Water/Wastewater Utility Greenhouse Gas (GHG) Emissions Inventory Tool

User Guide

WEAO/OWWA Climate Change Committee Task Group

Version History

Version	Date	Description
01	March 10, 2023	First Release for Beta Testing
02	April 17, 2023	First official release on OWWA & WEAO websites
03	September 14, 2023	Corrections & minor updates
04	August 1, 2024	Additions, corrections & updates

Disclaimer

Use of the WEAO/OWWA GHG Inventory Tool and its accompanying user guide shall indicate agreement with the following conditions:

1. Neither OWWA nor WEAO may be held liable for any losses that may be incurred directly or indirectly from use of this model. Those who use this model do so at their own risk.
2. Anyone who downloads or uses this model in any way shall not sell it or profit in any manner from its sale, distribution or use.

For all questions or comments regarding the GHG Inventory Tool, please email ghgtool@weaocommittee.org

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1. Introduction & Background

The Greenhouse Gas Emissions Inventory Tool (GHG Inventory Tool) is hosted and maintained by a Task Group of the joint Climate Change Committee of the Water Environment Association of Ontario (WEAO) and the Ontario Water Works Association (OWWA). The tool was based on a GHG Inventory developed by the University of Toronto, under contract to Toronto Water.

The first step toward reducing emissions is understanding all emission sources and their relative contributions to their total. Completing a GHG emissions inventory helps utilities to achieve this and to effectively target their emission reduction efforts.

Although the tool was primarily developed for the use of Ontario water and wastewater utilities, guidance is provided further in this guide to enable its use by any Canadian utility. The GHG Inventory Tool is free, transparent, and was designed to be accessible to all users, with inputs that utilities commonly already use. The spreadsheet tool and this user guide are both living documents that the Climate Change Committee has committed to keep current. The Task Group welcomes feedback and users are encouraged to send corrections and improvement suggestions to the committee at ghgtool@weaocommittee.org. As the tool will continue to be updated over time, users are encouraged to always access the latest version online.

2. About this User Guide

This guide provides background information for understanding the GHG Inventory Tool including its inputs, calculation methods and outputs. Step-by-step instructions for using the GHG Inventory Tool are also provided here.

Where practical, guidance to users of the GHG Inventory Tool has been provided right in the spreadsheet. In some areas however, the amount of supporting detail needed to make the tool fully transparent was too much for spreadsheet comments.

3. Version History

3.1. Changes in V04

The following changes were made for V04:

- Updated value for digester gas Higher Heating Value (HHV) from 27 MJ/m^3 to 26 MJ/m^3
- Unit for F_{bypass} – Annual Average Secondary Treatment Bypass Flow updated to volume in cubic meters per year (m^3/year)
- The calculation of emissions from fleet biodiesel combustion has been fixed. The prior version included both Scope 1 and Scope 3 emissions together as Scope 1. This has been corrected to properly separate out the Scope 3 emission into the Scope 3 upstream tab. The missing cradle-to-consumer EF for biodiesel was also added.
- Emission factors updated per latest references update based on NIR2024 and Canada Fuel LCA Mode June 2024

- Combustion Efficiency for Boilers – CH_4 conversion rate to CO_2 updated to 98% per Canada's Greenhouse Reporting Program – Quantification Requirements 2023
- Added functionality to be able to add more than 4 WTP or WWTP facilities (Beta Feature)
- Readily available emission factors for certain chemicals added to Section 13 of the Guide
- Default method for emissions from the anaerobic digestion of sludge has been changed to Method 2
- Addition of Type of Effluent Discharge for WWTP's and related emission factors
- Ontario Electricity Current EF update based on NIR2024 (Canada National Inventory Report (NIR) 1990-2021)
- Error corrected in the User Guide in the section called "N_2O emissions from sludge incineration" (deleted statement that the N_2O emission factor for sludge incineration is the same factor referenced in NIR 2022)
- Added calculation of process emissions for lagoons
- Fixed cell reference error on summary for Fugitive CH_4 from Anaerobic Digester which wouldn't include method 2 emissions if the user had chosen that method.
- Minor tool edits
- Minor user guide edits

3.2. Changes in V03

The following changes were made for V03:

- Added guidance for wastewater treatment plants that don't routinely measure Nitrogen in effluent
- Emission Factor (EF) for N_2O from sludge incineration changed from
  990 g N_2O /tonne wet sludge to 900 g N_2O/tonne wet sludge
  to align with the noted reference (IPCC 2006, Vol 5 Chap 5 Table 5.5)
- Reference for CH_4 Emission Factor from sludge incineration corrected to
  IPCC 2006, Vol 5 Chap 5 Section 5.4.2
- Minor tool edits
  Minor user guide edits

3.3. Changes in V02

V02 incorporated all comments and corrections from the initial Beta test.

3.4. V01

The V01 release was a Beta version sent to a group of interested stakeholders for testing.

4. Scope of the GHG Inventory Tool

The GHG Inventory Tool goes beyond direct facility GHG emissions to quantify the most significant impacts utility operations have on GHG emissions on and off site. This section outlines which GHG emission sources have been included, and which significant sources have been excluded, from the tool.

4.1. Scope 1, 2 & 3 Emissions

Some GHG emissions occur directly on a facility site- these are known as "direct" or "Scope 1" emissions. Other "indirect" emissions occur offsite, but because of the plant operations (e.g. because a chemical is purchased by the utility, that chemical is manufactured and shipped which results in GHG emissions). In carbon accounting, indirect emissions are further subdivided into "Scope 2" (offsite emission from imported electricity) and "Scope 3" (all other indirect emissions), as follows:

- Scope 1 emissions are direct GHG emissions related to onsite combustion and treatment processes within the system boundary, as well as mobile combustion of fleet vehicles owned and operated by the utility.
- Scope 2 encompasses indirect emissions related to the consumption of purchased electricity, steam, heating, or cooling. These emissions are a result of the treatment plant operations, but offsite.
- Scope 3 includes all other (non-Scope 2) indirect GHG emissions that result from treatment plant operations, as well as any offsets.

Scope 3 emissions are less commonly included in GHG inventories but are important to consider because although not generated on utility-owned sites, they are controlled by the utility through their decisions and purchasing power. It is especially important to include Scope 3 emissions when comparing emissions from different alternatives. If for example an alternative with higher chemical usage is being compared to an alternative with higher electricity emissions, it is important to include all these GHG emissions sources in the analysis.

4.2. Included Emission Sources

The GHG Inventory Tool accounts for the three types of GHG emissions found to be produced in meaningful quantities in the urban water cycle: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The tool cover emissions from the following utility operations:

- Wastewater treatment
- Wastewater collection
- Drinking water treatment
- Drinking water transmission
- Fleet vehicles
- Support services (fuel combustion & purchased electricity)

The GHG Inventory Tool includes all the emissions sources that utilities who report to regulators will be familiar with, like natural gas combustion, digester gas combustion, and process and fugitive emissions of nitrous oxide and methane.

There are also a few “lifecycle” emissions sources included in this tool that historically have been less commonly included in utility GHG inventories. These include:

- Upstream (Scope 3) Electricity- Scope 2 electricity is commonly the only electricity emissions included in inventories. Scope 2 electricity includes the direct emissions from power generation facilities, like the emissions from the stack of the natural gas power plant. Scope 3 electricity emissions include all upstream emissions from power generation, like the emissions from extracting the natural gas or nuclear fuel, and the emissions from building the nuclear power plant.
- Upstream (Scope 3) Fuel Combustion- Similarly to electricity, Scope 1 is commonly the only scope reported for fuel combustion. Scope 1 for fuel combustion includes emissions from burning the fuel on your site or in your fleet vehicle. Scope 3 fuel combustion includes all the

upstream emissions from extracting and refining the fuel and transporting it to where it is combusted.

- Scope 3 Chemicals- The GHG Inventory Tool and this guide contain some information about quantifying emissions from chemicals imported by a utility, both from manufacturing and from transportation to the site. Chemical lifecycle emissions can be significant and are worth quantifying, especially on the scale of a drinking water treatment facility's total emissions.

4.3. Excluded Emission Sources

There are also some significant emissions sources that have been excluded from the first iteration of the GHG Inventory Tool, although it is hoped that more sources will be added over time. Significant exclusions include:

- Scope 1 Sewer Methane- emerging research shows that sewer methane emissions may be very significant, potentially on the same scale as a wastewater facility's total onsite process emissions (Willis 2017). However, there are currently no standard approaches available to quantify this emission. These methods are however under development and are anticipated to be included in future versions of the GHG Inventory Tool.
- Scope 3 Construction and Embodied Emissions- The GHG Inventory Tool is intended to cover operational emissions only (not one-time capital emissions).
- Some treatment process types are not included. Users are encouraged to provide suggestions for improvement by emailing ghgtool@weaocommittee.org, as the Task Force intends to continuously improve the tool.

4.4. Notes on Using the GHG Inventory Tool Outside Ontario

The GHG Inventory Tool was adapted from an inventory developed for an Ontario utility and has been validated and tested for Ontario utilities. However, the tool could be adapted relatively easily for use by any Canadian utility.

Some of the emission factors used in the tool were taken from Ontario Guidelines for Greenhouse Gas Emissions Reporting. Replacement factors for other provinces can be found in Canada's National Inventory Report (NIR) and Canada Fuel LCA Methodology.

The following inputs should be revised for use in other Canadian provinces and territories:

- Scope 1 combustion- Use High Heating Values and emission factors from Canada's National Inventory Report (NIR) instead of Ontario GHG reporting guidelines, or just use Ontario factors (combustion emissions per unit of each fuel type do not vary significantly across regional boundaries)
- Electrical grid intensity (Scope 2)- using the same reference source as noted in the spreadsheet tool (NIR), look up factors for the applicable province/territory
- Upstream electrical emissions (Scope 3)- using the same reference source as noted in the spreadsheet tool (Canada Fuel LCA Methodology), look up factors for the applicable province/territory
- Upstream fuel combustion emissions (Scope 3)- using the same reference source (Canada Fuel LCA Methodology), look up factors for the applicable province/territory

4.5. Notes on Updates and Tool Currency

Emission factors, global warming potentials and other referenced values in the tool will not always reflect the most frequent available information, and they will not align with all reporting protocols. The intent of the WEAO/OWWA Climate Change Committee Task Group is to update the tool annually, or more frequently. The planned approach for updates will be to update the tool with the most recently available information.

5. GHG Inventory Tool Overview

The GHG Inventory Tool is a fully editable Excel spreadsheet. The spreadsheet includes the following tabs:

- Instructions- contains basic instructions for using the tool and directs users toward this User Guide
- References- contains links to all the commonly referenced data sources in the spreadsheet
- Inputs- this is where all the inputs are entered by the user- all subsequent tabs summarize calculations and results but have no inputs
- Summary- where results are summarized and displayed
- Detailed Tabs:
    - Scope 1- Process
    - Scope 1- Combustion
    - Scope 2 - Electricity
    - Scope 3 - Electricity upstream
    - Scope 3 - Fuel upstream
    - Scope 3- Biosolids
    - Scope 3- Chemicals

The following colour coding has been used throughout the spreadsheet tool:

Utility-Specific Data
Value Adopted by Utility
Default Input, Typical Range or Value Adapted from Literature
Output Calculated based on Utility-Specific data

6. Steps for Using the GHG Inventory Tool

Here are the steps to follow to use the GHG Inventory Tool:

1. Save a backup version of the tool and give it a meaningful filename in case you make unintended changes and want to go back to the file you originally downloaded (e.g. “GHG Inventory- BLANK”).
2. Save the version you will work on and give it a meaningful file name (e.g. “GHG Inventory- Town Name- April 2023”).
3. Read the “Instructions” and “References” tabs.
4. In the “Inputs” tab:
    a) Populate the names of your facilities. The Tool provides columns for minimum of four wastewater treatment plants and minimum of four drinking water treatment plants- it is

suggested that additional columns be left blank rather than deleted- additional facilities can be removed in the Summary tab at the end of the process

b) Enter utility data into all blue cells
c) Feel free to overwrite yellow cells as well (default inputs) if utility-specific data are available

5. Delete additional facilities from the Summary Tab.
6. You are now ready to review and interpret results on the Summary tab.
7. Refer to this User Guide, when desired, in places where comments in the Tool indicate that the User Guide offers more detailed information/guidance.

7. References Tab

This tab provides web links for a few references that are commonly used throughout the rest of the GHG Inventory Tool. Each reference is also given a "Short Name" which is then used elsewhere throughout the document. For example, "2006 IPCC Guidelines for National Greenhouse Gas Inventories" becomes "IPCC 2006".

8. Inputs Tab

As previously noted, the Inputs tab is where all the inputs are entered by the user. All subsequent tabs summarize calculations and results but have no inputs. The Inputs tab is where users will spend most of their time.

8.1. Adding Additional WWTPs and WTPs

The functionality to add more than 4 WTP or WWTP facilities is available as a Beta Feature. Please report any issues by emailing ghgtool@weaocommittee.org.

VBA macros are provided to add additional WWTPs and WTPs. These macros are linked to the buttons included on the Inputs tab. To add additional plants, simply click the appropriate button to add one additional plant, repeating as many times as necessary to add the number of plants required. In order to use this feature, the user must enable the use of macros (see this link for details: https://support.microsoft.com/en-us/office/enable-or-disable-macros-in-microsoft-365-files-12b036fd-d140-4e74-b45e-16fed1a7e5c6). It should be noted that any added plants must be removed manually if they are no longer needed; therefore it is recommended to make a copy of the Excel file as a backup prior to adding more plants.

8.2. Nitrogen Concentrations

Note that for municipal wastewater facility influent, "Average Total Nitrogen Concentration in Wastewater Influent" will be equivalent to Total Kjeldahl Nitrogen (TKN), which is what most facilities measure. Note the units are "as N". This is typically what laboratories use as reporting units, but this should be confirmed before data is entered. As a reminder, Total Kjeldahl Nitrogen (TKN) measures organic nitrogen + ammonia nitrogen. Total Nitrogen includes all forms of nitrogen: TKN, nitrate and nitrite.

8.3. Alternative Wastewater Facility Bypass Configurations

The GHG Inventory Tool was originally developed for a facility that was configured to bypass primary treated flows around secondary treatment during high flows. Users will notice that the sheet is therefore set up to estimate emissions from “secondary treatment effluent flow” and “secondary treatment bypass flow”.

If the user’s facility has filters/tertiary treatment, tertiary quality and flow numbers can be entered instead of secondary. Facilities without any bypass capability can just leave the bypass flows as blank or “0”. Facilities with different bypassing configurations may have to adapt the tool to work for them. The spreadsheet is fully editable by design so that users can adapt it to fit their facilities.

8.4. Lagoons

The GHG Inventory Tool as of version 4 allows estimating treatment emissions of methane from lagoons (sometimes called treatment ponds). The emission factors are based on Canada’s National Inventory Report (note: Canada’s NIR values differ from IPCC). The tool allows three different types of lagoons: (i) anaerobic, (ii) aerobic or aerated, and (iii) facultative. If the user is unsure of the lagoon type, choose facultative, which covers “unspecified” lagoon types. All three types of lagoons can be included under a single WWTP but the user needs to sum up all lagoons of the same type. For example, if your facility has two aerated cells and one facultative cell, consider the two aerated cells as a single aerated lagoon. Lagoon methane emissions are summed together with other treatment emissions into the same category on the summary tab (i.e. “Process CH4 from Treatment”).

Nitrous oxide is not included for lagoons, as they are assumed to have no N_2O emission.

8.5. Biosolids Management

This GHG Inventory Tool has been designed to accept inputs from the widely adopted BEAM models (BEAM 2011 or BEAM 2022) for biosolids management emissions. BEAM 2011 and 2022 links are in the "References" tab in the spreadsheet.

BEAM 2011 (v1.1) was developed by the Canadian Council of Ministers of the Environment (CCME) based on work done by SYLVIS Environmental under contract to CCME. It has been freely, publicly available and has been used by biosolids programs and consultants around the world.

BEAM 2022 includes numerous updates beyond the original BEAM v1.1 based on recent research and reviews - including:

- additional spreadsheet tabs for additional unit processes, such as different landfill conditions and pyrolysis
- improved flow of inputs and data through the spreadsheet
- updated default values and assumptions based on reviews of recent literature

Although BEAM 2022 is the more up-to-date reference, access to BEAM 2022 is not free. It was therefore decided to enable for users of the GHG Inventory Tool to easily import values from BEAM 2011 as well, since this older version is still available for free.

The purpose of facilitating data input from BEAM is to account for biosolids-related emissions that were not included in the rest of the GHG Inventory. This is intended to primarily cover emissions from "outside the fence" of the WWTP, such as from biosolids transport and land application.

It is possible that some of the processes in BEAM may be co-located with user wastewater treatment facilities. In this case, when completing the BEAM model, it is important that users do not include emissions that are already included in the main inventory. For example, if alkaline stabilization is co-located at the wastewater facility and the electricity use for that process has already been included in the total facility electricity consumption, users should enter zero electricity use in the alkaline stabilization module of BEAM to avoid double counting.

9. Summary Tab

This tab displays summarized results of the assessment. Users are free to tabulate and display the data in other ways.

10. Scope 1- Process

10.1. N_2O emissions from secondary treatment

The GHG Inventory Tool uses a default factor for centralized aerobic treatment plants from the 2019 IPCC Refinements to the 2006 guidelines. This was the most up to date global emissions factor at the time of the tool's release in early 2023. The 2019 IPCC factor is 0.016 kg N_2O (as N) of emission per kg influent N. In other words, the factor assumes that 1.6% of the nitrogen entering the facility is released as nitrous oxide.

Use of the 2019 IPCC emissions factor results in a very significant nitrous oxide emission estimate. Utilities on a low-carbon grid (e.g. Ontario, British Columbia, and Quebec) will find that use of this factor will make N_2O their largest wastewater facility emission. It should be emphasized that there is significant uncertainty in this estimate; the real N_2O emission might be significantly lower or higher than the estimate. This is because nitrous oxide formation has very significant spatial and temporal variability and can vary by many orders of magnitude depending on process configuration and operational conditions.

Some countries have developed their own country-specific default emissions factors for process N_2O emissions, based on research undertaken in the country. Canada does not have its own country-specific factor, which is why the IPCC global default has been used in the GHG Inventory Tool.

It is also noted that some recent studies (de Haas and Andrews, 2022), suggest 1.1% is a more appropriate global default factor based on identifying errors in the original IPCC data analysis.

The best way for a utility to determine its N_2O emissions is onsite measurement. It is recommended that this be done over the course of a full year to capture seasonal variations, and continuously if possible. More detail on how to approach N_2O onsite measurement can be found in an excellent open-access book from the IWA: Quantification and Modelling of Fugitive Greenhouse Gas Emissions from Urban Water Systems, IWA, 2022.

10.2. Liquid Train CH_4 Emissions

The GHG Inventory Tool utilizes the approach in Canada's National Inventory Report (NIR) for calculating methane emissions which differs slightly from IPCC 2019. The difference being that NIR uses a lower B_0 factor. The user is referred to page 293 of NIR 2022 for further discussion.

10.3. CH_4 Emission from Effluent Discharge

The GHG Inventory Tool uses an Emission Factor of 0.068 from Table 6.3 of IPCC 2019, which is Tier 1 for discharge to aquatic environments. This assumes little to no knowledge of the characteristics of the receiving waters . Table 6.3 in IPCC 2019 provides other factors (Tier 2) if better understanding by the user is available.

10.4. CH_4 Emissions from Anaerobic Digestion

Two methods are offered for calculation of this emission. The two methods (generally) lead to similar results. One uses mass of organic waste and the other uses volume of digester gas produced & assumes 2.1% fugitive emissions as per NIR (IPCC default is 5% but range in IPCC is 0-10%). IPCC is global whereas NIR should in theory provide more accurate estimates for Canadian facilities. Both are included to give users a choice based on the data they have available.

Like N_2O process emissions, onsite CH_4 emissions vary widely by site and as for nitrous oxide, the best way for utilities to determine their methane emissions is onsite measurement. More detail on how to approach onsite measurement of CH_4 can be found in an excellent open-access book from the IWA: Quantification and Modelling of Fugitive Greenhouse Gas Emissions from Urban Water Systems, IWA, 2022.

11. Scope 1- Fuel Combustion

11.1. N_2O Emissions from Sludge Incineration

The Emission Factor provided in the GHG Inventory Tool for sludge incineration N_2O emissions is 900 g N_2O / tonne wet sludge. This value comes from IPCC 2006, Volume 5, Chapter 5, and is also used in the ICLEI Community Protocol. Interestingly, IPCC 2006 Volume 5, Chapter 5 provides two emission factors: 900 g N_2O/wet tonne (Japan), and 990 g N_2O /dry tonne (Germany). These two factors would yield significantly different results from each other.

The GHG Inventory Tool has adopted the higher emissions factor (900 g N_2O / tonne wet sludge) because of its prevalence in other protocols. However, the sub-committee plans to review this emissions factor in future against available literature. For plants with solids incinerators, periodic stack testing of flue gasses would be a better way to arrive at a more accurate emissions estimate.

12. Scope 3- Fuel Upstream

A generic emissions factor for biodiesel has been provided and is appropriate to use where a small proportion of the fuel being combusted is biodiesel. It is important to note that if using a significant amount of biodiesel, an emissions factor should be researched based on the type of biodiesel being combusted, as lifecycle emissions can vary significantly between different biodiesel feedstocks.

13. Scope 3- Chemicals

Most utilities purchase chemicals like chlorine, coagulants, polymers and others to achieve various treatment goals. The manufacturing and transport of these chemicals to the treatment plant results in Scope 3 emissions. Although many Scope 3 emissions have been left out of the GHG Inventory Tool to reduce complexity, chemicals are an emission source that is worth some effort to include, for two reasons:

1. Chemicals are a significant emission source- the carbon footprint of imported chemicals for a drinking water treatment plant in Ontario can be about the same as the imported electricity carbon footprint
2. Utilities have some control over how much and which chemicals are purchased and used

To estimate the emissions associated with each imported chemical, the first step is to determine the following for each chemical:

- How much was purchased in that inventory year (kg)
- Where was it manufactured
- How it was shipped from manufacturing facility to treatment plant (truck, rail, or sea freight) (km)

For transport emissions, the GHG Inventory Tool includes a calculation using emission factors per tonne shipped per kilometre transported.

For manufacturing emissions, however, utilities must derive their own emissions factors. This can be accomplished in one of two ways:

1. Request emissions factors from the chemical manufacturer, or
2. Use a lifecycle Inventory (LCI) database to find an appropriate emissions factor for each chemical

The gold standard for an emissions factor from the manufacturer would be an Environmental Product Disclosure (EPD). This is an analysis of GHG emissions from manufacturing of that chemical which has been independently 3rd party verified. Another good alternative is obtaining the Carbon Footprint of a Product (CFP) per ISO14067 - Verification – Greenhouse Gases – Carbon Footprint of Products from the chemical suppliers.

If an emissions factor is not available from the chemical manufacturer, a life cycle inventory (LCI) database can be used (#2 above). Some of the common LCI databases include Ecoinvent, GaBi and Environmental Footprint. Other common LCI databases are listed at https://nexus.openlca.org/databases. They may also be called LCA (lifecycle assessment) databases. LCI databases bring together emissions information from the available body of LCA literature to give estimates for manufacturing each product in each geographical location. They include emissions from production processes and everything upstream (e.g. extraction and transport of raw materials). It should be noted that LCI databases are generally not free and interpreting data from LCI databases benefits from specialized expertise in lifecycle assessment. Obtaining information from the chemical manufacturer is recommended as the preferred approach, both because the estimate will likely be more accurate, and because that approach is simpler and does not require specialized expertise.

The use of emission factors through the methods described above is preferable, however, the difficulty in obtaining EPD's/CFP's for chemicals and accessing and navigating LCI databases is recognized. Therefore, the table below provides available emission factors for common chemicals used in WTP's and WWTP's so utilities can start tracking the Scope 3 GHG for chemicals until more accurate information becomes available. However, the GHG calculation using these generic emission factors provides a high level of uncertainty due to the following:

- The manufacturing method, manufacturing geographic location or commercial product concentration often differs from the actual chemical being used
- Outdated reference data
- Not all information provided, i.e. system boundary manufacturing method, commercial concentration of chemical, methodology, and GWP used

In order to estimate the emissions associated with each imported chemical, the first step is to determine how much chemical, in kg of the commercial product, was purchased in that inventory year. If the chemical is a liquid, use the following conversion:

- kg of Chemical per Year = L of Chemical per Year x Specific Gravity of Chemical
- The specific gravity of the chemical can be found on the supplier provided Material Safety Data Sheet (MSDS)
- Specific Gravity = Density of Chemical / Density of Water at $4^{o}C$

Table 13 – Generic Emission Factors for Common Chemicals used in WTP's and WWTP's

Chemical	Formula	Commercial Product Concentration, Form	Emission Factor	Unit	Reference, Source (Reference Data Year)	Geographic Location	System Boundaries
Chlorine Gas	Cl_2	100%, Gas	0.900	kg CO_2eq/ kg product	Euro Chlor EPD 2013 (2011) [1]	Europe	Cradle to gate
Sodium Hypochlorite	NaClO	20%, Liquid[a]	0.930	kg CO_2eq/ kg product	Euro Chlor EPD 2013 (2011) [1]	Europe	Cradle to gate
Sodium Bisulphite	$NaHSO_3$	30%, Liquid	0.416	kg CO_2eq/ kg product	ASTEE Facteur Emission 2024 (2013) [2]	Europe	Cradle to gate
Aluminum Sulphate or Alum	$Al_2(SO_4)_3$	48.5%, Liquid[b]	0.148	kg CO_2eq/ kg product	INCOPA 2014, SimaPro [3]	Europe	Cradle to gate
Polyaluminum Chloride (PACl)	$[Al_2(OH)nCl_{6-n}]_m$	18%, Liquid[b]	0.537	kg CO_2eq/ kg product	INCOPA 2014, SimaPro [3]	Europe	Cradle to gate
Ferric Sulphate	$Fe_2(SO_4)_3$	60%, Liquid[b]	0.029	kg CO_2eq/ kg product	INCOPA 2014, SimaPro [3]	Europe	Cradle to gate
Ferric Chloride	$FeCl_3$	40%, Liquid[b]	0.395	kg CO_2eq/ kg product	INCOPA 2014, SimaPro [3]	Europe	Cradle to gate
Fluosilicic Acid	$H_2(SiF_6)$	22%, Liquid	0.916	kg CO_2eq/ kg product	Manual CCaLC PVC V2.0 2011, Ecoinvent 2.2, 2010 (2001) [4]	USA	Not provided
Sodium Silicate	Na_2SiO_3	48%, Liquid	0.748	kg CO_2eq/ kg product	Manual CCaLC PVC V2.0 2011, Ecoinvent 2.2, 2010 (2001) [4]	Europe	Not provided
Aqua Ammonia	NH_4OH	29%, Liquid[a]	2.100	kg CO_2eq/ kg product	Manual CCaLC PVC V2.0 2011, Ecoinvent 2.2, 2010 (2001) [4]	Europe	Not provided
Liquid Oxygen	O_2	100%, Liquid	0.409	kg CO_2eq/ kg product	Manual CCaLC PVC V2.0 2011, Ecoinvent 2.2, 2010 (2001) [4]	Europe	Not provided
Sulphur Dioxide	SO_2	100%, Gas	0.418	kg CO_2eq/ kg product	Manual CCaLC PVC V2.0 2011, Ecoinvent 2.2, 2010 (2001) [4]	Europe	Not provided
Polymer	-	100%, Dry or Liquid	4.600	kg CO_2eq/ kg product	Solenis, Carbon Footprint 2023 (2022) [5]	USA	Cradle to gate
Sulphuric acid	H_2SO_4	94.5%, Liquid	0.120	kg CO_2eq/ kg product	Spolana EPD 2023 (2021) [6]	Europe	Cradle to gate
Lime Hydrated	$Ca(OH)_2$	100%, Dry	0.762	kg CO_2eq/ kg product	US EPA SEFA 2016, Ecoinvent data V2.2, 2010 (2007) [7]	Not provided	Cradle to gate
Ferrous Sulphate	$Fe\ SO_4 \cdot 7H_2O$	100%, Dry	0.167	kg CO_2eq/ kg product	US EPA SEFA 2016, Ecoinvent data V2.2, 2010 (2007) [7]	Not provided	Cradle to gate
Hydrogen Peroxide	H_2O_2	50%, Liquid	1.190	kg CO_2eq/ kg product	US EPA SEFA 2016, Ecoinvent data V2.2, 2010 (2007) [7]	Not provided	Cradle to gate
Phosphoric Acid	H_3PO_4	70%, Liquid	0.882	kg CO_2eq/ kg product	US EPA SEFA 2016, Ecoinvent data V2.2, 2010 (2007) [7]	USA	Cradle to gate
Potassium Permanganate	$KMnO_4$	100%, Dry	1.160	kg CO_2eq/ kg product	US EPA SEFA 2016, Ecoinvent data V2.2, 2010 (2007) [7]	Not provided	Cradle to gate
Sodium Hydroxide	NaOH	50%, Liquid	1.090	kg CO_2eq/ kg product	US EPA SEFA 2016, Ecoinvent data V2.2, 2010 (2007) [7]	Not provided	Cradle to gate

Notes:

a Assumed based on most common concentration.

b Assumed based on Fe or Al content.

References:

1 European Chlor-Alkali Industry, Chlorine (The Chlor-Alkali Process) Euro Chlor Final Report, 2022- https://www.eurochlor.org/wp-content/uploads/2022/02/2022-Euro-Chlor-Eco-profile.pdf

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4 University of Manchester, CCaLC© PVC Manual (V2.0) 2011 - http://www.ccalc.org.uk/downloads/Manual_CCaLC_PVC_V2.0.pdf

5 Solenis, Product Carbon Footprint for Solenis Products per ISO 14067:2018, 2023 provided to Waterloo Region

6 International EPD System, SPOLANA Sulphuric acid technical grade EPD - https://api.environdec.com/api/v1/EPDLibrary/Files/7a552da7-a89e-495c-2531-08db259f9365/Data

7 EPA, Life Cycle Inventory (LCI) Data – Treatment Chemicals, Construction Materials, Transportation, On-site Equipment, and Other Processes for Use in Spreadsheets for Environmental Footprint Analysis (SEFA) - https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=338320

14. Scope 3- Biosolids Management

See comments under "Inputs Tab" on how to bring biosolids management numbers in from BEAM 2011 or BEAM 2022.

Important notes on maintaining GWP value consistency between BEAM and the inventory tool:

- BEAM 2011 uses old GWP values from The Climate Registry Protocol. If users use BEAM 2011, they should change the GWP values on the "References Assumptions" tab (cell B217 for methane, cell B220 for nitrous oxide) to the same AR values used in the inventory tool (found on the Inputs Tab under generic data).
- BEAM 2022 uses AR4 GWP values. If users choose AR5 or AR6 GWP values in the inventory tool, they should also update the 100-year GWP values in cells F285 and F286 in the BEAM model on the "References Assumptions" tab to the same GWP values (found on the Inputs Tab under generic data).

15. References

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