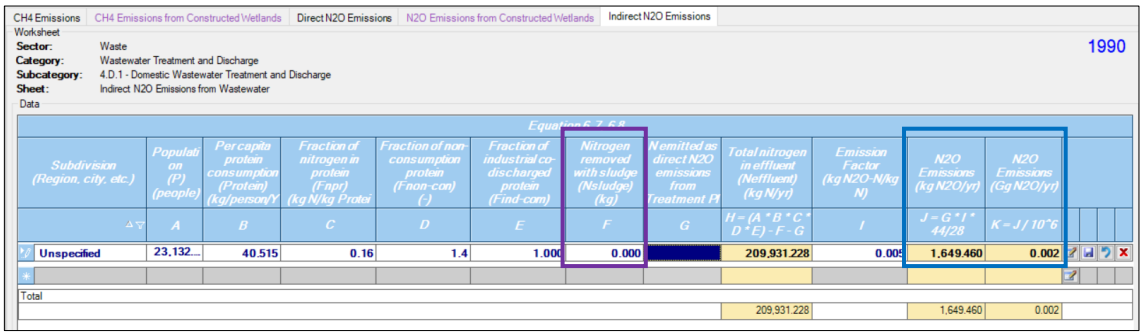
IV. The |Fraction of nitrogen in protein| column has already been completed with the default value but the |Fraction of non-consumption protein| needed to completed by selecting from the available dropdown. As Country A has garbage disposal the value of 1.4 is selected.

V. The |Fraction of industrial co-discharged protein| column is automatically filled assuming co-discharge. However, Country A has no industrial co-discharge so this pre-filled value is replaced with a "1".



VI. Country A has no data on nitrogen removal from sludge so |Nitrogen removed with sludge| column was completed with zero.

VII. The emissions were then completed by *the Software* in both kg and Gg.



There are no wastewater treatment plants or wastewater treated in constructed wetlands so the **Direct N_2O Emissions** and **N_2O Emissions from Constructed Wetlands** worksheets were left blank.

The compilation Country A's emissions from this sector were then complete in *the Software* for 1990.

Country B

Country B is a small developing nation who also has no national data for domestic waste water treatment and disposal. As for Country A, the only data for which default values are not available in the 2006 Guidelines are population and the amount of protein consumed per capita.

Country B's inventory team sourced the data from:

- ✓ World bank for population[109]. The value of 1,341,296 for 2022 was used.
- ✓ FAO for protein consumption[111]. There was no protein consumption data available for Country B or nearby equivalent countries. However, data on protein supply for Country B was available. Equation 6.10a and a relevant default value from Table 6.10a from the 2019 Refinement was used to convert this to protein consumption. The value of 62.0 g/cap/day was therefore used.

Country B does not have specific values for the remaining parameters (B_o, MCF, urbanisation and degree of utilisation of treatment/discharge pathway per income group) within the 2006 Guidelines but they are available for a neighbouring country thought to be equivalent. The values are presented in the table below. Some expert judgement was required to assign MCFs to the treatment pathways provided with a degree of utilisation as well as whether Country B has sink garbage disposals (no) or co-discharge of industrial wastewater (yes).

Urbanisation	Fraction of population	Treatment/discharge pathway	Degree of utilisation
Rural	0.54	Septic tank	0
		Latrine[a]	0.47

[111] FAOSTAT (accessed October 2024)

		Other	0
		Sewer[b]	0.1
		None[c]	0.43
Urban high income	0.12	Septic tank	0.18
		Latrine[a]	0.08
		Other	0
		Sewer[b]	0.74
		None	0
Urban low income	0.34	Septic tank	0.14
		Latrine[a]	0.10
		Other[d]	0.03
		Sewer[b]	0.53
		None[c]	0.20

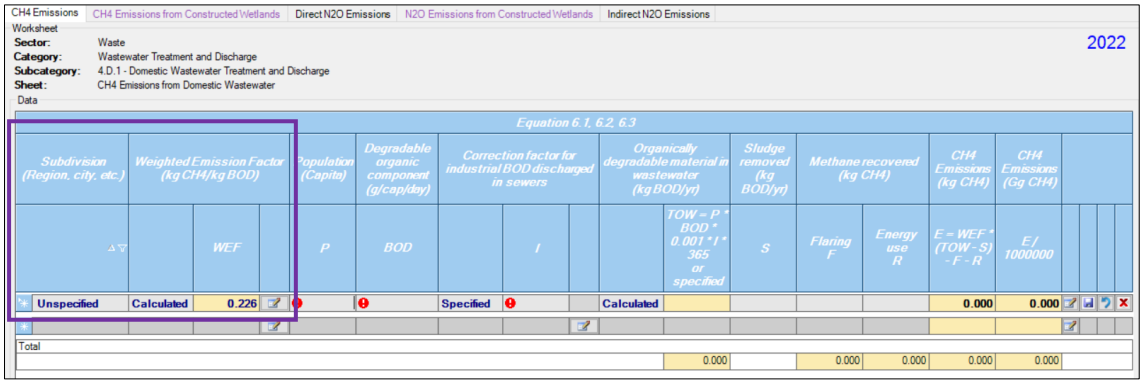
a The MCF for a communal latrine in a dry climate was used.
b The sewer was assumed to be stagnant using expert judgement.
c None was assumed to be discharge to rivers (untreated) using expert judgement.
d Other was also assumed to be discharge to lakes (untreated) using expert judgement.

Having sourced the data needed to estimate emissions compilation was then completed in *the Software* by the inventory team.

CH_4 Emissions

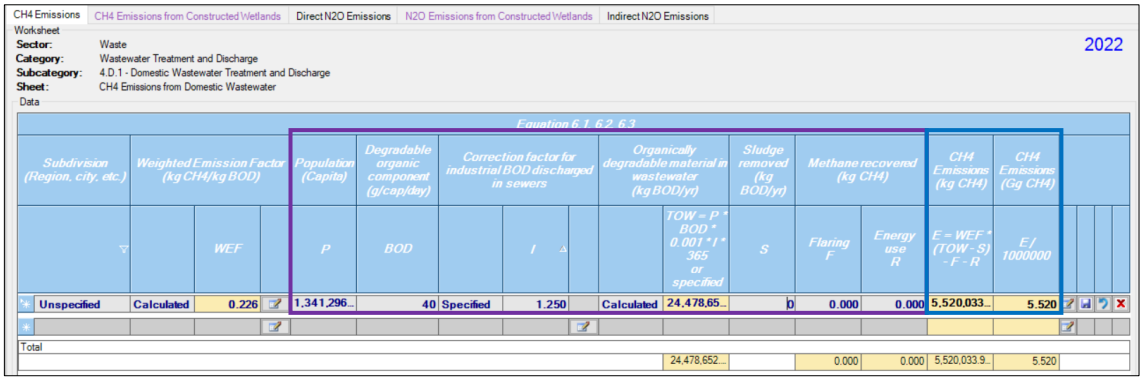
I. In the **CH_4 Emissions** worksheet, under 4.D.1 Domestic Wastewater Discharge and Treatment "Unspecified" was used in the |Subdivision| column as emissions were being estimated for the country as a whole.

II. In the |Weighted Emission Factor| column the selection of "Calculated" was kept and the data required to calculate the WEFs (see example above for the detailed method) was entered.



III. Population, BOD and sludge removed was completed using the default values and world bank data. Country B has co-discharge of industrial wastewater so the default value of 1.25 was used for this field.

IV. The |Organically degradable material in wastewater| was kept as "calculated" and as there was no data on sludge removed, or methane flaring/utilisation the |Sludge removed| and |Methane recovery| columns were completed with zeros. This completed the data entry for the calculation of CH_4 emissions which are presented.

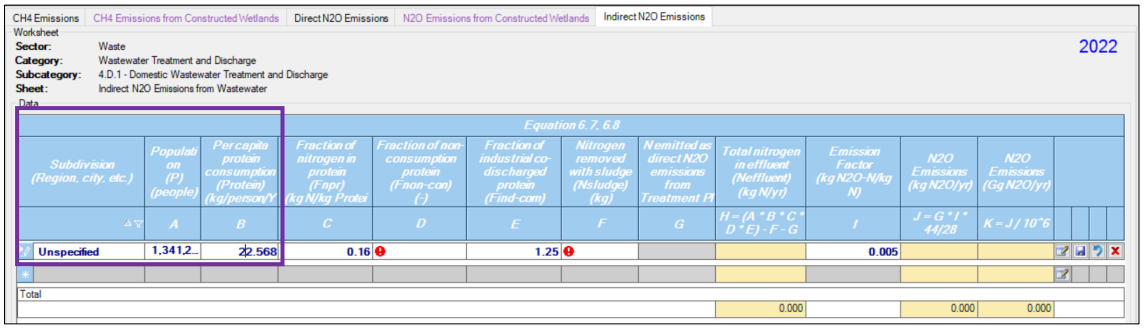


As no wastewater is treated in constructed wetlands the **CH_4 Emissions from Constructed Wetlands** worksheet is left blank.

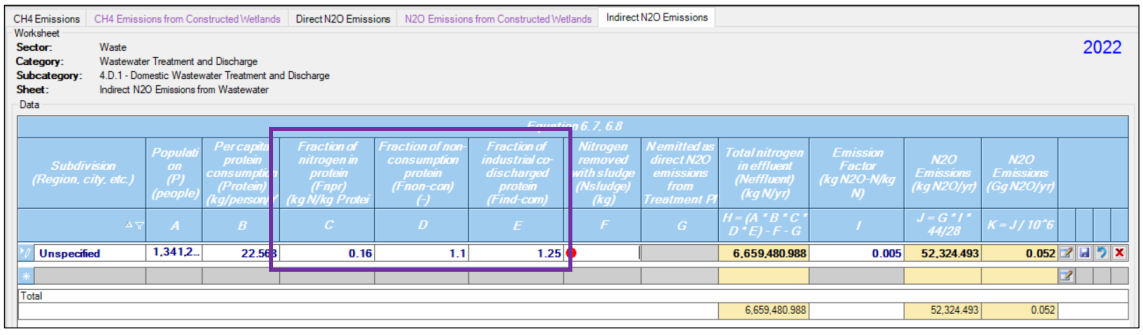
N_2O Emissions

I. In the **Indirect N2O Emissions** worksheet the |Subdivision| column was completed with "Unspecified" as emissions are being estimated for the country as a whole (as for CH4 emissions).

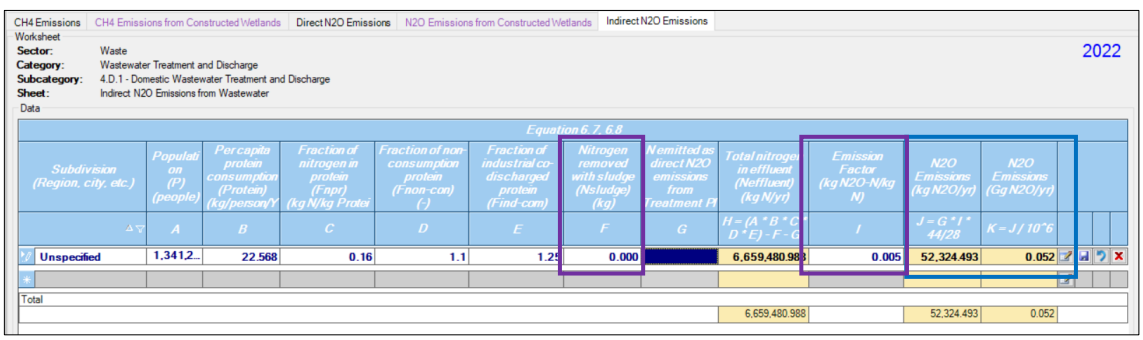
II. The |Population| column was completed and protein consumption added to the |Per capita protein consumption| column. Ahead of entry into *the Software* the protein consumption was converted from g/cap/day to kg/cap/year by multiplying by 0.001 and 365.



III. The |Fraction of nitrogen in protein| and |Fraction of industrial co-discharged protein| columns were already completed with the default value but the |Fraction of non-consumption protein| needed to be completed using the dropdown. As Country B does not have garbage disposal the value of 1.1 was selected.



IV. Country B has no data on nitrogen removal from sludge so |Nitrogen removed with sludge| column was completed with zero. The EF was automatically completed so the data entry was finished and emissions presented in *the Software* in both kg and Gg.



There are no wastewater treatment plants or wastewater treated in constructed wetlands, so the **Direct N_2O Emissions** and **N_2O Emissions from Constructed Wetlands** worksheets were left blank.

The compilation Country B's emissions from this sector were then complete in *the Software* for 2022.