

# User Manual

# Energy Performance and Carbon Emissions Assessment and Monitoring Tool - ECAM





**Elaborated by:** WaCCliM - Water and Wastewater Companies for Climate Mitigation

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**Cite as:** Silva, B. E.; Cabral, C.; Rosenfeldt, S.; Kerres, M.; Veizaga, A.; Moskopp, D. (2022): ECAM User Manual

**Involved institutions:**



September 2022

The Water and Wastewater Companies for Climate Mitigation (WaCCliM) project is a joint initiative between the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the International Water Association (IWA). This project is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) supports this initiative on the basis of a decision adopted by the German Bundestag.

On behalf of:



Federal Ministry  
for the Environment, Nature Conservation,  
Nuclear Safety and Consumer Protection

of the Federal Republic of Germany

Implemented by:



Deutsche Gesellschaft  
für Internationale  
Zusammenarbeit (GIZ) GmbH





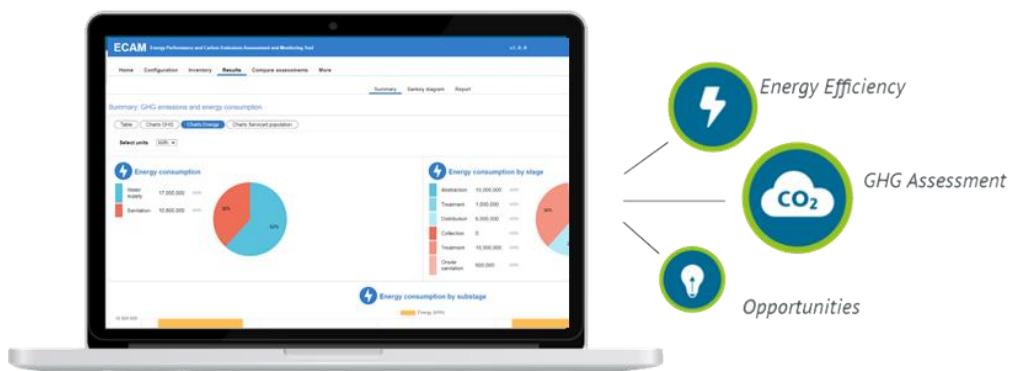
## Executive summary

The **ECAM User Manual** was conceived in the context of **WaCCliM** (Water and Wastewater Companies for Climate Mitigation). WaCCliM is a global project implemented by the **Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)** GmbH in collaboration with the **International Water Association (IWA)**, which seeks to contribute to a low-carbon and climate-resilient water and sanitation sector. In this sense, WaCCliM developed the ECAM tool (Energy Performance and Carbon Emissions Assessment and Monitoring) to monitor greenhouse gases (GHG) emissions and their reduction achieved through the implementation of mitigation measures.

The **User Manual** was developed as an instrument to support the use of the **ECAM tool** (Energy Performance and Carbon Emissions Assessment and Monitoring). It can help users to estimate greenhouse gases (GHG) emissions from the **Urban Water Sector** activities. This document is intended to be practical, accessible and "straight to the point". To understand the conceptual framework of the ECAM tool, the user can consult the additional document "Methodology Guide".

The document is **organized into topics and sections covering** features and benefits of the tool; contextualization about the methodology; step-by-step instructions on how to use the main functions, including how to fill in data and generate results; case scenario examples and exercises; and a troubleshooting section.

The **ECAM tool** assists water utilities in using their own data to transform it into a source of valuable information on energy performance and GHG emissions. ECAM is the first of its kind to allow for a holistic approach of the urban water cycle to drive GHG emission reduction in water utilities, even those with limited data availability. It promotes transparency, accuracy, completeness, comparability, and consistency. It is designed to assess the carbon emissions that utilities can control within the urban water cycle and prepares utilities for future reporting needs on climate mitigation.



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the international  
water association

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# Abbreviations

BMUV	German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
BOD	Biochemical Oxygen Demand
CC	Climate Change
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> eq	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
ECAM	Energy Performance and Carbon Emissions Assessment and Monitoring
EF	Emission Factor
EIB	European Investment Bank
GHG	Greenhouse Gas
GWP	Global Warming Potential
ICRA	Institut Català de Recerca de l'Aigua
IFI	International Financial Institutions
IKI	International Climate Initiative
IPCC	Intergovernmental Panel on Climate Change
N	Nitrogen
N <sub>2</sub> O	Nitrous Oxide
TN	Total Nitrogen
UNFCCC	United Nations Framework Convention on Climate Change
WaCCliM	Water and Wastewater Companies for Climate Mitigation
WWTP	Wastewater Treatment Plant
WTP	Water Treatment Plant

# Glossary

Activated sludge	Flocs of sludge particles containing living microbes, mainly bacteria and protozoans, which are formed in the presence of oxygen in aeration tanks.
Activity data	Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period. Data on energy use, metal production, land areas, management systems, lime and fertilizer use and waste arisings are examples of activity data.
Aerobic	Conditions with free oxygen in the wastewater.
Anaerobic	Conditions in which oxygen is not readily available. These conditions are important to produce methane emissions. Whenever organic material decomposes in anaerobic conditions methane is likely to be formed.
Assessment	Type of diagnosis that allows a utility to create an inventory over its activities within a period, of all its greenhouse gas emissions broken down by emission items
Base year	The starting year for the inventory.
Benchmark	Objective comparison of utilities or facilities.
Carbon footprint	A carbon footprint is the total greenhouse gas emissions caused by an individual, event, organization, service, or product, expressed as carbon dioxide equivalent.
Census	Data collected by interrogation or count of an entire population.
Chemical oxygen demand (COD)	An indication of the amount of organic matter in wastewater. It refers to the amount of oxygen equivalent consumed in the chemical oxidation of organic matter by strong oxidants such as potassium dichromate.
Code	In ECAM, a code is a name associated with a variable, which is used by the tool's algorithm for calculations. Example: "wwt_serv_pop" is the code for Serviced Population with wastewater treatment
Country-specific data	Data for either activities or emissions that are based on research carried out on sites either in that country or otherwise representative of that country.
Direct emission	Emissions originated from sources owned (or controlled) by the utilities. Some examples are CO <sub>2</sub> emissions from in-situ engines and CH <sub>4</sub> and N <sub>2</sub> O emissions from wastewater treatment plants.
Dropdown menus	Selectable list in ECAM, based on a reference table.
Emission Factor	A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

# Glossary

Estimates	Input activity data that can be estimated by the tool or filled in by the user. The estimations are based in user input data.
Fossil carbon	Carbon derived from fossil fuel or other fossil source.
Fuel	Any substance burned as a source of energy such as heat or electricity.
Fuel combustion	Within ECAM, it is the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus.
Global Warming Potential (GWP)	Global Warming Potentials (GWP) are calculated as the ratio of the radiative forcing of one kilogramme greenhouse gas emitted to the atmosphere to that from one kilogramme CO <sub>2</sub> over a period (e.g., 100 years).
Greenhouse gas	Gas that absorbs and emits radiant energy within the thermal infrared range and contributes to the global warming effect.
Indirect emission	Emissions derived from the acquisition of electrical or thermal energy, consumed by the utility. It also includes emissions that the utility considers that are not part of its operations, such as CH <sub>4</sub> emissions from wastewater generated by the population not connected to the sewer system.
Input	It includes both the activity data that must be added by the user and the estimates calculated by the software (or calculated by the user). It also includes data chosen from dropdown menus.
Inventory	List of emission sources and the associated emissions quantified using standardized methods.
Organic matter	Organic waste of plant or animal origin from homes or industry, or originated from storm water run-offs, and so on., which mainly contains volatile fraction of solids.
Output	Results of calculations performed by ECAM for GHG emissions and for Energy performance and Service Level indicators.
Output variable	Variable belonging to the outputs Section of ECAM.
Scope	The choice that the utility should do regarding the boundaries of its GHG assessment. It may include defining which emissions will be considered, or which stages will be accounted for.
Stage	Refers to “Water Abstraction”, “Water Treatment”, “Water Distribution”, “Wastewater Collection”, “Wastewater Treatment”, and “Onsite Sanitation”.
Substage	Refers to the facilities that are to be evaluated in each of the stages. Example: Pumping station number 1; or WWTP number 3.

# Glossary

System	Refers to Water Supply and Sanitation.
Tier (Level of information)	A tier represents a level of methodological complexity. Usually, three tiers are provided. Tier 1 is the basic method, Tier 2 intermediate and Tier 3 most demanding in terms of complexity and data requirements. Tiers 2 and 3 are sometimes referred to as higher tier methods and are generally considered to be more accurate.
Uncertainty	Lack of knowledge of the true value of a variable that can be described as a probability density function characterizing the range and likelihood of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods.
Variable	Field name of an element used for ECAM calculations, whether in the Input section or output section. Example: "Serviced population with wastewater treatment."
Wastewater	The used water including solids discharged from communities, businesses, industry, or agriculture that flows into a wastewater treatment plant. Storm water, surface water, and groundwater infiltration also may be included.
Urban Water Cycle	It covers the engineered systems that provide essential and safe drinking water and ensure wastewater and sewage removal. In ECAM, those are the "Water Supply" and "Sanitation" systems, which are composed of six stages: "Water Abstraction", "Water Treatment", "Water Distribution", "Wastewater Collection", "Wastewater Treatment", and "Onsite Sanitation".
Urban Water Sector	Refers to utilities, facilities, and urban water activities.
Urban Water Services	Refers to activities provided by urban water utilities.
Urban Water System	Systems designed to meet human demands related to Water Supply and Sanitation.
Urban Water Utilities	Refers to the institutions (public or private) responsible for carrying out the urban water services of a municipality or state.

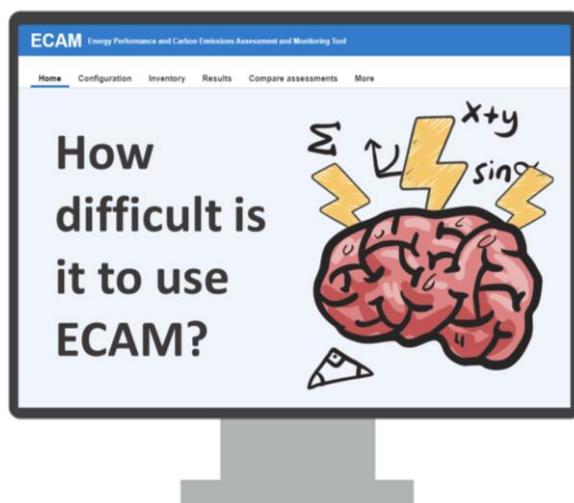
***Note: This glossary describes the terms as they are used in this manual and ECAM.***

# ENERGY PERFORMANCE AND CARBON EMISSIONS ASSESSMENT AND MONITORING TOOL

ECAM may seem like a difficult tool to use, but it is not.

All equations and formulas are already loaded into the tool, which is programmed to calculate emissions without requiring you to pick up your calculator.

You, as a user, will need to give some inputs for these calculations to take place. You can fill in the activity data available for your utility. For several cases, the ECAM tool suggests estimates based on the Intergovernmental Panel on Climate Change (IPCC), on databases, and on reference literature<sup>1</sup>.



Source: images adapted from Flaticon.com

## The choice is yours:

- ECAM is a flexible tool that can work with detailed and high-quality data as well as estimations and minimal data to provide relevant outputs to users.
- ECAM performs an automated calculation of Greenhouse Gas (GHG) emissions in urban water and wastewater utilities, integrating the various stages of the water cycle.
- ECAM provides estimations based on literature references or calculations from databases.

<sup>1</sup> The ECAM User Manual does not address the sources behind the emission calculation process, nor the estimates that can be made. These sources can be consulted in the supporting document "Methodology Guide".

# Introduction

## About the ECAM Tool

The Energy Performance and Carbon Emissions Assessment and Monitoring Tool (ECAM) is the first Greenhouse gases (GHG) emissions calculation tool focused on the urban water sector, which was developed to promote the reduction of GHG emissions in urban water utilities, designed for utilities with both high-quality data and limited data availability. The advantage over the isolated use of empirical formulas is the possibility of evaluating different systems in parallel, in addition to involving more variables in the calculations, increasing their precision, and facilitating the handling of emissions information by the urban water utilities.

The tool was developed within the framework of the Water and Wastewater Companies for Climate Mitigation - WaCCliM project, which is a joint initiative between the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the International Water Association (IWA). WaCCliM is commissioned by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) in framework of the International Climate Initiative (IKI).

It has the purpose of evaluating and monitoring GHG emissions from water and sanitation utilities. ECAM is available online, open source and free to use. Together with IWA and GIZ, the web interface and features were developed by the Institut Català de Recerca de l'Aigua (ICRA). The tool was first developed for WaCCliM project in 2015 as a spreadsheet tool by the consortium Urban Water Commons (LNEC and ITA, Universitat Politècnica de València) in collaboration with Cobalt Water Global. The spreadsheet tool laid the foundation and basic equations for the web-tool.

To cover all utilities, including those that have limited data on their processes, the tool proposes default values based on the literature, which can be modified by the user to better illustrate local conditions. ECAM also allows to incorporate more data as the utility's data management capacity grows. Methodologically, ECAM is based on the *Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories*, including their 2019 refinement (IPCC, 2019).

Based on the GHG estimations generated by the tool, the utility can identify areas with GHG reduction potential and operating expenses, also strengthening performance monitoring and decision-making.

The tool's functionalities include:

- GHG emissions assessment
- Energy performance assessment
- Identification of opportunities for reducing GHG emissions and reducing energy consumption
- Developing scenarios when investigating possible measures to improve performance
- Monitoring the results after the implementation of improvement measures

In terms of data security and privacy, no information is stored in fixed memory on the users' server, but available as a downloadable file containing the assessment. Therefore, all data entered is processed locally and stored solely on the user's computer.

As first of its kind, ECAM follows a holistic approach to the urban water cycle, as it is designed to calculate GHG emissions at all stages of the cycle, enabling integrated comparisons and assessments. By this means, the user can create assessments accounting only some stages of a system, the complete system, or even all the systems of a utility.

It is also possible to include energy performance and service level analyses calculated by the tool, such as: topographic energy use; electromechanical efficiency; sludge management; treatment performance; biogas production; and more.

### **What ECAM can do:**



**ECAM** can calculate the GHG emissions of urban water and wastewater utilities at each stage of drinking water supply and sanitation systems.

**ECAM** can evaluate energy performance and service level indicators.

### **What ECAM can be used for:**



**ECAM** can be used to report and monitor GHG emissions. It allows users to compare the greenhouse gas emissions of a utility over time and with those of other utilities.

**ECAM** can be used to develop scenarios on the impact of GHG mitigation measures. It allows users to identify opportunities for action and facilitates decision making.

## So, what are the **BENEFITS** of using ECAM?

ECAM is a first step towards a climate-smart urban water management. It provides a starting point for reducing greenhouse gas emissions and running a more efficient water facility.



## About the User Manual

The **User Manual** has the aim of helping users to calculate emissions, present results, evaluate scenarios, and compare assessments using the ECAM tool. The target group for this document is composed by technicians, consultants, climate change professionals, academics, policy makers, and other general users who seek to calculate GHG emissions for the Urban Water sector.

In this manual, the user will learn how to use the tool's functions through step-by-step instructions and with the help of screenshots and practical examples and exercises, which will strengthen the learning process. In topic "**Section 4: Key points when entering data in ECAM**" some key aspects will be explored when filling in the ECAM data, so check it if you have doubts about specific procedures.

In addition to describing the steps to use the tool, this document also includes a basic background that provides context to the user on the topic of GHG emissions in the urban water sector. This approach is quite brief, but it can be consulted in more detail in another support document for ECAM: the **Methodology Guide**.

## Getting started as a new user

As a new user there are a few things you should **know and do** that will make your ECAM experience more effective:

- We encourage you to use spreadsheets to manage your input data. Input errors are easily made by users and will lead to incorrect results!
- Measurement units make all the difference. Use the correct unit. If necessary, it is possible to convert the units with the ECAM itself.
- If needed, there are other training materials that can enhance your ECAM experience.
- ECAM is available in both English and Spanish. Select the most convenient language for your use. Do not use automatic translation in your browser, as this may generate incorrect terms.
- Emission and country specific factors are under constant discussion and research, which means they can potentially change in the future. In this sense, when performing the exercises in this manual, cross-check the factors and, if necessary, change them before comparing the results.



# Background

## How are climate change and the urban water sector related?

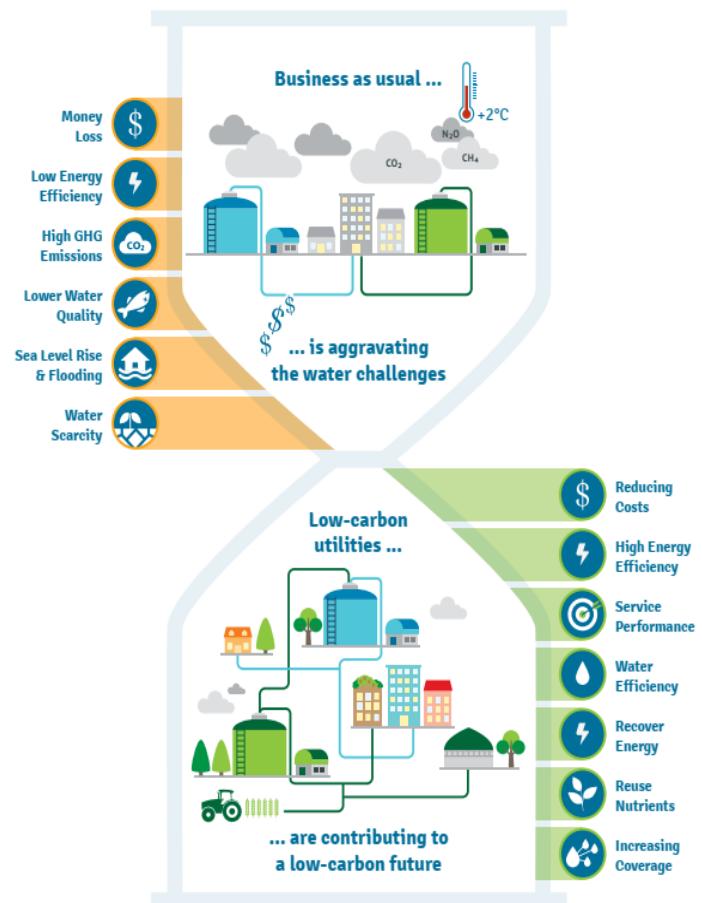
The impacts caused by climate change should be considered during design, construction, operation, and maintenance of the urban water sector infrastructure. These **impacts include**:

- Increased variability and uncertainty in hydrological cycles.
- Prolonged droughts and frequent flooding.
- Extreme hydrometeorological phenomena.
- Sea level rise.
- Increased evaporation and decreased precipitation rates accompanied by higher water extraction rates.

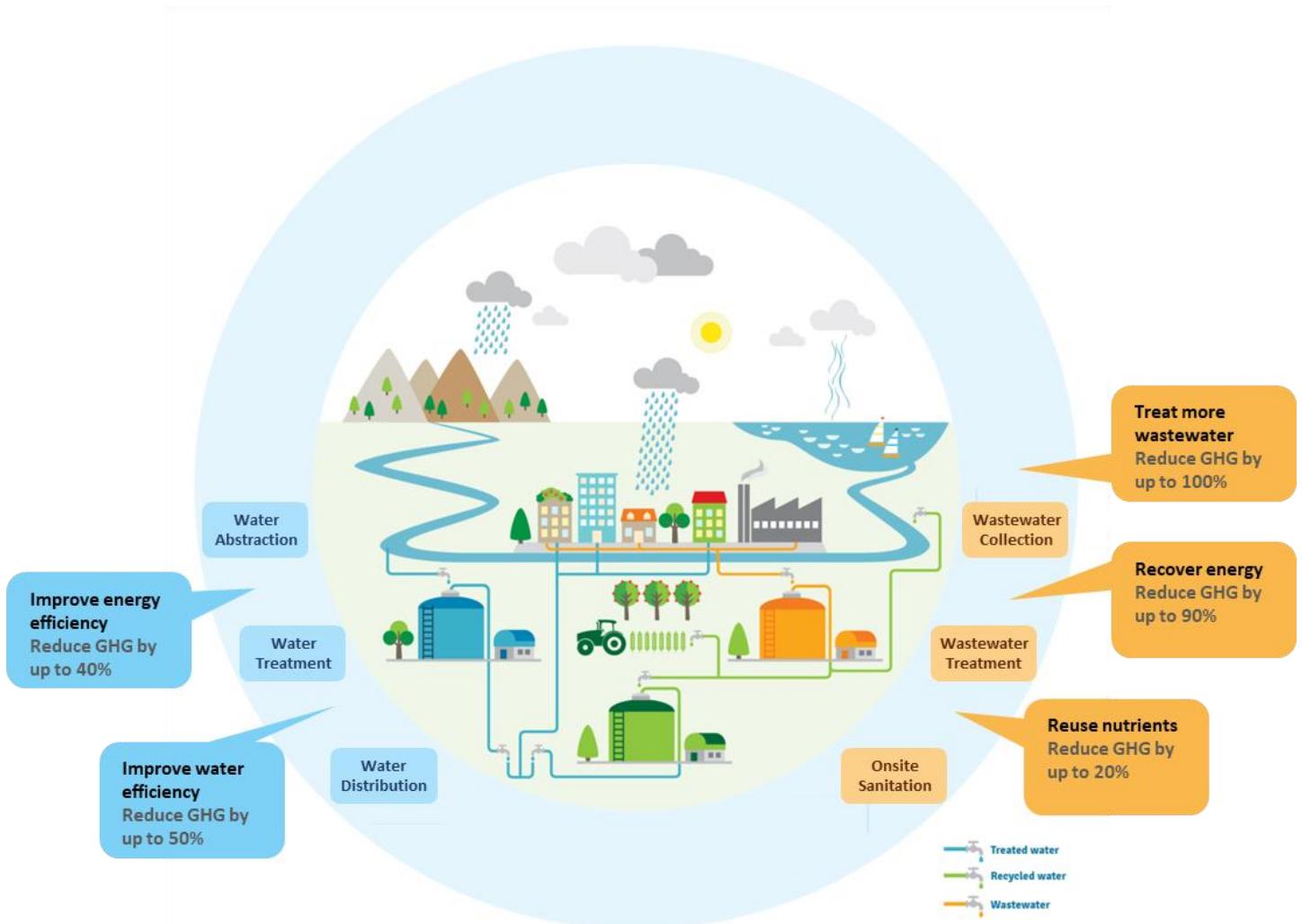
Along with pollution, the effects of climate change fall on the availability and quality of water sources for human consumption. In this sense, urban water utilities face increasing treatment requirements, while having to deal with structural damage caused by extreme weather.

From another perspective, the operation of urban water systems contributes to the generation of greenhouse gases (GHG) emissions, either directly or indirectly. These gases are the main drivers of climate change, which increases the occurrence of extreme events and hinders the availability of natural resources. Therefore, **the relationship between climate change and urban water utilities is cyclical and mutually impacting**.

In this context, business as-usual is no longer a viable option: utilities are challenged to adapt to impacts of climate change but also to champion the transition to a carbon-neutral future, to avoid compounding their challenges.



There is therefore a great opportunity to promote better planning of the urban water services. This also means creating mitigation strategies for GHG emissions within the operation of facilities, ensuring the sustainability of the services and benefiting human life.



- The urban water sector contributes **directly** and **indirectly** to the generation of GHG.
- GHG are the main drivers of climate change, which **increase the occurrence of extreme events** and **reduces the availability of resources**.
- The **greater occurrence** of extreme events and issues related to the resources **impact the urban water sector**.

## Which methodology does ECAM use to account for GHG emissions?

The ECAM tool was developed to be consistent with the **Intergovernmental Panel on Climate Change (IPCC)** Guidelines for National Greenhouse Gas Inventories, including the IPCC 2019 refinement and peer-reviewed literature. The 2019 Refinement (IPCC, 2019) does not replace the original 2006 IPCC Guidelines (IPCC, 2006), but updates, supplements and elaborates it where gaps have been identified.

The IPCC Guidelines for National Greenhouse Gas Inventories have been used as the main reference for equations used to calculate the GHG emission from the different stages of the urban water cycle. In most cases the equations from the IPCC guidelines have been used directly, but in some cases alternate resources have been applied.

When actual data from the utility are not available, default values are set to calculate the GHG emissions. If in the assessment process real data are available, the user can change the default values and, in this way, increment the accuracy of the evaluation.

To consult more details about the conceptual framework of the ECAM tool, as well as the sources and equations used, we suggest accessing the **Methodology Guide** document.

## Which greenhouse gases are generated in urban water services?

The three main GHGs emitted from urban water services are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O).

### Carbon Dioxide (CO<sub>2</sub>)

Carbon dioxide is mainly associated with the burning of fossil fuels in stationary and mobile combustion engines. In the urban water sector, it is also the main GHG associated with the consumption of electrical energy from the grid. In many cases, the energy consumed is obtained from a traditional fossil fuel source, such as coal, oil or natural gas, and energy production from these sources generates carbon dioxide emissions. Water and Sanitation utilities encompass high energy-intensive processes, which makes this a significant emission to be considered.

Carbon dioxide can also be emitted from biogenic sources, i.e., emissions related to the natural carbon cycle, as well as those resulting from the combustion, harvesting, digestion, fermentation, decomposition, or processing of bio-based materials. These emissions are not considered in the ECAM tool, and further discussion is given in the document **Methodology Guide**.

### Methane (CH<sub>4</sub>)

Methane is a gas generated by methanogenesis of organic matter under anaerobic conditions. These conditions can be present in wastewater and sludge. The amount of this gas generated is related to the amount of organic matter and the temperature.

Methane emissions from wastewater treatment can make up a significant portion of a Wastewater Treatment Plant (WWTP) carbon footprint. It also escapes from digested sludge storage facilities.

Methane could also be generated in flowing closed sewers, which is not considered in the ECAM tool. Further discussion is given in the document **Methodology Guide**.

### Nitrous oxide ( $\text{N}_2\text{O}$ )

Nitrous oxide, on the other hand, is a GHG associated with the degradation of nitrogenous compounds present in wastewater, such as urea, nitrate, and proteins. Its production is associated with nitrification and denitrification processes. Both processes can occur in a WWTP and in the water body into which the treated and untreated wastewater is discharged.

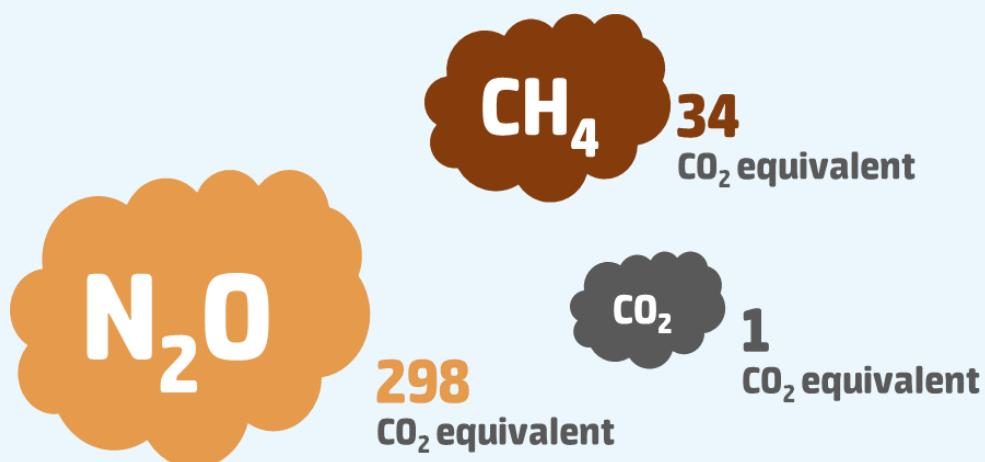
In WWTP, the highest production of nitrous oxide is generally associated with aeration processes, but it also occurs in other units, such as sludge recirculation, digester sludge, pre-treatment, effluent, and secondary clarifiers.

The generation of  $\text{N}_2\text{O}$  is a very complex process to properly estimate/quantify emissions. In the past, the UNFCCC did not consider WWTPs as relevant sources and further research is still being conducted to properly determine oxide nitrous emissions in wastewater treatment plants. Further discussion is given in the document **Methodology Guide**.

### Different gases, different Global Warming Potential (GWP):

The reporting unit of emissions results is expressed as the mass (tons, gigagrams, megatons) of the emitted gas, converted to its  $\text{CO}_2$  equivalent, that is, expressed in  $\text{CO}_2$  equivalent ( $\text{CO}_{2\text{eq}}$ ).

This conversion is based on the Global Warming Potential (GWP) of the specific gas. The ECAM tool does this conversion automatically.



**Attention:** some gases have very high GWP, for example the N<sub>2</sub>O, and therefore small amounts of their emission are equivalent to large amounts of CO<sub>2eq</sub>.

## Which terms should I know before using the tool?

There are some essential terms that need to be known for the user to understand this manual and the basic functions of the ECAM tool. For additional terms, see the "**Glossary**" topic at the beginning of this document.

<b>Activity data</b>	The activity data is information that can be related to the magnitude of a human activity resulting in emissions or removals taking place during a given period. Some examples include population; energy consumption from the grid; fuel consumption; BOD load; etc.
<b>Benchmark</b>	Objective comparison of utilities or facilities.
<b>Code</b>	In ECAM, a code is a name associated with a variable, which is used by the tool's algorithm for calculations. Example: "wwt_serv_pop" is the code for Serviced Population with wastewater treatment.
<b>Direct emissions</b>	Emissions originated from sources owned (or controlled) by the utilities. Some examples are CO <sub>2</sub> emissions from in-situ engines and CH <sub>4</sub> and N <sub>2</sub> O emissions from wastewater treatment plants.
<b>Dropdown menu</b>	Selectable list in ECAM, based on a reference table.
<b>Emission Factors</b>	A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.
<b>Indirect emissions</b>	Emissions derived from the acquisition of electrical or thermal energy, consumed by the utility. It also includes emissions that the utility considers that are not part of its operations, such as CH <sub>4</sub> emissions from wastewater generated by the population not connected to the sewer system.
<b>Inputs</b>	It includes both the activity data that must be added by the user and the estimates calculated by the software (or calculated by the user). It also includes data chosen from dropdown menus.
<b>Inventory</b>	List of emission sources and the associated emissions quantified using standardized methods.
<b>Outputs</b>	Results of calculations performed by ECAM for GHG emissions and for Energy performance and Service Level indicators.
<b>Stages</b>	It refers to "Water Abstraction", "Water treatment", "Water Distribution", "Wastewater Collection", "Wastewater Treatment", and "Onsite Sanitation".
<b>Substages</b>	It refers to the facilities that are to be evaluated in each of the stages.  It may be necessary to adapt them according to what you want to evaluate. For example: if the user needs to calculate the GHG emissions of a water pumping facility in the "Abstraction" stage, the substage will be the water pumping facility; if the user wants to evaluate the individual efficiency of the pumps in this system, each equipment must be a substage.
<b>Systems</b>	It refers to "Water Supply" and "Sanitation".
<b>Variable</b>	Field name of an element used for ECAM calculations, whether in the Input section or Output section. Example: Serviced Population with wastewater treatment.

## Which emissions can I calculate with ECAM?

*Table 1 – List of emissions that can be calculated with ECAM, categorized according to the ECAM standard names for the urban water cycle stages.*

Emissions calculated by ECAM <sup>2</sup>	Water supply			Sanitation		
	Abstraction	Treatment	Distribution	Collection	Treatment <sup>3</sup>	Onsite Sanitation
<b>Direct emissions</b>						
CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O from onsite engine stationary fossil fuel combustion.	●	●	●	●	●	●
CH <sub>4</sub> from sewers or biological wastewater treatment.				●	●	
N <sub>2</sub> O from sewers or biological wastewater treatment.				●	●	
CH <sub>4</sub> and N <sub>2</sub> O from collected wastewater discharge without treatment.				●		
CH <sub>4</sub> and N <sub>2</sub> O from collected treated wastewater discharge.					●	●
CH <sub>4</sub> and N <sub>2</sub> O from sludge digestion.					●	●
CH <sub>4</sub> from faecal sludge containment.						●
CH <sub>4</sub> and N <sub>2</sub> O from faecal sludge treatment.						●
N <sub>2</sub> O from open defecation.						●
<b>Indirect emissions</b>						
CO <sub>2</sub> from grid electricity usage.	●	●	●	●	●	●
CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O from the combustion of fossil fuels in vehicles.			●		● <sup>4</sup>	●
CH <sub>4</sub> and N <sub>2</sub> O from sludge and faecal sludge management. <sup>5</sup>					●	●

<sup>2</sup> Further specifications on these emissions and a list of emissions that CANNOT be calculated by ECAM can be checked in the **Methodology Guide**.

<sup>3</sup> In ECAM, it includes emission from wastewater treatment and discharge.

<sup>4</sup> It includes emissions from sludge transport, but which are accounted in "sludge management"; and emissions from truck transport of reused water.

<sup>5</sup> In the case of wastewater treatment, it includes storage at WWTP (direct emission), transportation, and off-site final disposal. In the case of on-site sanitation, it includes transportation and final disposal.

# Using ECAM

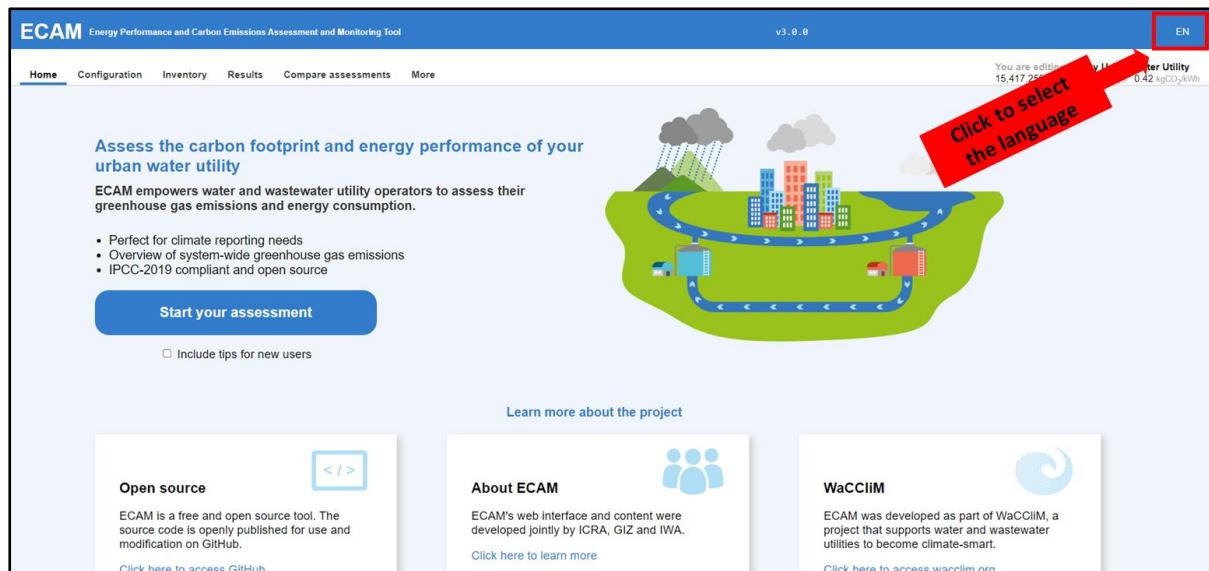
This topic presents the ECAM's features and how to use each one. The subtopics are divided according to the structure of the ECAM tool.

## Section 1: Configuration

### Select the language

The first thing you will probably feel the need to do is to select your preferred language.

ECAM currently has two language versions: **English** and **Spanish**. Click on the indicated location to select the language.

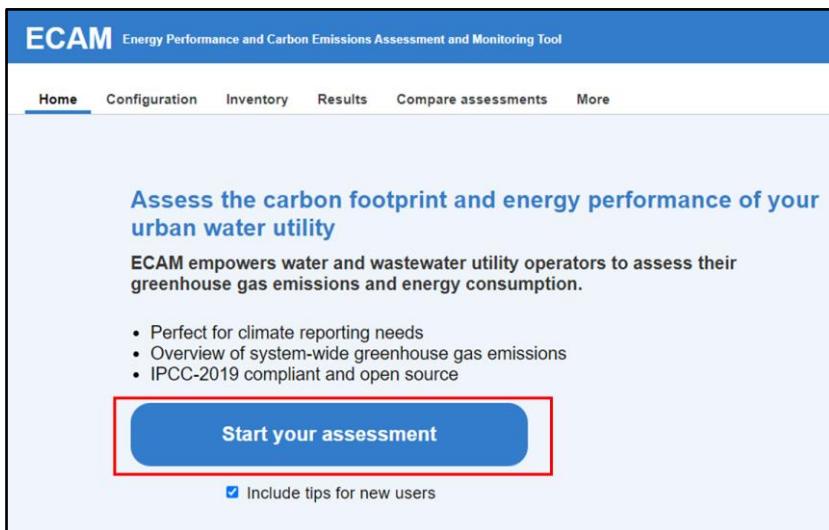


**Attention:** The use of automatic translation tools associated with the internet browser is strongly contraindicated, as it may lead to the use of incorrect terms.

### How to start and configure a new assessment

#### *Setting the main functions*

Click on the “Home” tab and access the “Start your assessment” option.



This will lead you to the **Configuration tab**, where the user can choose the Global Warming Report, and select country, evaluation period, file name, and currency.

Each of these functions should be chosen with care, since they will influence the entire assessment performed by the ECAM tool. However, the inputs can be also adapted subsequently. In the Configuration tab it is also possible to add comments for the assessment.

## Reference GWP Report

Global Warming Potential (GWP) is the ratio of how many times a specific gas emitted is more potent than carbon dioxide (CO<sub>2</sub>) in the ability to generate global warming. It is expressed as units of "CO<sub>2</sub> equivalent (CO<sub>2eq</sub>)" (see also page 9).

You must select the IPCC GWP Report that you want to use as a reference to convert your CH<sub>4</sub> and N<sub>2</sub>O emissions to equivalent CO<sub>2</sub> emissions. **It is suggested to always use the most recent report.** But you may need to use an older version for comparison purposes, or as required by your institution.

#### Assessment name

You can select a name for your assessment. It is important that this name represents the scope of your analysis/inventory so that it is easier to use in future comparisons. For example, to differentiate two assessments of the same wastewater treatment plant, but with different technology solutions, you may want to add an additional identification in the title: "WWTP Central (activated sludge)" and "WWTP Central (UASB)".

#### Assessment period

The ECAM tool calculates the number of days from the start date to one day before the selected end date. In this sense, to consider a full complete year, the user must **select January 1st of the corresponding year as the start date, and January 1st of the following year as the end date**. The tool will also calculate for leap years.

<p>change assessment name</p> <p><b>Assessment period</b></p> <p>From: 01/01/2019 To: 31/12/2019 364 days</p>	
<p>change assessment name</p> <p><b>Assessment period</b></p> <p>From: 01/01/2019 To: 01/01/2020 365 days</p>	

The assessment period must be selected by the user based on the data that will be input into the tool. In this sense, all data will be associated with this period. For example: the user selects assessment period from 01/01/2019 to 01/01/2020. When filling in the energy consumption from the grid (kWh), the user must consider a consumption referring to the corresponding Assessment Period. In other words, the consumption during the 365 days included in 2019.

If the assessed period is less than one year, the ECAM emissions can be displayed for the chosen period or yearly. See topic "**How to show outputs**" for that.

#### Selection of the country

With this option you can select the country where your system is located. This selection is important since it defines the first four general factors, which will be used to **calculate emissions** and **estimate activity data** in the inventory tab.

### ***Choosing the general factors***

As stated in the previous topics, the selection of the IPCC GWP Report defines the conversions of quantified GHGs to CO<sub>2eq</sub>, while the selection of the country defines the first four "General factors"<sup>6</sup>: (1) **currency**; (2) **emission factor for grid electricity**; (3) **annual protein consumption per capita**; and (4) **BOD<sub>5</sub> generation** (wastewater). The next three factors have default values adopted by the ECAM tool, they are: (5) **industrial and commercial co-discharged protein into the sewer**; (6) **non consumed protein added to the wastewater**; and (7) **additional nitrogen from household products added to the wastewater**.

The screenshot shows the ECAM Configuration interface. At the top, there are tabs for Home, Configuration, Inventory, Results, Compare assessments, and More. The Configuration tab is selected. In the top right corner, there is a status bar showing 'Tool name: WaCCliM Sunny Urban Water Utility' and some numerical values. Below the tabs, there is a 'Configuration' section with a 'Load and save file' area and a 'List of assessments' area. The 'List of assessments' area shows a single entry for 'Sunny Urban Water Utility' with details like Assessment period (2019-01-01 to 2020-01-01), GHG (kgCO<sub>2eq</sub>) (14,885,835), Energy (kWh) (2,390,100), Substages (7), and Options (settings, duplicate). Below this, there is an 'Assessment period' section with date inputs. The main focus is on the 'General factors' section, which is highlighted with a red box and a red arrow pointing to it. This section contains numbered steps (1-7) corresponding to the factors listed in the text above. Step 1 is 'Country' (Select United States of America). Steps 2-4 are dropdown menus: 'Currency (3 letters code)', 'Emission factor for grid electricity', and 'Annual protein consumption per capita'. Steps 5-7 are input fields with placeholder values: 'BOD<sub>5</sub> generation (wastewater)', 'Industrial and commercial co-discharged protein into the sewer', and 'Non consumed protein added to the wastewater'. To the right of these fields are their respective units: 'kgCO<sub>2</sub>/KWh', 'kg/person/year', and 'kgN/kgN'. At the bottom of this section is a blue 'Access inventory' button.

Most of these<sup>7</sup> are all defined based on the IPCC Guidelines (2006 and 2019) and will be used for later calculations by the tool. You can keep the adopted values, or you can modify them by values of your own or from pertinent literature. In this case, expert judgement is recommended to proceed.

The following considerations regarding the exchange of these values by the user must be considered:

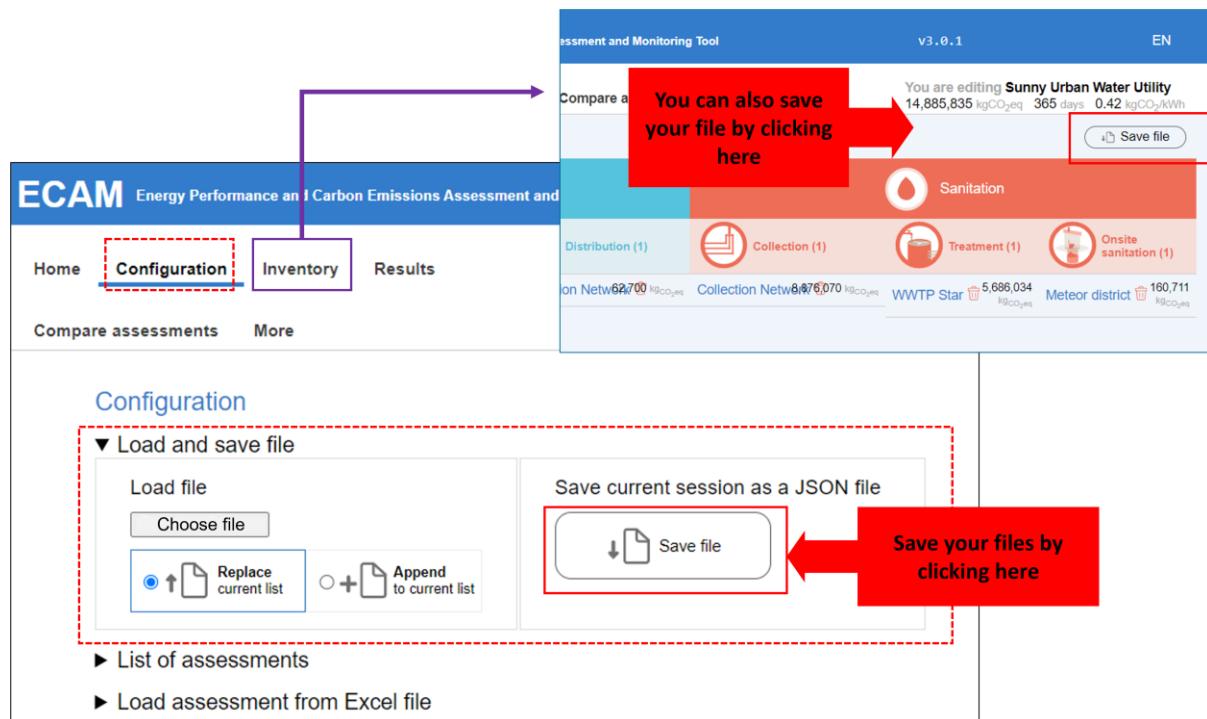
<sup>6</sup> It may be interesting for the user to modify these factors. Check the “Methodology Guide” document for more information.

<sup>7</sup> The exceptions are the **grid electricity fator** and the **annual protein concumption per capita**. Check the Methodology Guide for details on the sources of each one of them.

- Factor (1) refers only to the currency of the country. It is recommended for the user to modify it **only if there is apparently an error** by the tool.
- Factors (2), (3) and (4) are automatically selected by ECAM referring to tables based on the selected country. Modify these values only if you have **more updated values, from reliable methodology, or that are official in your country**. You might also check the Methodology Guide. Local factors (with a robust and reliable methodology) should be prioritized since they better represent the characteristics of the region's population.
- Factors (5), (6) and (7) are values that depend on conditions associated with each country's sanitation system. In ECAM, **the same default values are adopted for all countries**. Consult the Methodology Guide if you wish to modify them based on the IPCC. You can also use local values from a robust and reliable methodology.

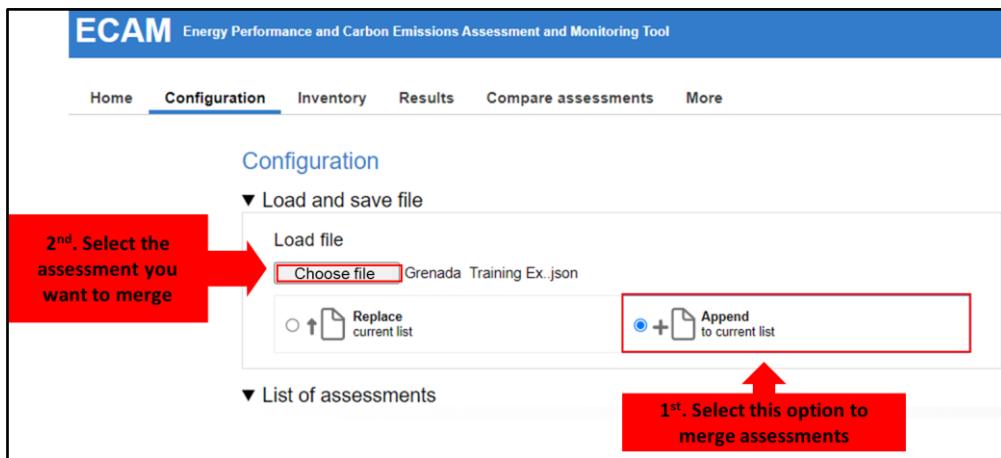
## Save, Load, and Merge assessments

While in the "Configuration" tab, select "load and save file".



The files are saved with the extension JSON. The ECAM tool does not store your information, so if you want to save your assessment progress it is highly recommended that you do so. If you refresh the webpage, the tool will delete all data and calculations performed. You can also save the file from the Inventory Tab.

If you already have a JSON file, you can load it as well. You can merge multiple JSON files into one file by using the button 'Append'.



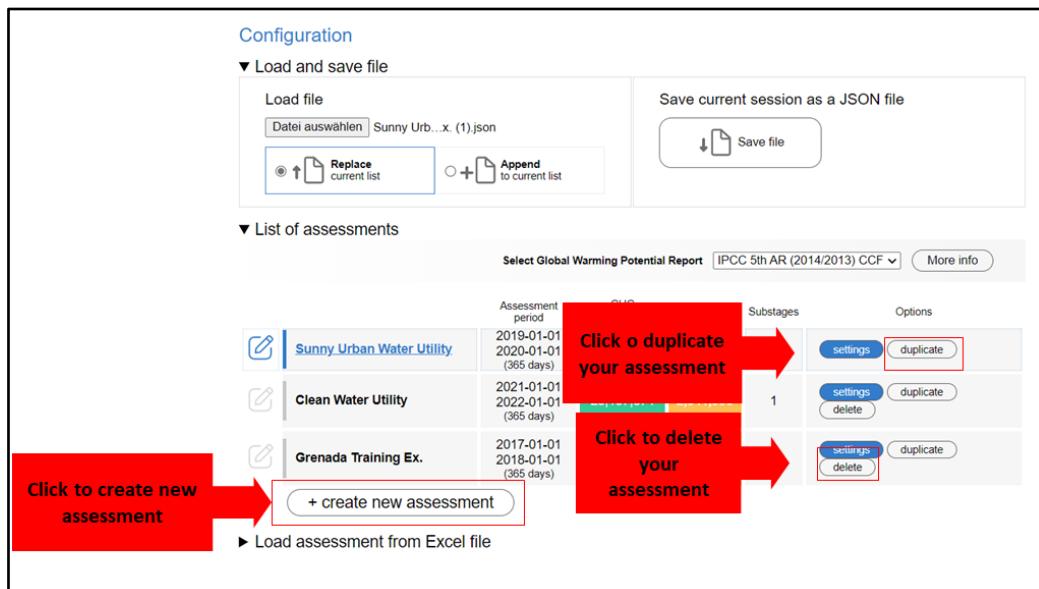
## How to create multiple assessments

One of the options to start evaluating more than one assessment is by using the "Load" option as seen before. But the user may also want to create more assessments from scratch.

In "**List of assessments**", you can create an assessment by clicking in "**+ create new assessment**" and you can duplicate one by clicking on the button "**duplicate**".

You can use the duplicate feature if you want to create multiple assessments where most inputs remain the same, but only a few of the inputs need to be adapted. This is the case, for example, when you are evaluating a complete sanitation system and would like to change just the treatment technology for comparison. Comparing assessments is addressed in topic **Comparing assessments**.

You can delete an assessment by clicking "**delete**". Be aware that it is only possible to delete an assessment if it is not selected for editing.



You can only edit one assessment at a time. Click on the assessment that you would like to edit. It will turn blue once you have selected it. If you want to unfold country specific information, click on the assessment again or on the button 'settings'.

The process of creating new assessments can be useful in the following cases:

- **Comparing the time evolution of a system.**
- **Comparing a baseline scenario with project intervention in a same stage.** For example: the exchange of a WWTP composed of lagoons for a new activated sludge system.
- **Comparing different intervention options for the same stage.** For example: we currently send sludge to landfill, but now we would like to check if it is better to compost it or use a sludge digester.
- **Comparing whole systems.** For example: a wastewater utility might want to compare the urban water system of two different cities. These systems would include sub-systems of several stages (collection + treatment + discharge).
- **Comparing solutions that involve more than one stage:** For example, the utility wants to compare the wastewater treatment of three different neighborhoods, but WWTP3 is also partially composed of on-site sanitation.
- And any other creative case the user may come up with!

## How to load data from excel files

While in the Configuration tab, you can also **load an assessment in an Excel format**. You can do it by accessing the option “**Load assessment from Excel file**”, and then choosing your file. Make sure you used the template provided in this space as a strict reference to allow data to be recognized.

The screenshot shows the ECAM Configuration tab interface. At the top, there are tabs for Home, Configuration, Inventory, Results, Compare assessments, and More. The Configuration tab is active. On the right, a message says "You are editing Sunny Urban Water Utility 14,885,835 kgCO2eq 365 days 0.42 kgCO2/kWh". Below the tabs, there's a "Configuration" section with a "Load and save file" panel containing "Load file" and "Save current session as a JSON file" buttons. A "List of assessments" table follows, showing three entries: "Sunny Urban Water Utility" (selected), "Clean Water Utility", and "Grenada Training Ex.". Each entry has columns for Assessment period, GHG (kgCO2eq), Energy (kWh), Substages, and Options (with "settings" and "duplicate" buttons). A "Select Global Warming Potential Report" dropdown is set to "IPCC 5th AR (2014/2013) CCF". At the bottom, there's a "Load assessment from Excel file" section with steps: "1. Download ECAM input template" (with a "Download 'ecam-template.xlsx'" link) and "2. Fill out template file.". A red arrow points from the text "Load your excel file according to the input template" to the "Fill out template file" step.

## Section 2: Inventory

### Systems and stages

The "Inventory" tab is the place where the user should input data, which will be used as a basis for the tool to calculate GHG emissions and efficiency indicators.

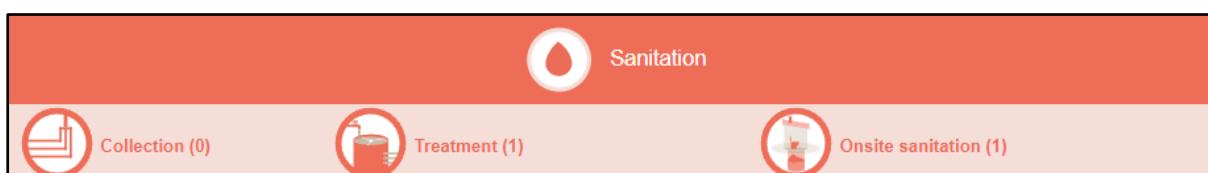
Two types of systems can be calculated by ECAM: **Water Supply** and **Sanitation**.

For "**Water Supply**", the tool calculates emissions for the following stages of the urban water cycle: **Abstraction**; **Treatment**; and **Distribution**.



- "Water Abstraction" refers to the process of extracting water from the water source, whether surface or underground. Emissions generated at this stage are mainly calculated based on energy consumption and water abstraction volume.
- "Water Treatment" is the stage that may take place in a Water Treatment Plant (WTP), where the physical, chemical, and bacteriological characteristics are corrected, making it suitable for consumption. Emissions at this stage are calculated primarily based on the volume of treated water and energy consumption data.
- "Water Distribution" is the final stage for Water Supply, in which treated water is transported from the WTP to storage tanks or directly to the final consumer. In this stage, emissions are calculated primarily based on the volume of water injected to distribution, and energy consumption data.

For "**Sanitation**", the tool calculates emissions for the following stages of the urban water cycle: **Collection**; **Treatment**; and **Onsite Sanitation**.



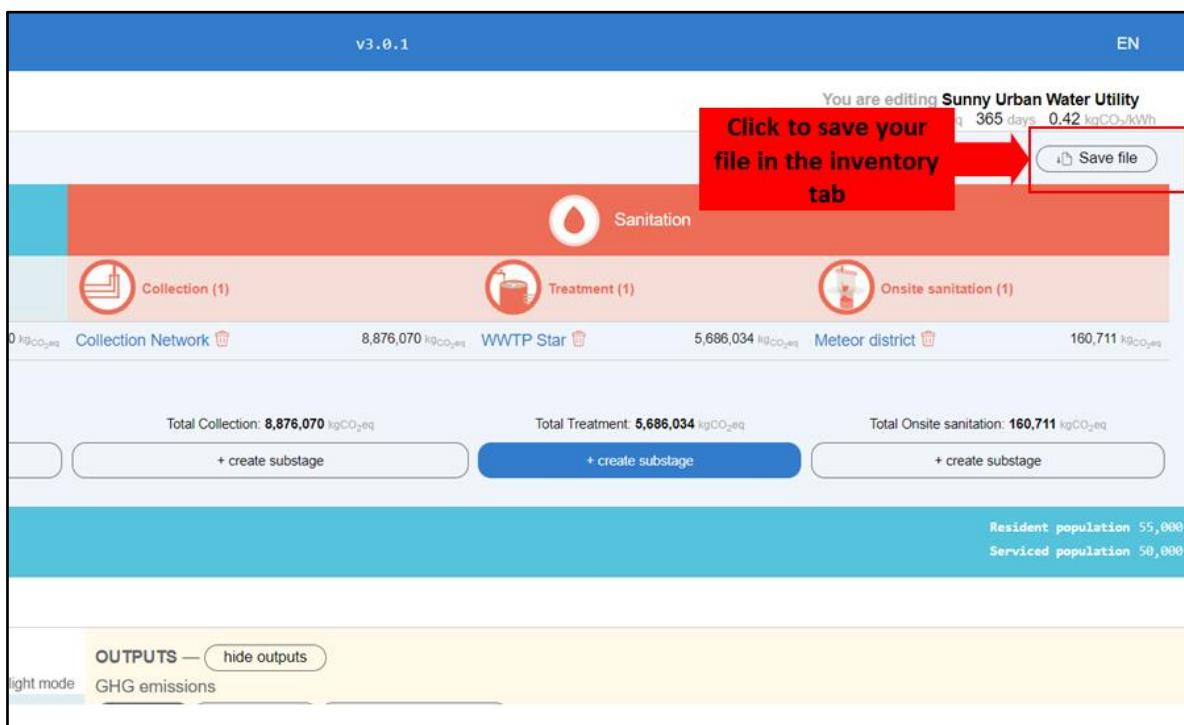
- "Sanitation Collection" is the stage in which there is collection of wastewater generated by the population connected to the sewage system, which also includes wastewater that will not be treated later and will be discharged directly into water bodies. The emissions of this stage are calculated by ECAM mainly from the loads of BOD and Nitrogen that enter the system, and the energy consumption.

- "Sanitation Treatment" is the stage of the urban water cycle in which collected wastewater is treated at the WWTP. In ECAM, this stage also includes wastewater that is discharged into water bodies after treatment. Emissions are calculated primarily based on data about the influent and effluent BOD and Nitrogen loads, and energy consumption.
- "Onsite sanitation" refers, in the ECAM tool, to the onsite treatment of faecal sludge, ie, at this stage, emission calculations are carried out for decentralized sanitation. GHG calculations are primarily based on data about influent and effluent BOD and Nitrogen loads, and energy consumption.

## How to save a file directly from the inventory

The user can also save an assessment directly from the inventory Tab.

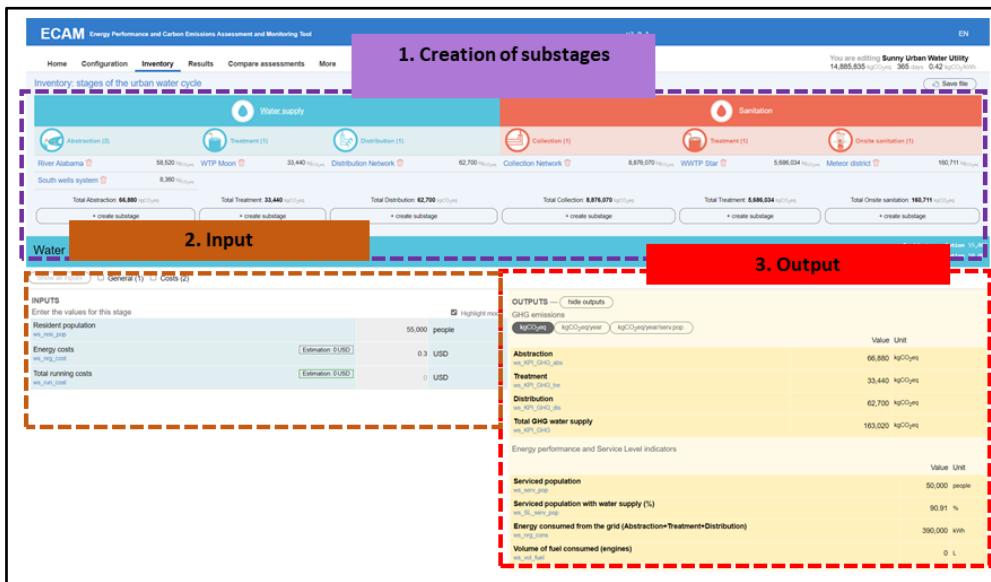
To do it, click on the "Save File" button in the top right corner of the tab.



## Inputs

### Where inputs are required

The Inventory tab has three important areas: the **first (1)** is the space for creating substages within the same assessment; the **second (2)** is the space for inputs; and the **third (3)** is the space for the outputs.



The **substages (1)** are created under each stage and represent the facilities to be evaluated. For example: if users want to calculate the emissions for two different water abstraction facilities, they should add 2 substages under "Abstraction" stage, naming them individually.

### When defining substages for pumping stations:

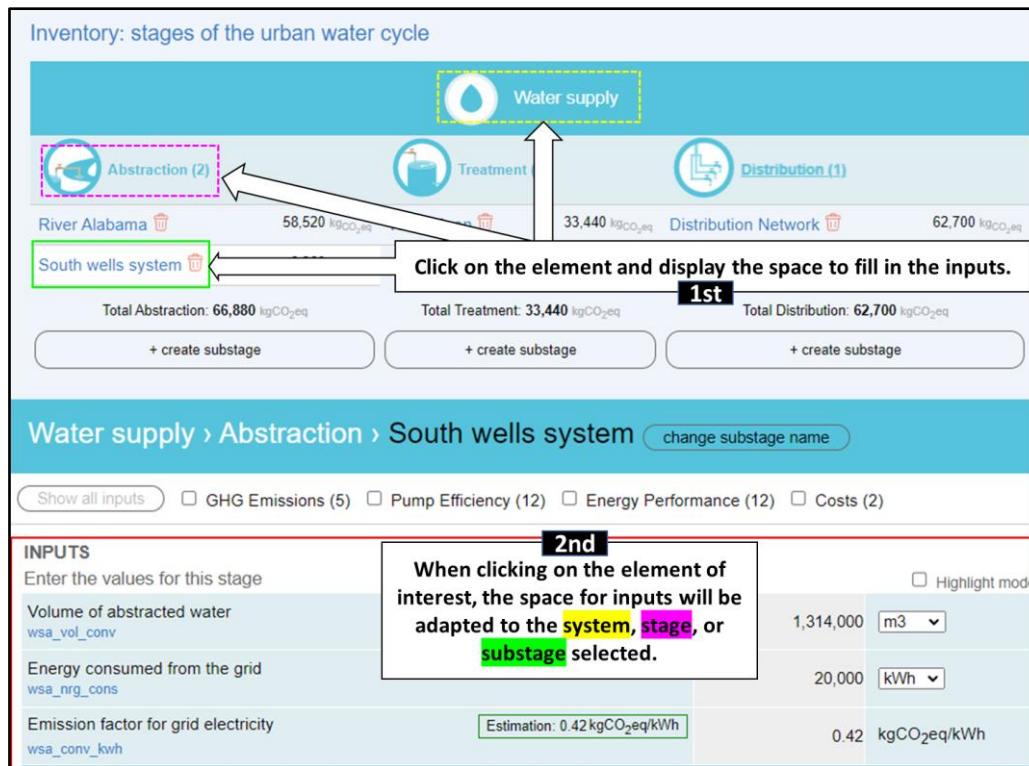
When having multiple water pumping stations or areas for the same or different water distribution systems, the best criteria to consider and define substages would be:

1. Adapt your substages according to data available and objectives of the assessment. For example, if the objective is to analyze the electromechanical efficiency of each pump separately, substage for each pump can be created. If the objective is to calculate the total emissions for the pumping station, just add one substage.
2. Make sure that you are not duplicating sources of emissions when considering pumping stations or volumes of water.

To create a substage, the user should click on “+ create substage”.



The "Inputs" section (2) is where the user must fill in the data of the selected system, stage, or substage. Each of these elements has a specific input area. To access them, click on the element you want to fill in the data.



If the user selects a substage, it will be possible to modify the name inside the input section. The names of the substages could be the names of the assessed facilities.

Inventory: stages of the urban water cycle

The screenshot shows the 'Water supply' stage of the urban water cycle. It includes three substages: 'Abstraction (2)', 'Treatment (1)', and 'Distribution (1)'. Under 'Abstraction (2)', there are two entries: 'River Alabama' (58,520 kgCO<sub>2</sub>eq) and 'South wells system' (8,360 kgCO<sub>2</sub>eq). Below these are summary totals: 'Total Abstraction: 66,880 kgCO<sub>2</sub>eq', 'Total Treatment: 33,440 kgCO<sub>2</sub>eq', and 'Total Distribution: 62,700 kgCO<sub>2</sub>eq'. There are buttons for '+ create substage' under each section. A red box highlights the 'change substage name by clicking here' button, which has a red arrow pointing down to the 'change substage name' button in the breadcrumb navigation bar below.

Water supply › Abstraction › South wells system

[change substage name](#)

Show all inputs  GHG Emissions (5)  Pump Efficiency (12)  Energy Performance (12)  Costs (2)

The process of creating substages and renaming them is done in the same way for all the stages of the urban water cycle.



Once an Input Section is opened, the user will find three types<sup>8</sup> of inputs:

- **User input:** Input activity data that must be filled in by the user.
- **Estimates:** Input activity data that can be estimated by the tool or filled in by the user. The estimations are based in user input data.
- **Dropdown menus:** Selectable list, based on a reference table.

<sup>8</sup> Access the Methodology Guide to understand how the ECAM tool proposes each estimate and what the sources for the dropdown menus are. From there, you could prefer to use your own data instead of the suggested ones.

**INPUTS**  
Enter the values for this stage

Volume of treated water <i>wst_vol_trea</i>	3,285,000 m <sup>3</sup>
Treatment type (potabilization chain) <i>wst_treatment</i>	(3) C/F/S/Filt/Des
Energy consumed from the grid <i>wst_nrg_cons</i>	80,000 kWh
Emission factor for grid electricity <i>wst_conv_kwh</i>	Estimation: 0.42 kgCO <sub>2</sub> eq/kWh 0.42 kgCO <sub>2</sub> eq/kWh

**User inputs** are identifiable because it is necessary to fill in some data. Dropdown menus have a clickable element that allows you to choose options based on a table. Estimates can be filled in by the user, or it is possible to click on the "Estimation" button.

Some input options include additional analysis on Energy performance and Service Level indicators. The user can select these options by clicking on "Yes" and then also fill in the available input fields.

Water supply > Treatment > WTP Moon [change substage name](#)

Show all inputs  General (4)  GHG Emissions (4)  Pump Efficiency (10)  Energy Performance (9)  Costs (2)

**INPUTS**  
Enter the values for this stage

Volume of treated water <i>wst_vol_trea</i>	3,285,000 m <sup>3</sup>
Treatment type (potabilization chain) <i>wst_treatment</i>	S/Filt/Des
Energy consumed from the grid <i>wst_nrg_cons</i>	80,000 kWh
Emission factor for grid electricity <i>wst_conv_kwh</i>	Estimation: 0.42 kgCO <sub>2</sub> eq/kWh 0.42 kgCO <sub>2</sub> eq/kWh
Do you have fuel engines?	<input type="radio"/> No <input checked="" type="radio"/> Yes
▼ Do you want to evaluate treatment performance?	<input checked="" type="radio"/> No <input type="radio"/> Yes
Percent of quality tests in compliance <i>wst_tst_carr</i>	0 %
Treatment capacity <i>wst_trea_cap</i>	0 m <sup>3</sup>
Do you want to evaluate pumping efficiency?	<input type="radio"/> Yes <input checked="" type="radio"/> No

**Fill in the user input data by clicking on it**

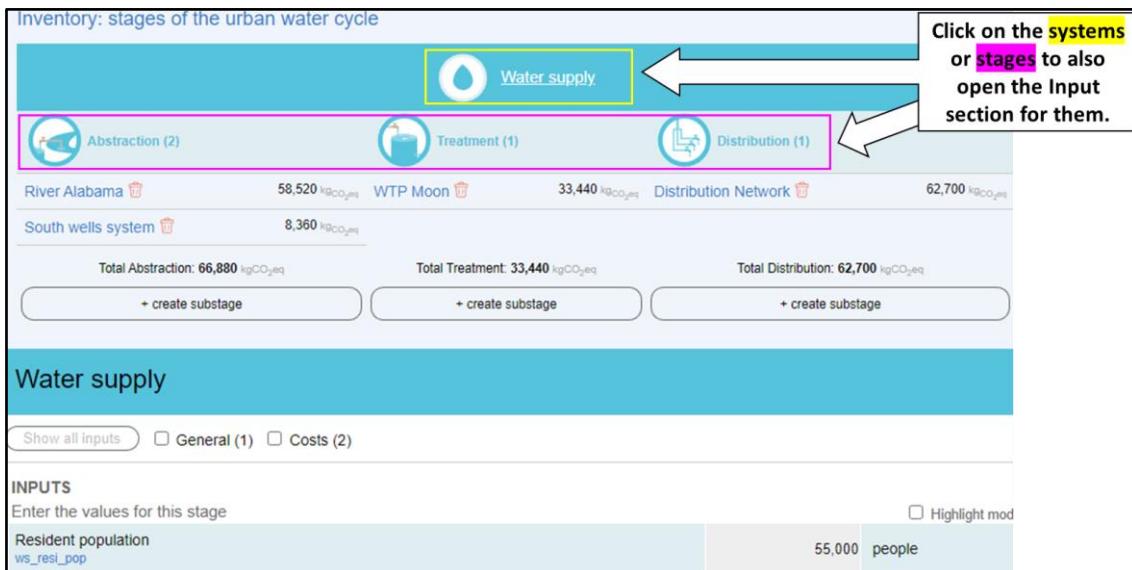
**Use the estimation option when necessary**

**Change the unit if necessary**

**Click on "yes" to open the option and fill in the optional inputs**

It is also possible to open the Inputs section for **systems** and **stages**, just clicking on them, as done with substages.

The information provided as inputs to systems and stages will not be used to calculate GHG Emissions by the tool, but only to calculate Energy performance and Service Level Indicators.



### How to use estimates in ECAM

Estimates are an option provided by ECAM to automatically fill some of the input fields. Some of them come directly from the GWP report selected in the configuration tab or from the country specific factors, while others are calculated based on other inputs<sup>9</sup>.

The calculated estimates are based on equations from the literature or the IPCC. However, the user can always choose to fill in the Input instead of using the estimation.

The "Methodology Guide" support document provides the sources for each of the estimates performed by ECAM.

Sanitation > Treatment > WWTP Star [change substage name](#)

Show all inputs  General (3)  GHG Emissions (31)  Pump Efficiency (10)  Sludge Management (41)  Energy Perf

**INPUTS**  
Enter the values for this stage

Serviced population wwt_serv_pop	50,000	people
Volume of treated wastewater wwt_vol_trea	3,650,000	m <sup>3</sup>
Volume of discharged effluent wwt_vol_disc	3,450,000	m <sup>3</sup>
Influent BOD <sub>5</sub> load	1,551,250	kg

Highlight mode

Note that if one of the inputs used by ECAM for estimation is not filled in, the tool will show the value "0" for the estimate. You can click on the estimate code to see which variables it is calculated from.

<sup>9</sup> The sources of each estimate and the formulas used by ECAM to calculate them are covered in the document "Methodology Guide".

## Outputs

### How to show outputs

The "outputs" are the results of the calculations performed by the ECAM tool. The outputs section (3) is on the right side of the inventory tab main page.

The screenshot shows the ECAM tool's user interface for urban water cycle inventory. It is divided into three main sections:

- 1. Creation of substages:** This section displays various stages of the urban water cycle: Water supply, Treatment, Distribution, Collection, Treatment, and Onsite sanitation. Each stage has associated values and a '+ create substage' button.
- 2. Inputs:** This section contains input parameters for a specific stage. It includes fields for population (500 people), BOD entering containments (15.513 kg), and a dropdown for flooding or infiltration.
- 3. Outputs:** This section presents calculated results. It includes a table for Energy Performance (23) and a table for GHG emissions. The GHG emissions table shows:

	Value	Σ sum (1 substages)	Unit
kgCO <sub>2</sub> eq	41.8	41.8	kgCO <sub>2</sub> eq
kgCO <sub>2</sub> eq/year			
kgCO <sub>2</sub> eq/year/servev.pop.			

It presents the calculated results in two categories:

- **GHG emissions**, which include all calculations related to the stages.
- **Energy performance and Service level indicators**, which include the optional analysis regarding the operational efficiency of the systems.

To show the outputs, click on the "**Show Outputs**" button. The results will be indicated by type of GHG emission and by type of indicator.

In the Output section it is also possible to modify the units of the results. If the period of assessment is less than 1 year, it is possible to select the unit **kgCO<sub>2</sub>eq/year** to extrapolate the results. However, the user must be aware that this will bring more uncertainty to the generated results.

Resident population 55,000  
Serviced population 50,000

General (10)  GHG Emissions (8)  Pump Efficiency (11)  Energy Performance (14)  Costs (2)

**Click on "show outputs" to display the outputs section**

**Choose from the available unit options.**

**OUTPUTS**

	Value	Σ sum (1 substages)	Unit
<b>Electricity (indirect)</b> wsd_KPI_GHG_elec	62,700	62,700	kgCO <sub>2</sub> eq
<b>Total GHG water distribution</b> wsd_KPI_GHG	62,700	62,700	kgCO <sub>2</sub> eq

Energy performance and Service Level indicators

	Value	Unit
<b>Energy consumption per volume injected to distribution</b> wsd_KPI_nrg_per_vd	0.048	kWh/m <sup>3</sup>
<b>Energy consumption per authorized consumption</b> wsd_KPI_nrg_per_m3	0.061	kWh/m <sup>3</sup>
<b>Non revenue water</b> wsd_SL_nr_water	5	%
<b>Water losses</b> wsd_SL_water_loss	21	%

### How to traceback a result using the highlight function

An option to visibilize the filling process by the user and the calculation by the tool is to turn on the **Highlight mode**.

The Highlight Mode displays the relationships between inputs and outputs, which can make it easier for the user to check for errors and where they come from. You can hover the outputs to check which inputs are required to calculate them and vice versa.

To activate this option, enter the "**Inventory**" tab and click on the "**Highlight mode**" option, which is next to the space dedicated to inputs.

**Inventory Results Compare assessments More**

urban water cycle

**Water supply**

Treatment (1)	Distribution (1)	Collection (1)
58,520 kgCO <sub>2</sub> eq WTP Moon	33,440 kgCO <sub>2</sub> eq Distribution Network	62,700 kgCO <sub>2</sub> eq Collection Network
8,360 kgCO <sub>2</sub> eq		
Total Treatment: 33,440 kgCO <sub>2</sub> eq	Total Distribution: 62,700 kgCO <sub>2</sub> eq	Total Collection: 8,874,884 kgCO <sub>2</sub> eq
+ create substage	+ create substage	+ create substage

Segment > WWTP Star [change substage name](#)

(3)  GHG Emissions (31)  Pump Efficiency (10)  Sludge Management (41)  Energy Performance (14)  Costs (2)

**Check the box to activate highlight mode.**

Highlight mode

Estimation: 3,650,000 m <sup>3</sup>	3,450,000 m <sup>3</sup>
Estimation: 3,450,000 m <sup>3</sup>	3,450,000 m <sup>3</sup>
Estimation: 1,551,250 kg	912,500 kg

**OUTPUTS — hide outputs**  
GHG emissions  
kgCO<sub>2</sub>eq kgCO<sub>2</sub>eq/year kg

**Electricity (indirect)**  
[wwt\\_KPI\\_GHG\\_elec](#)

**Fuel engines**  
[wwt\\_KPI\\_GHG\\_fuel](#)

**Treatment process**  
[wwt\\_KPI\\_GHG\\_tre](#)

This mode highlights the relationship between codependent inputs and outputs. With the mode on, placing the mouse over an Input will highlight related outputs. The same goes for clicking the mouse pointer over an output, which will highlight the inputs used for its calculation.

**Turn on highlight mode**

Highlight mode

**when you place the mouse pointer over an input ecam will show you a description of it and highlight the outputs related to it**

INPUTS	OUTPUTS — hide outputs
Resident population <a href="#">wwt_res_pop</a>	GHG emissions kgCO <sub>2</sub> eq kgCO <sub>2</sub> eq/year serv.pop.
Energy costs <a href="#">wwt_eng_cost</a>	Abstraction <a href="#">wwt_KPI_GHG_abs</a>
Total running costs <a href="#">wwt_run_cost</a>	Treatment <a href="#">wwt_KPI_GHG_tre</a>
	Distribution <a href="#">wwt_KPI_GHG_distr</a>
	Total GHG water supply <a href="#">wwt_KPI_GHG</a>
	Energy performance and Service Level indicators
	Serviced population <a href="#">wwt_serv_pop</a>
	Serviced population with water supply (%) <a href="#">wwt_serv_wat</a>
	Energy consumed from the grid (Abstraction+Treatment+Distribution) <a href="#">wwt_eng_cons</a>
	Volume of fuel consumed (engines) <a href="#">wwt_volt_fuel</a>

## How to see formulas, constants, and sources behind the equations

It may be interesting for the user to check the formulas, constants and sources behind an estimate or calculation of an output.

Below the name of each variable there is a **code**, which is unique and represents that variable in the software algorithm. To check the information behind this variable, just click on this code, which will be highlighted in blue.

INPUTS  
Enter the values for this stage  
Serviced population  
50.000 people

Outputs —  Hide outputs  
GHG emissions  
kgCO<sub>2</sub>eq kgCO<sub>2</sub>eq/year kgCO<sub>2</sub>eq/year/serv.pop.  
Abstraction  
ws\_KPI\_GHG\_abs

Clicking on the code will take you to a section called "**Detailed info**". The information on this page depends on the type of variable being checked.

**User inputs:** the detailed info will show a description for the variable and the outputs that use it for calculation. You can check related outputs detailed infos by clicking on their codes.

Detailed info → ws_d_serv_pop	
Serviced population	
Stage	— Water supply / Distribution
Description	Serviced population is referred to the number of inhabitants, within the area of service managed by the utility, which are connected to the distribution system and are receiving the service
Type	Input
Current value	<p>Distribution Network</p> <p>50000 people</p> <p>Value filled in by the user</p>
Magnitude	People
Outputs that use this variable	<p>ws_SL_auth_con 135.1 L/serv.pop./day</p> <p>ws_serv_pop 50,000 people</p> <p>Related outputs</p>

**Estimates (inputs):** detailed info will additionally show the formula used to estimate the input based on other inputs filled in by the user. You can click on the code of these inputs and go to their detailed info section. You can check related inputs and outputs detailed infos by clicking on their codes.

Influent BOD <sub>5</sub> load	
Stage	← Sanitation / Treatment
Description	BOD <sub>5</sub> load entering the WWTP during the assessment period. It can be estimated by multiplying the average BOD <sub>5</sub> concentration in the influent by the volume entering the plant. If this is done daily and summed over the duration of the assessment period the value will be most accurate
Reference	Equation 6.3. Total Organically degradable material in domestic wastewater • frontend/docs/2019-ipcc/v5_Volume5\19R_V5_6_Ch06_Wastewater.pdf#page=21
Type	Input
Current value	WWTP Star 912500 kg
Magnitude	Mass
Outputs that use this variable	wwt_KPI_GHG_tre ["4,817.082"] wwt_bod_rmvd ["775.625"]  wwt_bod_effl (drop-down selection)
Estimation of this input based on other inputs	<p>[*1,551,250"] kg</p> <pre>wwt_bod_infl(substage){     let P = substage.wwt_serv_pop; //population     let BOD = bod_pday; //g/person/day     return P * BOD * 0.001 * Days(); //kg }</pre> <p>Inputs involved Days 365 days bod_pday 85 g/person/day wwt_serv_pop [*50,000"] people</p>

Related outputs

Code / Formula

Inputs necessary to perform the estimation

**Dropdown menus (inputs):** detailed info will additionally display the table that makes up the menu options, as well as the source it is based on, which can also be consulted at the Methodology Guide support document. You can check related inputs and outputs detailed infos by clicking on their codes.

Total Nitrogen load in the effluent													
Stage	← Sanitation / Treatment												
Description	Total Nitrogen load in the effluent during the assessment period												
Reference	Table 6.10C from 2019 IPCC revision • frontend/docs/2019-ipcc/v5_Volume5\19R_V5_6_Ch06_Wastewater.pdf#page=21												
Type	Input												
Current value	WWTP Star 194942.0616000002 kg Primary + Secondary (biologi▼)												
Magnitude	Mass												
Data table used for suggestions All data tables	<p>WW treatment organics removal fractions (centralised) (Table 6.0B and 6.10C), Table 6.0B from 2019 IPCC revision Table 6.10C from 2019 IPCC revision</p> <table border="1"> <tbody> <tr> <td>name: Untreated systems</td> <td>bod_effl: 1</td> <td>N_effl: 1</td> </tr> <tr> <td>name: Primary (mechanical treatment plants)</td> <td>bod_effl: 0.8</td> <td>N_effl: 0.9</td> </tr> <tr> <td>name: Primary + Secondary (biological treatment plants)</td> <td>bod_effl: 0.15</td> <td>N_effl: 0.8</td> </tr> <tr> <td>name: Primary + Secondary + Tertiary (advanced biological treatment plants)</td> <td>bod_effl: 0.1</td> <td>N_effl: 0.2</td> </tr> </tbody> </table> <p>• table_field: function(){return 'N_effl' } • percent_of: function(stage){return stage.wwt_tn_infl} wwt_tn_infl [*324,903"] kg</p>	name: Untreated systems	bod_effl: 1	N_effl: 1	name: Primary (mechanical treatment plants)	bod_effl: 0.8	N_effl: 0.9	name: Primary + Secondary (biological treatment plants)	bod_effl: 0.15	N_effl: 0.8	name: Primary + Secondary + Tertiary (advanced biological treatment plants)	bod_effl: 0.1	N_effl: 0.2
name: Untreated systems	bod_effl: 1	N_effl: 1											
name: Primary (mechanical treatment plants)	bod_effl: 0.8	N_effl: 0.9											
name: Primary + Secondary (biological treatment plants)	bod_effl: 0.15	N_effl: 0.8											
name: Primary + Secondary + Tertiary (advanced biological treatment plants)	bod_effl: 0.1	N_effl: 0.2											

References

Option selected by the user

Table related to the dropdown menu

**Outputs:** detailed info from outputs will show the formula, the inputs used to calculate the output, the results, references, and other outputs using these results. You can check related inputs and outputs detailed infos by clicking on their codes.

Detailed info → <a href="#">wsd_KPI_GHG_elec</a>													
<b>Electricity (indirect)</b>													
Stage	← Water supply / Distribution												
Description	GHG indirect emissions from electricity												
Reference	Conversion from kWh to kgCO <sub>2</sub> eq using the emission factor for grid electricity												
Type	<p><b>Formula:</b></p> <pre>wsd_KPI_GHG_elec(){     let co2 = wsd_nrg_cons*wsd_conv_kwh;     let ch4 = 0;     let n2o = 0;     let total = co2+ch4+n2o;     return {total,co2,ch4,n2o}; }</pre> <p><b>Inputs involved</b></p> <ul style="list-style-type: none"> <li>wsd_conv_kwh [ "0.42" ] kgCO<sub>2</sub>eq/kWh</li> <li>wsd_nrg_cons [ "150,000" ] kWh</li> </ul>												
Current value	<table border="1"> <caption>Distribution Network</caption> <thead> <tr> <th></th><th>TOTAL</th><th>kgCO<sub>2</sub>eq</th></tr> </thead> <tbody> <tr> <td>CO<sub>2</sub></td><td>62,700</td><td>kgCO<sub>2</sub>eq</td></tr> <tr> <td>CH<sub>4</sub></td><td>0</td><td>kgCO<sub>2</sub>eq</td></tr> <tr> <td>N<sub>2</sub>O</td><td>0</td><td>kgCO<sub>2</sub>eq</td></tr> </tbody> </table>		TOTAL	kgCO <sub>2</sub> eq	CO <sub>2</sub>	62,700	kgCO <sub>2</sub> eq	CH <sub>4</sub>	0	kgCO <sub>2</sub> eq	N <sub>2</sub> O	0	kgCO <sub>2</sub> eq
	TOTAL	kgCO <sub>2</sub> eq											
CO <sub>2</sub>	62,700	kgCO <sub>2</sub> eq											
CH <sub>4</sub>	0	kgCO <sub>2</sub> eq											
N <sub>2</sub> O	0	kgCO <sub>2</sub> eq											
Magnitude	Mass												
Outputs that use this variable	<ul style="list-style-type: none"> <li>elec_GHG 999,062 kgCO<sub>2</sub>eq</li> <li>wsd_KPI_GHG [ "62,700" ] kgCO<sub>2</sub>eq</li> </ul>												

## Section 3: Results and assessments

### How to show the results

To show the results, the user should click on the "Results" tab. There will be sub-tabs to select from: Summary; Sankey diagram; or Report.

#### Summary

The results are displayed in the Summary sub-tab. In this tab you can select different ways **to display your assessment results**. You can choose between tables, bar charts and pie charts. To do that, just click on the selected option.

When selecting the table option, the user can **present the results** based on the GHG emission or also on the energy consumption in each created substages (when data were provided for such calculation). You can select the unit for both options. The table is intuitive and divided by systems and stages.

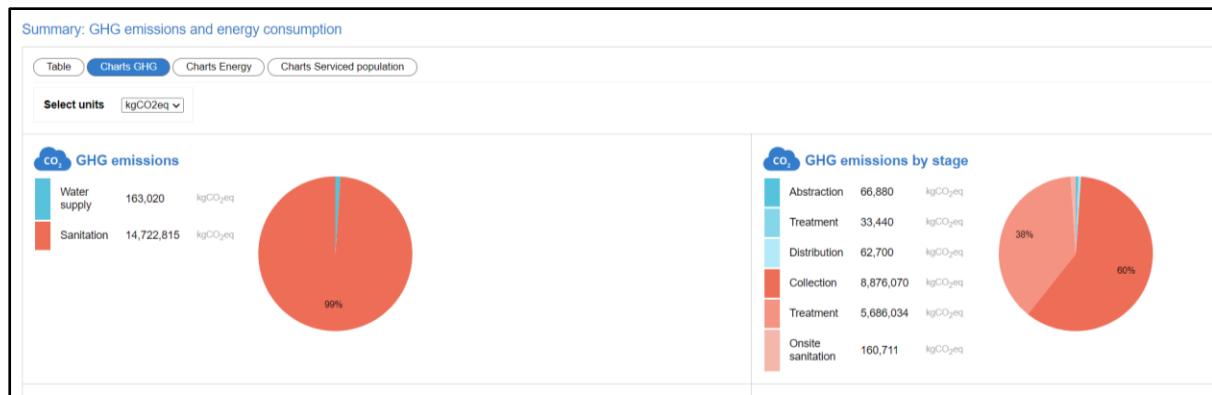
The standard for reporting emissions by the IPCC is CO<sub>2</sub> equivalent. However, it may be interesting for the user to display the emissions according to the specific gases. You can do this by selecting the option "**Show emissions in CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O**".

The screenshot shows the ECAM tool interface with the following details:

- Header:** ECAM Energy Performance and Carbon Emissions Assessment and Monitoring Tool, v3.0.1, EN.
- Top Navigation:** Home, Configuration, Inventory, **Results** (highlighted with a red box), Compare assessments, More.
- User Information:** You are editing Sunny Urban Water Utility, 14,885,835 kgCO<sub>2</sub>eq, 365 days, 0.42 kgCO<sub>2</sub>/kWh.
- Sub-navigation:** Summary (highlighted with a red box), Sankey diagram, Report.
- Section Title:** Summary: GHG emissions and energy consumption.
- Filter Options:** Table (highlighted with a red box), Charts GHG, Charts Energy, Charts Serviced population.
- Selection Options:** Select summary table (radio buttons for GHG and Energy), Show emissions in CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O (radio buttons for No and Yes, Yes is selected), Hide zero (0) values in results (checkbox checked).
- Table Headers:** Total (kgCO<sub>2</sub>eq), System (kgCO<sub>2</sub>eq), Stage (kgCO<sub>2</sub>eq), Emission source, Emission (kgCO<sub>2</sub>eq).
- Data Rows:**

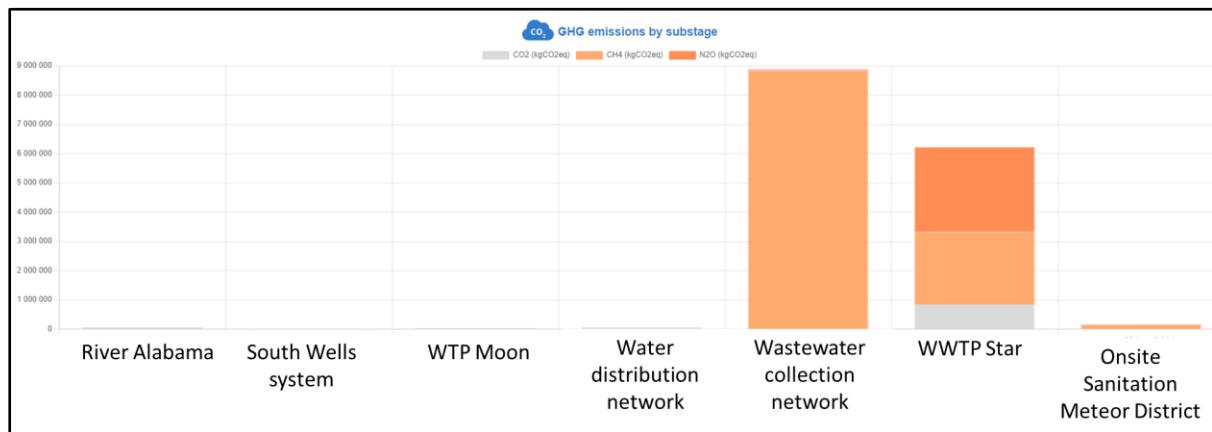
Total (kgCO <sub>2</sub> eq)	System (kgCO <sub>2</sub> eq)	Stage (kgCO <sub>2</sub> eq)	Emission source	Emission (kgCO <sub>2</sub> eq)
	Water supply 163,020		Abstraction 66,880	Electricity (indirect) 66,880
			Treatment 33,440	Electricity (indirect) 33,440
			Distribution 62,700	Electricity (indirect) 62,700

Another option is to **present the results as pie charts**. Graphs are generated by system, by emitted gas, and by stage.



A third option is the **bar charts**, which are just below the pie charts. The bar graphs present the results by substages created within the stages.

Note that bar graphs should be used with caution when substages have very different outputs. In the example below, the emissions from the water system are much lower than those from the sanitation system, which makes it impossible to visually compare water system emissions. If the user is going to present these results, it may be interesting to manually add also the analytical values found for each substage.



## Sankey Diagram

Another way to present results is using a **sankey diagram**.

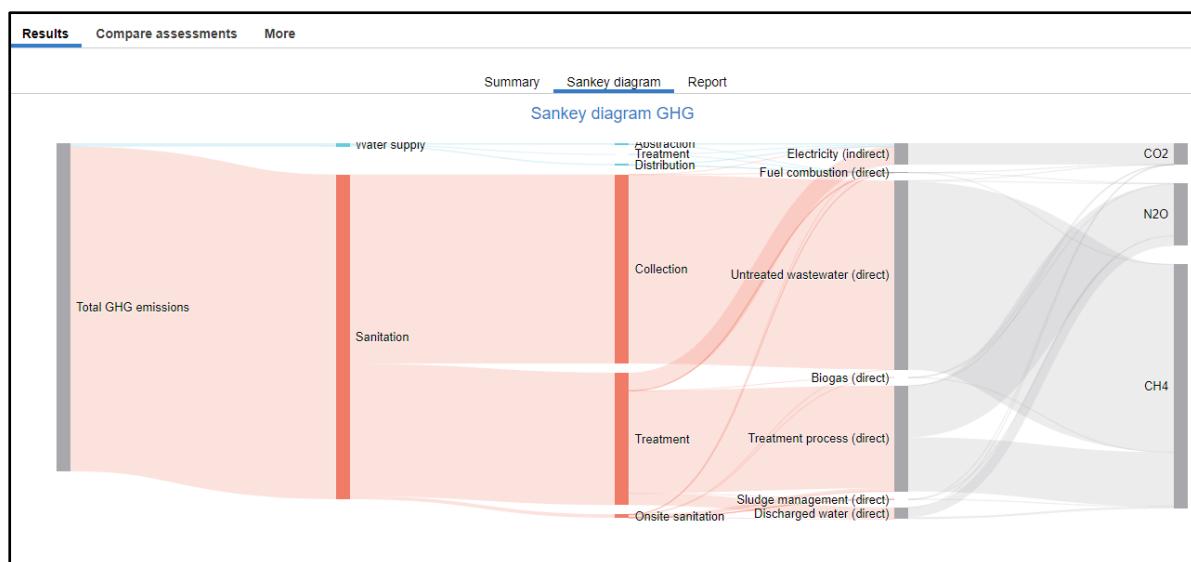
The Sankey Diagram presents the amount of GHG emissions as "flows" following the logic:

- The greater the thickness, the more GHG emissions were generated.

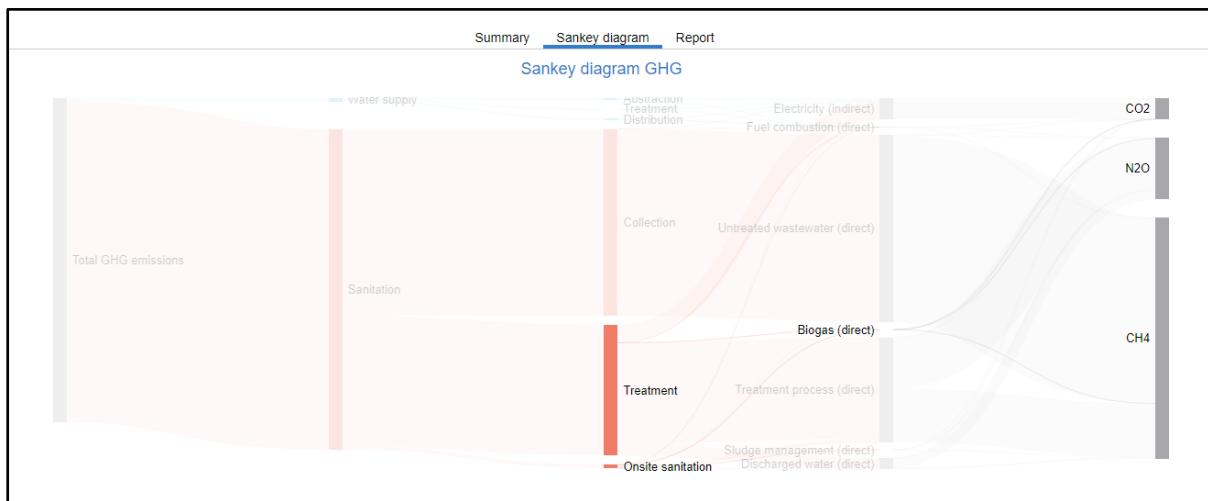
- Colored results refer to **total emissions in CO<sub>2</sub> equivalent**.
- The **black and white results** are the division of these emissions according to the **specific gases**.

Sankey diagrams allow you to show complex processes visually, with a **focus on a single aspect** that you want to highlight. They also support **multiple viewing levels**, as you can analyze the entire assessment in general, or focus on specific stages or specific emissions, or even on specific gases.

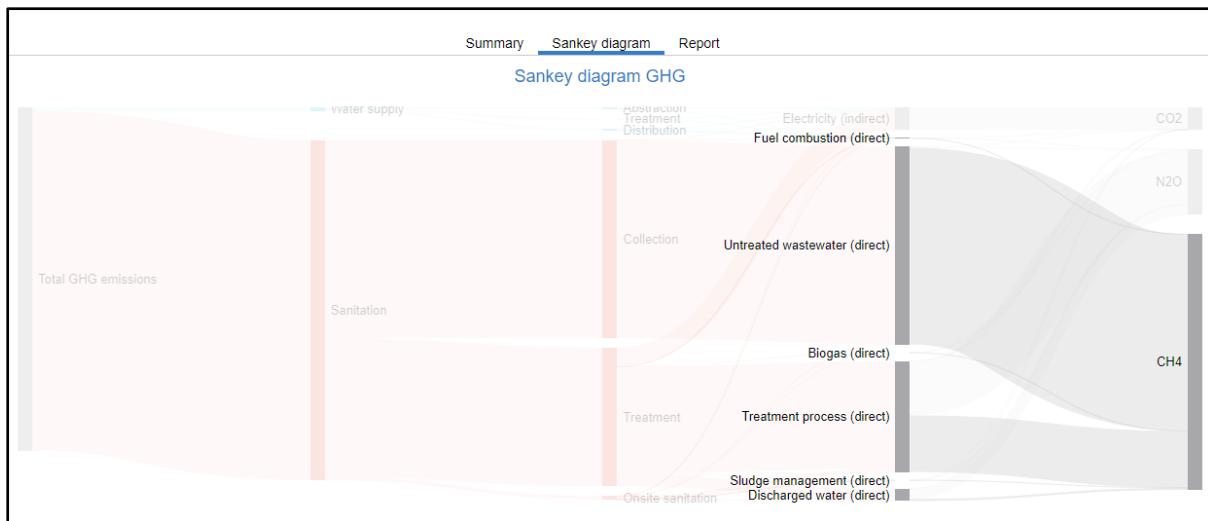
The example below shows the Sankey diagram of an urban water utility. Starting the reading from the left to the right, it is possible to see right away that the **Sanitation system generates much more emissions than the Water Supply system**. Apparently, the **largest** emissions are related to the **wastewater collection and wastewater treatment stages**. Remember that the amount is defined by the thickness of the flow, and that colored emissions are in CO<sub>2</sub> equivalent.



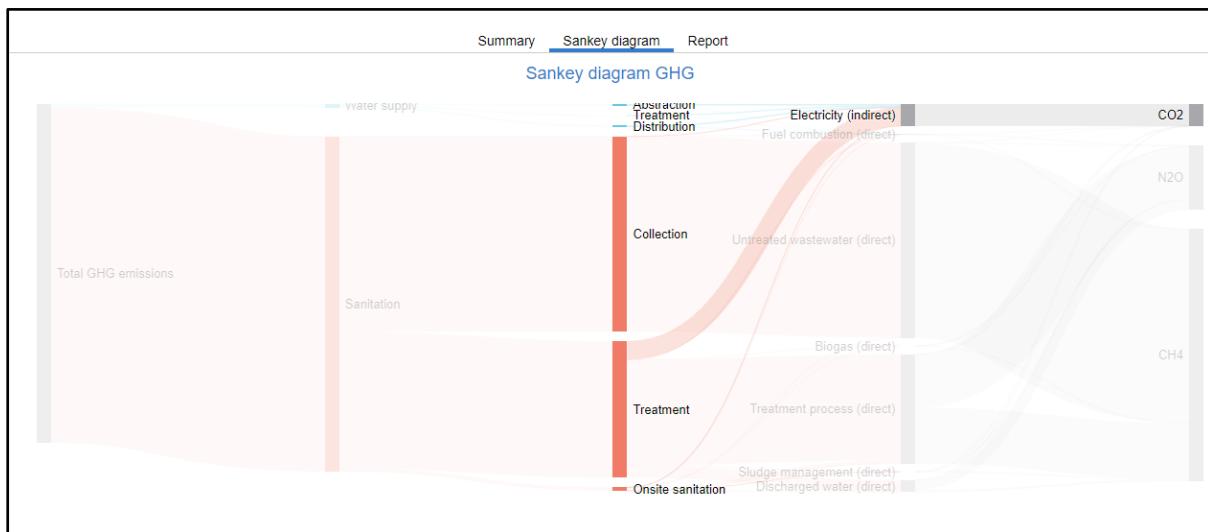
To analyze the diagram in multiple levels, it is necessary to **place the mouse pointer over the name** of which element you want to visualize and check its correlations. For example, by hovering over "**Biogas (direct)**" it is possible to verify that this type of emission comes from the wastewater treatment and onsite sanitation stages, when reading from the right to the left. Additionally, reading from left to right, biogas emissions are generating CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>, and it is not possible in this case to differentiate the quantities between them.



In another example, when hovering over CH<sub>4</sub>, we observe that most methane emissions come from wastewater collection. From this information, it is possible to search for additional information in other features of the ECAM tool.



As a last example, if we want to analyze emissions related to electricity, we should place the mouse over "**Electricity (indirect)**". It is therefore noted that most of these emissions come from the Wastewater Treatment stage, and that they are exclusively CO<sub>2</sub>.



## Report

In the Report sub-tab it is possible to access a **summary of all of the charts and diagrams** related to your assessment.

It also displays a **summary of GHG emissions by systems and stages**, as well as **energy consumption** for these elements.

All **inputs** and **outputs** of each created **substage** are also shown, which can be interesting to archive the background referring to your assessment. This way it will be possible to understand the results, look for possible errors, and even ensure that future discrepant results are justified.

There is also the option to hide input fields disabled in substages and to hide results equal to zero (0), which may be interesting to keep your report clearer and shorter.

It is possible to print your report clicking on "print report" option and saving it as a pdf.

**ECAM Energy Performance and Carbon Emissions Assessment and Monitoring Tool**

v3.6.1

You are editing: Sunny Urban Water Utility  
14,885,835 kgCO<sub>2</sub>eq 365 days 0.42 kgCO<sub>2</sub>/kWh

Home Configuration Inventory Results Compare assessments More

Summary Sankey diagram Report

Double-click the report to re-size/resize the printable view.

Hide optional input fields if they are disabled in all subtables  
 Hide zero (0) values in results

**ECAM Energy Performance and Carbon Emissions Assessment and Monitoring Tool**

Sunny Urban Water Utility

Assessment period: 2019-01-01 — 2020-01-01 (365 days)  
Country: United States of America  
Currency: USD  
Global Warming Potential Source: IPCC 5th AR (2014/2013) CCF

**SUMMARY**

Stage	GHG emissions	Energy consumption
Abstraction	66,869 kgCO <sub>2</sub> eq	180,000 kWh
Treatment	33,440 kgCO <sub>2</sub> eq	80,000 kWh
Distribution	62,700 kgCO <sub>2</sub> eq	150,000 kWh
Total Water supply	163,009 kgCO <sub>2</sub> eq	390,000 kWh
Collection	8,876,070 kgCO <sub>2</sub> eq	0 kWh
Treatment	5,688,034 kgCO <sub>2</sub> eq	2,000,000 kWh
Osmose sanitation	169,711 kgCO <sub>2</sub> eq	100 kWh
Total Sanitation	14,722,815 kgCO <sub>2</sub> eq	2,000,100 kWh
<b>Total</b>	<b>14,885,835 kgCO<sub>2</sub>eq</b>	<b>2,390,100 kWh</b>

**SUMMARY - Charts - GHG emissions**

**GHG emissions**

**GHG emissions by stage**

**Attention:** Remember that this option generates a document for visual presentation only. To save your data, use the **save as JSON option**, as previously explained in topic **Save, Load, and Merge assessments**.

## Comparing assessments

When the user is working with more than one assessment, there is an option to compare assessments. This option will generate a table comparing all the outputs and inputs of both assessments.

Select the assessments that you would like to compare with each other. Please note that the order of the selection determines the order of the compared assessments. For example, if you have 3 assessments for the years 2018, 2019 and 2020, you will need to select the assessments in this order. If you select 2019, 2020 and 2018, the order would be different.

**ECAM Energy Performance and Carbon Emissions Assessment and Monitoring Tool**

v3.6.1

You are editing: Sunny Urban Water Utility  
14,885,835 kgCO<sub>2</sub>eq 365 days 0.42 kgCO<sub>2</sub>/kWh

Home Configuration Inventory Results **Compare assessments** More

Overview Inputs & outputs Total GHG emissions Emissions by gas (CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>) Emissions by stage Total energy consumption

Compare assessments

Select the assessments to be compared:  
 Sunny Urban Water Utility  Clean Water Utility  Grenada Training Ex.

Select units:

Compare:  inputs  outputs

Hide zero (0) values in results

	Sunny Urban Water Utility	Clean Water Utility	Grenada Training Ex.
General			
Emission factor for grid electricity	0.42	0.16	0.62
Annual protein consumption per capita	33.21	29.4	23.81
NO <sub>x</sub> generation (wastewater)	85	50	40
Industrial and commercial co-discharged protein into the sewer	1.25	1.25	1.25
Non consumed protein added to the wastewater	1.1	1	1.1
Additional Nitrogen from household products added to the wastewater	1.1	1.1	1.1

You can also display the comparison in the form of bar and line graphs. These options can be accessed in the subtabs.



## Section 4: Key points when entering data in ECAM

This topic presents some key points that the user should know when entering data in the ECAM tool.

### What should I consider when choosing my inventory scope?

Typically, in the urban water sector, emissions are assessed separately and using different tools. The ECAM tool, however, has been developed to facilitate the assessment of systems via a holistic approach, considering all stages of the urban water cycle and the interlinkages between stages. The aim is to maintain the overview on the entire urban water cycle in the analysis, to convey the notion that sub-systems are inter-related.

The choice of which systems will and will not be considered is called **scoping**. A scope of a GHG emissions inventory may include, for example: only one specific WWTP that needs diagnosis; a specific water distribution zone; or a set of systems belonging to the same urban water utility. The decision on which scope to consider should consider:

- The **context of the inventory**, i.e., what is the user's objective of realization, what are the purposes, etc.
- **Organizational boundaries**, that is, the specific characteristics of the utility (geographical location, service municipalities, responsibilities within a shared system, etc.)
- **Operational boundaries**, which refer to deciding which processes to consider (on-site and off-site activities? Just a part of my treatment because I am interested in switching to another technology? Etc.)

### Where can I get the data to enter in the ECAM tool?

Filling Input data in the ECAM tool is done in the following ways:

- Data that must be provided directly by the user (user input data), considering inputs for the whole time-period defined.
- Data estimated or suggested by ECAM:
  - Data suggested by the tool based on the selected country and GWP report, which can also be modified by the user.
  - Data calculated through estimations, which can also be modified by the user.
  - Data calculated based on dropdown menus, which are supported by reference literature, and which can also be modified by the user.

Data that must be filled in by the user include those related to population, volume of water/wastewater, energy consumption, among others. Table 2 shows the main user input variables, and from which sources it is possible to obtain them. The user must consider the possible errors associated with each of these sources. Utilities might use standardized sources defined in official

documents. (the suggested sources are suggestions, and therefore they do not exclude others that are considered pertinent by the user).

**Table 2 - Possible sources for the main User Input variables**

Input User Variables	<b>Possible Sources (from top to bottom: most accurate to least accurate)</b>
<b>Resident population</b>	<ul style="list-style-type: none"> <li>• Most recent census</li> <li>• Project documentation</li> </ul>
<b>Serviced population</b>	<ul style="list-style-type: none"> <li>• Commercial registration</li> <li>• Estimated value based on monitored influent flow (WWTP)</li> <li>• Project documentation</li> </ul>
<b>Volume of water and wastewater</b>	<ul style="list-style-type: none"> <li>• Macrometer data</li> <li>• Operational control</li> <li>• Estimates based on measurements with series failures</li> <li>• Estimates based on instantaneous point measurements</li> <li>• Estimates from water balance</li> </ul>
<b>Energy consumed from the grid</b>	<ul style="list-style-type: none"> <li>• Energy bills</li> <li>• Operational log from the control panel</li> <li>• Estimates based on equipment operating hours</li> <li>• Extrapolated values based on the operation of pumps with frequency inverters</li> </ul>
<b>Volume of fuel consumed</b>	<ul style="list-style-type: none"> <li>• Operational control</li> <li>• Purchase receipts</li> </ul>
<b>Number of serviced connections</b>	<ul style="list-style-type: none"> <li>• Commercial registration</li> <li>• Project documentation</li> </ul>

The support document “**Methodology Guide**” presents the equations and data tables for each of the ECAM suggestions and estimates. But it is also possible to enter your own values (Table 3).

**Table 3 - Possible sources for the main Estimates**

Input ECAM estimates/suggestions	<b>Possible Sources (from top to bottom: most accurate to least accurate)</b>
<b>Emission factor for grid electricity</b>	<ul style="list-style-type: none"> <li>• Official country-specific factors, defined by local methodology</li> <li>• Updated data from the International Financial Institutions (IFI) Dataset of Default Grid Factors<sup>10</sup></li> <li>• ECAM suggestions</li> </ul>
<b>BOD<sub>5</sub> and Nitrogen influent loads</b>	<ul style="list-style-type: none"> <li>• Monitoring Protocol</li> <li>• ECAM estimates</li> <li>• Project documentation (influent and effluent)</li> </ul>
<b>BOD<sub>5</sub> and Nitrogen effluent loads</b>	<ul style="list-style-type: none"> <li>• Monitoring Protocol</li> <li>• ECAM estimates</li> <li>• Estimate in accordance with the treatment process adopted (effluent)</li> </ul>

<sup>10</sup> The ECAM tool suggests the IFI data released in its last update, 2020. However, this data is updated every two years, and is available at: <https://www.eib.org/en/publications/eib-project-carbon-footprint-methodologies>

Input ECAM estimates/suggestions	Possible Sources (from top to bottom: most accurate to least accurate)
Biogas produced	<ul style="list-style-type: none"> <li>• Monitoring Protocol</li> <li>• Operational control</li> <li>• Estimates based on instantaneous point measurements</li> <li>• ECAM estimates</li> <li>• Project documentation</li> </ul>
Sludge mass	<ul style="list-style-type: none"> <li>• Operational control</li> <li>• ECAM estimates</li> <li>• Project documentation</li> </ul>

## Wastewater Treatment stage

In this topic some specifics about the Wastewater Treatment stage will be addressed. They are:

- Information on **choosing wastewater treatment technologies** from the options provided by the ECAM dropdown menus
- Information on **how to calculate an average emission factor** for WWTP with **multi-step technologies without sludge removal**
- Information on **how to calculate an average emission factor** for WWTP with **multi-step technologies with sludge removal**
- Information on **how to calculate an average emission factor** for WWTP with **multi-step technologies with sludge removal and with biogas recollection**

### **How to choose the best option for the Treatment Technology Dropdown Menus**

The dropdown menus are a feature provided by the ECAM tool to facilitate the selection of options based on official guidelines and scientific reference. These sources include the IPCC Guidelines (2006; 2019); traditional literature (Chernicharo, 2015; Von Sperling, 2015); official technical publications (EIB, 2020; FAO, 2022; UNFCCC, 2022); and technical-scientific papers (Alegre et al., 2006; Cabrera et al., 2011; Silva; Rosa, 2014). These and other sources are further explored in the supporting document "Methodology Guide".

The terms used specifically in the Sanitation Treatment stage dropdown menus are broad, so you may find it difficult to relate them to your operational routine. To facilitate this correlation between the broader terms used by the IPCC for this specific stage and your operational routine, see Table 4.

**Table 4 - Types of wastewater treatment technology, categorized according to the level of treatment and the presence (or not) of aeration<sup>1112</sup>**

<p><b>Primary treatment</b></p> <ul style="list-style-type: none"> <li>• Anaerobic Reactors (depending on the WWTP design)</li> <li>• Coarse solids reducers</li> <li>• Grit and oil separators</li> <li>• Imhoff tanks</li> <li>• Primary clarifiers</li> <li>• Screens</li> </ul> <p><b>Secondary treatment</b></p> <ul style="list-style-type: none"> <li>• Activated Sludge</li> <li>• Anaerobic Reactors (depending on the WWTP design)</li> <li>• Biological aerated filters (BAF)</li> <li>• Constructed Wetlands</li> <li>• Lagoons</li> <li>• Membrane bioreactor (MBR)</li> <li>• Moving bed biofilm reactor (MBBR)</li> <li>• Packed bed reactor</li> <li>• Rotating biological contactor (RBC)</li> <li>• Trickling Filter</li> <li>• UASB (depending on WWTP design)</li> </ul> <p><b>Tertiary treatment</b></p> <ul style="list-style-type: none"> <li>• Adsorption</li> <li>• Air and steam stripping</li> <li>• Coagulation/Flocculation</li> <li>• Ion exchange</li> <li>• Membrane processes</li> <li>• Oxidation (chemical, wet air, supercritical water)</li> <li>• Tertiary Filtration</li> </ul>	<p><b>Centralised, aerobic, treatment plant</b></p> <ul style="list-style-type: none"> <li>• Activated sludge</li> <li>• Aerated Lagoons</li> <li>• Aeration Basin</li> <li>• Biological aerated filters (BAF)</li> <li>• Biological Trickling filters</li> <li>• Fixed Bed Bioreactors (FBBR)</li> <li>• Membrane bioreactor (MBR)</li> <li>• Moving bed biofilm reactor (MBBR)</li> <li>• Oxidation ditches</li> <li>• Packed bed reactor</li> <li>• Rotating biological contactor (RBC)</li> </ul> <p><b>Anaerobic reactor</b></p> <ul style="list-style-type: none"> <li>• Anaerobic Baffled Reactor (ABR)</li> <li>• Anaerobic contact reactor</li> <li>• Anaerobic filter</li> <li>• CSTR</li> <li>• Down flow fixed-film reactor</li> <li>• Expanded-bed process</li> <li>• UASB</li> <li>• Upflow packed bed reactor</li> </ul>
--	---

Choosing the correct option from the dropdown menus will ensure that the correct GHG emissions are accounted for. In this regard, note that:

- Primary level treatment generates mostly CO<sub>2</sub> emissions, while secondary and tertiary treatment may also generate N<sub>2</sub>O and CH<sub>4</sub> emissions.

<sup>11</sup> Lagoons are also referred as "Ponds".

<sup>12</sup> "Preliminary" and "primary" treatment technologies are both shown as primary in this table, as the base references to the dropdown menus do so.

- Aerobic treatments generate mostly N<sub>2</sub>O and CO<sub>2</sub>, while anaerobic treatments generate mostly CH<sub>4</sub> and CO<sub>2</sub>.
- Regardless of the technology selected, remember that the generation of GHG in a WWTP also depends on how the facility is being operated. The dropdown menu values are based on data tables which are results from an average of case studies, and therefore may not represent your reality<sup>13</sup>.

## **How to choose an emission factor for treatment if my WWTP has two or more technologies (without sludge removal)**

The GHG emission factor adopted for the Sanitation Treatment stage depends on the wastewater treatment technology used in a plant.

In the tool, you can select this factor in a dropdown menu by selecting your WWTP technology, as seen below.

INPUTS			
Enter the values for this stage			
Serviced population wwt_serv_pop	400,000	people	<input type="checkbox"/> Highlight mode
Volume of treated wastewater wwt.vol_trea	29,200,000	m <sup>3</sup>	<input type="button" value="m3"/>
Volume of discharged effluent to water body wwt.vol_disc	29,200,000	m <sup>3</sup>	<input type="button" value="m3"/>
Influent BOD <sub>5</sub> load wwt.bod_infl	7,300,000	kg	<input type="button" value="kg"/>
Effluent BOD <sub>5</sub> load wwt.bod_eff	1,095,000	kg	<input type="button" value="kg"/>
Primary + Secondary (biological treatment plants) wwt.tn_infl	2,599,227	kg	<input type="button" value="kg"/>
Total Nitrogen load in the effluent wwt.tn_eff	1,559,536	kg	<input type="button" value="kg"/>
CH <sub>4</sub> emission factor (treatment) wwt.ch4_efac_trea	0.018	kgCH <sub>4</sub> /kgBOD	
<div style="background-color: red; color: white; padding: 5px; text-align: center;"> <b>This dropdown menu contains a reference table with EF values depending on the treatment technology</b> </div>			
Centralised, aerobic, treatment plant (0.018)	0.016	kgN <sub>2</sub> O-N/kgN	
Type of treatment undefined (0)	0.021	kgCH <sub>4</sub> /kgBOD	
Centralised, aerobic, treatment plant (0.018)	0.005	kgN <sub>2</sub> O-N/kgN	
Anaerobic Reactor - CH <sub>4</sub> recovery not considered (0.48)			
Anaerobic Reactor - CH <sub>4</sub> recovery considered (0.14)			
Anaerobic shallow lagoon and facultative lagoons (<2m depth) (0.12)			
Anaerobic deep lagoon (>2m depth) (0.48)			
Anaerobic Lagoon covered (0)			
Wetlands - Surface flow (0.24)			
Wetlands - Horizontal subsurface flow (0.06)			
Wetlands - Vertical subsurface flow (0.006)			
Aerated Lagoon (0.06)			
Trickling Filter (0.036)			
Custom value			
Energy consumed from the grid wwt.nrg_cons	2,541,993	kWh	<input type="button" value="kWh"/>
Emission factor for grid electricity wwt.conv_kwh	0.16	kgCO <sub>2</sub> eq/kWh	

<sup>13</sup> Further discussion in the Methodology Guide.

This procedure is quite simple for users who are evaluating only one specific technology (eg. Anaerobic lagoon or Extended aeration activated sludge). In the case of more than one treatment technology (eg. Anaerobic lagoon followed by Facultative Lagoon) the procedure can become more complex.

It is therefore suggested that the user calculates an average emission factor<sup>14</sup> for these combinations of technologies.

If you know the efficiencies of your technologies individually, you can calculate the emission factor using Equation 1. If these efficiencies are not known, local or literature estimates can be used.

**Equation 1<sup>15</sup> - Calculating average emission factors for multi-step WWTP without sludge removal**

$$EF_{CH4,average} = EF_{CH4,1st\ technology} + (1 - \eta_{BOD,1st\ technology}) \cdot EF_{CH4,2nd\ technology}$$

$$EF_{N2O,average} = EF_{N2O,1st\ technology} + (1 - \eta_{BOD,1st\ technology}) \cdot EF_{N2O,2nd\ technology}$$

Where:

$EF_{CH4, average}$	Average methane emission factor [kgCH <sub>4</sub> /kgBOD]
$EF_{CH4, 1sttechnology}$	Methane emission factor – 1st technology [kgCH <sub>4</sub> /kgBOD]
$EF_{CH4, 2ndtechnology}$	Methane emission factor – 2nd technology [kgCH <sub>4</sub> /kgBOD]
$\eta_{BOD, 1st\ Technology}$	BOD removal efficiency in the 1st technology [%]
$EF_{N2O, average}$	Average nitrous oxide emission factor [kgN <sub>2</sub> O-N/kgN]
$EF_{N2O, 1sttechnology}$	Nitrous Oxide emission factor – 1st technology [kgN <sub>2</sub> O-N/kgN]
$EF_{N2O, 2ndtechnology}$	Nitrous Oxide emission factor – 2nd technology [kgN <sub>2</sub> O-N/kgN]
$\eta_{N, 1st\ Technology}$	Nitrogen removal efficiency in the 1st technology [%]

Table 5 presents a compilation of typical efficiencies based on the literature, as well as emission factors already calculated for these combinations, considering the reference efficiencies.

This is a suggestion of values that can be adopted if the utility does not know the specific efficiencies of its processes, preventing the calculation with Equation 1.

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<sup>14</sup> It is important to point out that this procedure is not valid for multi-technology treatment if there is a significant removal of sludge for one of them. In this case, refer to the topic **How to choose an emission factor for treatment if my WWTP has two or more treatment technologies (without sludge removal)**.

<sup>15</sup> This is a variation developed from Equation 6.1 of the IPCC (2019).

**Table 5 - Suggested emission factors for multi-step treatment technologies**

Treatment technology	Efficiency Removal in the first technology (%)						Emission Factor <sup>2</sup>			
	BOD <sub>5</sub>		N <sub>total</sub>		1 <sup>st</sup> technology		2 <sup>nd</sup> technology		Average	
	Literature <sup>1</sup>	Adopted	Literature <sup>1</sup>	Adopted	EF <sub>CH4</sub>	EF <sub>N2O</sub>	EF <sub>CH4</sub>	EF <sub>N2O</sub>	EF <sub>CH4</sub>	EF <sub>N2O</sub>
Facultative lagoon	75 – 85 %	90%	< 60 %	40%	0.120	0.016	-	-	0.120	0.016
Anaerobic lagoon + Facultative lagoon	- <sup>3</sup>	50%	- <sup>3</sup>	20%	0.480	0.000	0.120	0.016	0.540	0.013
Imhoff tank + facultative lagoon	- <sup>3</sup>	60%	- <sup>3</sup>	20%	0.480	0.000	0.120	0.016	0.528	0.013
Imhoff tank (no biogas flare)	- <sup>3</sup>	60%	- <sup>3</sup>	20%	0.480	0.000	-	-	0.480	0.000
Aerated lagoon	75 – 85 %	85%	< 30 %	20%	0.060	0.016	-	-	0.060	0.016
Anaerobic lagoon + Aerated lagoon	- <sup>3</sup>	50%	- <sup>3</sup>	20%	0.480	0.000	0.060	0.016	0.510	0.013
UASB + Aerated Lagoon	60 – 75 %	70%	< 60 %	20%	0.480	0.000	0.060	0.016	0.498	0.013
UASB + trickling filter	60 – 75 %	70%	60 – 75 %	20%	0.480	0.000	0.036	0.016	0.491	0.013
Anaerobic lagoon + trickling filter	- <sup>3</sup>	50%	- <sup>3</sup>	20%	0.480	0.000	0.036	0.016	0.498	0.013
UASB + Anaerobic Filter	60 – 75 %	70%	< 60 %	20%	0.480	0.000	0.480	0.000	0.624	0.000
Primary clarifier + Digester/Imhoff tank + Trickling filter	- <sup>3</sup>	60%	- <sup>3</sup>	20%	0.480	0.000	0.036	0.016	0.494	0.013
Extended aeration	90 – 97 %	90%	< 60 %	40%	0.018	0.016	-	-	0.018	0.016

<sup>1)</sup> According to Sperling (2005).

<sup>2)</sup> The unit for the CH<sub>4</sub> emission factors is kgCH<sub>4</sub>/kgBOD. For the N<sub>2</sub>O emission factor is kgN<sub>2</sub>O-N/kgN.

<sup>3)</sup> Adopted based on similarity with the other processes

## **How to choose an emission factor for treatment if my WWTP has two or more technologies (with sludge removal)**

If the deduction of the organic load related to sludge removal should be considered, it could be more complicated with multiple-technology processes. This would be the case, for example, for UASB (without biogas recollection) + Conventional Aerated Sludge. In this case, the second stage (aerated sludge) has considerable sludge removal.

For this case, Equation 2 can be used to calculate the emission factor, **but it must be customized for each case**, considering the **amount of BOD<sub>5</sub> removed as sludge**.

### **Equation 2 - Calculating average emission factors for multi-step WWTP with sludge removal**

$$\text{Emission}_{\text{treatment}} = (\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}}) \cdot \text{EF}_{1\text{st tech}} + (\text{Load}_{2\text{nd tech}} - \text{Sludge}_{2\text{nd tech}}) \cdot \text{EF}_{2\text{nd tech}} \quad (\text{IPCC, 2019})^{16}$$

$$\text{Emission}_{\text{treatment}} = (\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}} - \text{Sludge}_{2\text{nd tech}}) \cdot \text{EF}_{\text{average}} \quad (\text{IPCC, 2019})^{17}$$

$$\text{EF}_{\text{average}} = \frac{(\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}}) \cdot \text{EF}_{1\text{st tech}} + (\text{Load}_{2\text{nd tech}} - \text{Sludge}_{2\text{nd tech}}) \cdot \text{EF}_{2\text{nd tech}}}{\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}} - \text{Sludge}_{2\text{nd tech}}}$$

Where:

Load <sub>1st tech</sub>	Average methane emission factor [kg/year]
Load <sub>2nd tech</sub>	Methane emission factor – 1st technology [kgCH <sub>4</sub> /kgBOD]
EF <sub>1sttech</sub>	Emission factor – 1st technology [kgN <sub>2</sub> O-N/kgN or kgCH <sub>4</sub> /kgBOD]
EF <sub>2ndtech</sub>	Emission factor – 2nd technology [kgN <sub>2</sub> O-N/kgN or kgCH <sub>4</sub> /kgBOD]
Sludge <sub>1sttech</sub>	BOD <sub>5</sub> removed as sludge – 1st technology [kgBOD/year]
Sludge <sub>2ndtech</sub>	BOD <sub>5</sub> removed as sludge – 2nd technology [kgBOD/year]

Another option to consider would be to create two substages for Wastewater Treatment, one for each technology. In this case, it would be necessary to customize practically all the filling fields, calculating the influent and effluent Load data separately in a spreadsheet for each treatment step.

<sup>16</sup> Equation 6.1 from IPCC (2019), considering separate emissions from both treatment steps.

<sup>17</sup> Equation 6.1 from IPCC (2019), considering the whole wwtp as the boundary.

## **How to choose an emission factor for treatment if my WWTP has two or more technologies (with sludge removal and biogas recollection)**

A third case is when it is necessary to choose an Emission Factor for WWTP multi-step technology **with sludge removal and biogas recollection**. This is the case of UASB (with biogas recollection) + Conventional Aerated Sludge (with sludge removal), for example.

For this case, Equation 3 can be used to calculate the emission factor, **but it must be customized for each case**, considering the **amount of BOD<sub>5</sub> removed as sludge** and the **amount of CH<sub>4</sub> recollected**.

### **Equation 3 - Calculating average emission factors for multi-step WWTP with sludge removal**

$$\text{Emission}_{\text{treatment}} = [(\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}}) \cdot \text{EF}_{1\text{st tech}} - \text{CH}_4\text{-rec}] + [(\text{Load}_{2\text{nd tech}} - \text{Sludge}_{2\text{nd tech}}) \cdot \text{EF}_{2\text{nd tech}} - \text{CH}_4\text{-rec}]$$

(IPCC, 2019)<sup>18</sup>

$$\text{Emission}_{\text{treatment}} = (\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}} - \text{Sludge}_{2\text{nd tech}} - \text{CH}_4\text{-rec}) \cdot \text{EF}_{\text{average}}$$

(IPCC, 2019)<sup>19</sup>

$$\text{EF}_{\text{average}} = \frac{[(\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}}) \cdot \text{EF}_{1\text{st tech}} - \text{CH}_4\text{-rec}] + [(\text{Load}_{2\text{nd tech}} - \text{Sludge}_{2\text{nd tech}}) \cdot \text{EF}_{2\text{nd tech}} - \text{CH}_4\text{-rec}]}{\text{Load}_{1\text{st tech}} - \text{Sludge}_{1\text{st tech}} - \text{Sludge}_{2\text{nd tech}} - \text{CH}_4\text{-rec}_{1\text{st tech}} - \text{CH}_4\text{-rec}_{2\text{nd tech}}}$$

Where:

Load <sub>1st tech</sub>	Average methane emission factor [kg/year]
Load <sub>2nd tech</sub>	Methane emission factor – 1st technology [kgCH <sub>4</sub> /kgBOD]
EF <sub>1sttech</sub>	Emission factor – 1st technology [kgN <sub>2</sub> O-N/kgN or kgCH <sub>4</sub> /kgBOD]
EF <sub>2ndtech</sub>	Emission factor – 2nd technology [kgN <sub>2</sub> O-N/kgN or kgCH <sub>4</sub> /kgBOD]
Sludge <sub>1sttech</sub>	BOD <sub>5</sub> removed as sludge – 1st technology [kgBOD/year]
Sludge <sub>2ndtech</sub>	BOD <sub>5</sub> removed as sludge – 2nd technology [kgBOD/year]
CH <sub>4</sub> -rec	amount of CH <sub>4</sub> recollected from treatment step [kgCH <sub>4</sub> /year]

As for the second case, the user can consider creating two substages for Wastewater Treatment, one for each technology. In this case, it would be necessary to customize practically all the filling fields, calculating the influent and effluent load data separately in a spreadsheet for each treatment step.

<sup>18</sup> Equation 6.1 from IPCC (2019), considering separate emissions from both treatment steps.

<sup>19</sup> Equation 6.1 from IPCC (2019), considering the whole wwtp as the boundary.

## **How to choose an emission factor for discharge (using Tiers)**

In the IPCC (2006; 2019), a tier represents a level of **methodological complexity**. Usually, three tiers are mentioned in IPCC. Tier 1 is the basic method, Tier 2 intermediate and Tier 3 most demanding in terms of complexity and data requirements. Tiers 2 and 3 are sometimes referred to as higher tier methods and are generally considered to be more accurate.

In practice with the ECAM tool, the Tier concept will be used for the **selection of emission factors used to calculate wastewater discharge emissions**, which are generated in the Wastewater Collection, Treatment, and Onsite Sanitation stages. In this case, "Tier" can be understood as "**Level of Information**" related to:

1. **Level of activity data** that make up the equation for which the emission factor will be applied.
2. **Level of information** that the utility has **about the water body** where the discharge is taking place.

Table 6 presents the Tier options to be chosen when selecting the wastewater discharge EF, based on the activity data and water body level of information. To select the tier of the first column, **all requirements** of the columns in the corresponding row must be met.

Once the users have defined the Tier in which their wastewater discharge data is located, it is possible to select the emission factor within the options in the dropdown menu.

For example, if the user is in a dropdown menu for the definition of a CH<sub>4</sub> emission factor for wastewater discharge in the Treatment Stage, with the following data:

- The utility does not have effluent BOD load data, and therefore is using ECAM estimations (Tier 1).
- The utility knows that the discharge is carried out over a specific river (Tier 2).

In the example above, not all conditions were met to select the Tier 2 option (it would be necessary to have a more precise BOD load data), and therefore the Tier 1 option is selected in the dropdown menu. The exercises in this User Manual will address in practice this selection.

**Table 6 - Choosing Wastewater Discharge emission factors based on Tiers (Level of Information)**

Chosen Tier	Level of Information	
	When defining $\text{CH}_4$ emission factors for wastewater discharge:	When defining $\text{N}_2\text{O}$ emission factors for wastewater discharge:
<b>Tier 1</b> Methodologically, the data is scaled from a particular source, which will not respond to local changes. No information about the water body is known.	<b>Effluent BOD<sub>5</sub> load:</b> Defined from ECAM estimates, that is, based on the extrapolation of a series of studies carried out.  <b>Water body:</b> There is no need for the utility to know which type of water body the wastewater is discharged.	<b>Effluent Total Nitrogen load:</b> Defined from ECAM estimates, that is, based on the extrapolation of a series of studies carried out.  <b>Water body:</b> There is no need for the utility to know which type of water body the wastewater is discharged nor if this body is impacted by nutrients or it is in hypoxic conditions.
<b>Tier 2</b> Methodologically, the data are scaled from country-specific calculations or from local monitoring. No information about the water body is known.	<b>Effluent BOD<sub>5</sub> load:</b> Defined based on country-specific studies or on local monitoring by the utility (in this second case, the utility must consider uncertainties such as gaps in data sets).  <b>Water body:</b> The utility must know to what type of water body is discharged the wastewater, i.e., if it is a river, estuary, lake, etc.	Not applicable, because the selection of the $\text{N}_2\text{O}$ emission factors do not include a Tier 2.
<b>Tier 3</b> Methodologically, the data are scaled from country-specific calculations or local monitoring. The necessary information about the water body is known.	Not applicable, because the selection of the $\text{CH}_4$ emission factors do not include a Tier 3.	<b>Effluent Total Nitrogen load:</b> Defined based on country-specific studies or on local monitoring by the utility (in this second case, the utility must consider uncertainties such as gaps in data sets).  <b>Water body:</b> The utility must know the water body and know if it is impacted by nutrients and/or in hypoxic conditions.

## Section 5: Case Scenario examples

This topic presents practical examples of using the ECAM tool to calculate GHG emissions in the Urban Water Sector. The solution of these cases is provided step-by-step using screenshots.

This topic is a preparation for practicing the exercises in the next topic.

### Calculate emissions from a water pumping facility in the Abstraction Stage

The management of the Urban Water Utility "Hope" is thinking about which mitigation measures should be prioritized this year.

To gather more information, the manager asked the team to account for emissions from the water pumping facility used for ABSTRACTION in the hypothetical city of Turbalina, in Peru. After consulting their database, the technicians found the following information:

- The pumping system consumed **4,150,000 kWh/year** from the grid.
- The backup power supply system for the pumps is made up of two gasoline engines. These motors operated a few days throughout the year due to network failure or scheduled maintenance. In total, **52,000 liters of gasoline** were consumed in the year.

Now, in ECAM we are going to estimate the emissions related to **electricity (indirect)** and **fuel engines**.

To do the calculations, let's prepare the ECAM Configuration tab:

1. Select **the most recent IPCC GWP Report**, since there are no requirements for using older versions.
2. Choose the **name of your assessment**.
3. Choose the **evaluation period from 01/01/2021 to 01/01/2022**.
4. Choose "**Peru**" as your country.
5. Change the **electricity emission factor** to **0.1562 kg CO<sub>2eq</sub>/kWh**, since we have this information from official institutions.
6. Change the **BOD<sub>5</sub> generation factor** for wastewater to **50 g per person per day**, since we have this information from official institutions.
7. Change the value of the **non consumed protein added to wastewater factor to 1**, since we have this information from official institutions.

**Configuration**

- ▶ Load and save file
- ▼ List of assessments

1 Select Global Warming Potential Report [IPCC 5th AR (2014/2013) CCF] More info

	Assessment period	GHG (kgCO <sub>2</sub> eq)	Energy (kWh)	Substages	Options
2 Turbine city	2021-01-01 2022-01-01 (365 days)	0	0	0	<a href="#">settings</a> <a href="#">duplicate</a>

change assessment name

Assessment period

3 From: 01/01/2021 To: 01/01/2022 365 days

Country:  
Select Peru 4 more info

Currency (3 letters code) PEN Currency

Emission factor for grid electricity 5 0,1562 kgCO<sub>2</sub>/kWh

Annual protein consumption per capita 6 26,128598 kg/person/year

BOD<sub>5</sub> generation (wastewater) 7 50 g/person/day

Industrial and commercial co-discharged protein into the sewer 1,25 kgN/kgN

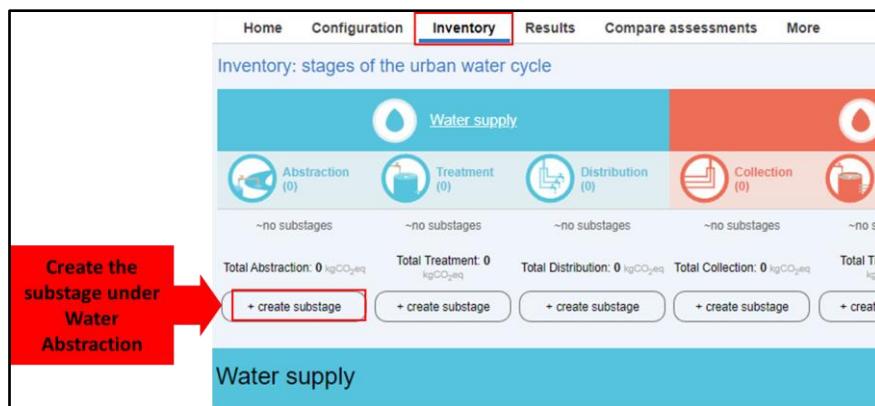
Non consumed protein added to the wastewater 1 kgN/kgN

Additional Nitrogen from household products added to the wastewater 1,1 kgN/kgN

[Access inventory](#)

Comments

As a next step, let's access the inventory. Then click on "create substage" under Abstraction, which is what we'd like to assess.



We will need to fill in the data we have to estimate the emissions.

1. Fill in the energy consumption from the grid for the whole year. The Emission factor for grid electricity was defined in the general factors section.

2. Activate the option to calculate emissions for onsite fuel engines.
3. Fill in the information about onsite fuel consumption. Remember to choose the type of fuel, which in this case is Gasoline.

**Water supply > Abstraction > Abstraction 1** [change substage name](#)

[Show all inputs](#)  GHG Emissions (5)  Pump Efficiency (12)  Energy Performance (12)  Costs (2)

**INPUTS**  
Enter the values for this stage

Volume of abstracted water <code>wsa_vol_conv</code>	Fill in the values provided by the exercise	0 <input type="button" value="m3"/>	<input type="checkbox"/> Highlight mode
Energy consumed from the grid <code>wsa_nrg_cons</code>		1 4,150,000 <input type="button" value="kWh"/>	
Emission factor for grid electricity <code>wsa_conv_kwh</code>		Estimation: 0.16 kgCO <sub>2</sub> eq/kWh	0.16 kgCO <sub>2</sub> eq/kWh
▼ Do you have fuel engines?	2 <input checked="" type="radio"/> No <input type="radio"/> Yes	(1) Gasoline/Petrol	
Fuel type (engines) <code>wsa_fuel_typ</code>	3	52,000 <input type="button" value="L"/>	
Volume of fuel consumed <code>wsa_vol_fuel</code>			

The resulting GHG emissions can be checked in the Outputs section. Click on "show outputs".

**Water supply > Abstraction > Abstraction 1** [change substage name](#)

[Show all inputs](#)  GHG Emissions (5)  Pump Efficiency (12)  Energy Performance (12)  Costs (2)

**INPUTS**  
Enter the values for this stage

Volume of abstracted water <code>wsa_vol_conv</code>	0 <input type="button" value="m3"/>	<input type="checkbox"/> Highlight mode
Energy consumed from the grid <code>wsa_nrg_cons</code>	4,150,000 <input type="button" value="kWh"/>	
Emission factor for grid electricity <code>wsa_conv_kwh</code>	Estimation: 0.16 kgCO <sub>2</sub> eq/kWh	0.16 kgCO <sub>2</sub> eq/kWh
▼ Do you have fuel engines?	● No <input type="radio"/> Yes	(1) Gasoline/Petrol
Fuel type (engines) <code>wsa_fuel_typ</code>	52,000 <input type="button" value="L"/>	
Volume of fuel consumed <code>wsa_vol_fuel</code>		

[show outputs](#)

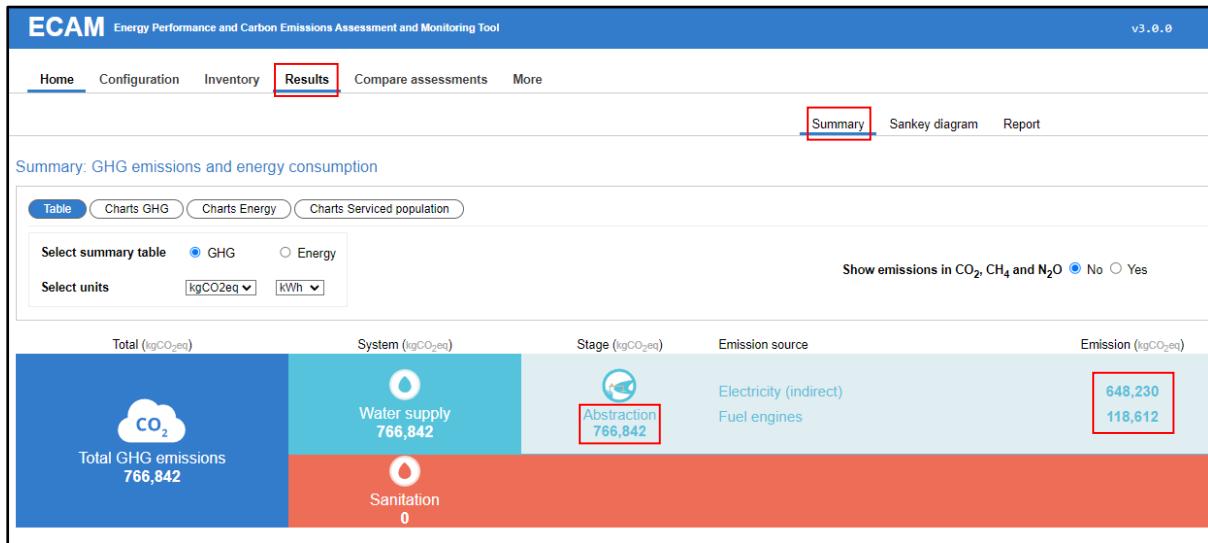
The Outputs section shows the results of the requested calculations. In the image below, we can see the result for the emissions referring to **Electricity from the grid (648,230 kg CO<sub>2</sub>eq)**, **Fuel Engines (118,612 CO<sub>2</sub>eq)**, and **Total Emissions in Water Abstraction (766,842 CO<sub>2</sub>eq)**.

**OUTPUTS — [hide outputs](#)**

GHG emissions [kgCO<sub>2</sub>eq](#) [kgCO<sub>2</sub>eq/year](#)

	Value	Σ sum (1 substages)	Unit
Electricity (indirect) <code>wsa_KPI_GHG_elec</code>	648,230	648,230	kgCO <sub>2</sub> eq
Fuel engines <code>wsa_KPI_GHG_fuel</code>	118,612	118,612	kgCO <sub>2</sub> eq
Total GHG water abstraction <code>wsa_KPI_GHG</code>	766,842	766,842	kgCO <sub>2</sub> eq

The same results could be inspected in the "Results - Summary" tab.



## Calculate emissions from a WWTP

In this case, the proposal is to calculate the **total GHG emissions of a WWTP** composed by a  **facultative lagoon**.

Relevant information about the process includes:

- The population serviced by the wastewater treatment system is **100,000 people**.
- The WWTP electricity consumption is entirely from the grid, with a total of **30,000 kWh** in 2021.
- We will **not consider removing sludge** from processes.
- The treated effluent is **discharged into a river**.

First, start your assessment, or create a new one under the Configuration tab.

**Assess the carbon footprint  
and energy performance of  
your urban water utility**

ECAM empowers water and wastewater utility operators to assess their greenhouse gas emissions and energy consumption.

- Perfect for climate reporting needs
- Overview of system-wide greenhouse gas emissions
- IPCC-2019 compliant and open source



**Start your assessment**

Now you will need to prepare the Configuration tab considering the following information:

1. Let's use the GWP Report IPCC 5th AR CCF.
2. The assessment period will be the full year of 2021.
3. The assessment will take place at a facility in Mexico.
4. For the general factors, we will keep the values suggested by ECAM, since we don't have local or official factors to replace them.

**Configuration**

- ▶ Load and save file
- ▼ List of assessments

Select Global Warming Potential Report		PCC 5th AR (2014/2013) CCF	More info	
Assessment period	GHG (kgCO <sub>2</sub> eq)	Energy (kWh)	Substages	Options
2021-01-01 2022-01-01 (365 days)	13,092,417	30,000	1	<a href="#">settings</a> <a href="#">duplicate</a>
<a href="#">change assessment name</a>				
<b>Assessment period</b> From: 01/01/2021 To: 01/01/2022 365 days 2				
<b>Country</b> select Mexico 3 More info				
Currency (3 letters code) Emission factor for grid electricity Annual protein consumption per capita 4 BOD <sub>5</sub> generation (wastewater) Industrial and commercial co-discharged protein into the sewer Non consumed protein added to the wastewater Additional Nitrogen from household products added to the wastewater				
<a href="#">Access inventory</a>				
<a href="#">Comments</a>				

The next step will be to create a substage within the Wastewater Treatment stage.

2nd Click on the substage to open the input section

1st Click to create a new substage

Now you must fill in the Input Section according to the data provided by the exercise.

1. The population serviced by the wastewater treatment system is **100,000 people**.
2. When filling in the serviced population, ECAM will suggest some **estimates** for the inputs (**green squares**). These values are also calculated based on the general factors selected in the Configuration tab (for example, from the BOD generated per capita it is possible to calculate the Load of Influent BOD to the WWTP<sup>20</sup>). **To use estimates, click on the suggested value.**

<sup>20</sup> Check more about that in the Methodology Guide.

3. We do not have information about the BOD load in the effluent (there is no monitoring in the WWTP). It would be possible to calculate it from the efficiency of our process, but we are not sure about this data either. In this sense, we are going to use the **dropdown menu** offered by ECAM, selecting the technology we have. The lagoon is a primary + secondary process. **The software also calculates the value in kg/year.**
4. If you don't have WWTP affluent monitoring data, you should also use estimation for the Nitrogen load in the influent. **To use estimates, click on the suggested value.**
5. Like step 3, we can calculate the Total Nitrogen load in the effluent from the dropdown menu. **Select the "primary + secondary process" option.**
6. Considering the technological composition of the treatment process (facultative lagoon), choose the right options in the dropdown menus. A facultative lagoon is also an aerobic treatment.
7. The discharge emission factor is defined based on the [type of discharge](#) and the [level of information](#) that we have:
  - For CH<sub>4</sub> emission factor (discharge):
    - We have information about the water body of discharge, we know it is a specific river (Level 2).
    - The BOD load data used are estimated by ECAM from the efficiency of our process, also based on an influent BOD estimate (Level 1).
    - Based on this, **choose the factor 0.068.**
  - For the N<sub>2</sub>O emission factor (discharge):
    - There is information about the water body, but there is no measurement of nutrients (Level 2).
    - Based on this, **choose the factor 0.005.**
8. The WWTP electricity consumption is entirely from the grid, with a total of **30,000 kWh** in 2021.
9. The emissions factor for grid electricity comes from the General factors in the Configuration tab.

**INPUTS**  
Enter the values for this stage

Serviced population <code>wvt_serv_pop</code>	<b>1</b> 100,000 people
Volume of treated wastewater <code>wvt_vol_trea</code>	Estimation: 7,300,000 m <sup>3</sup> <b>2</b> 7,300,000 m <sup>3</sup>
Volume of discharged effluent to water body <code>wvt_vol_disc</code>	Estimation: 7,300,000 m <sup>3</sup> <b>2</b> 7,300,000 m <sup>3</sup>
Influent BOD <sub>5</sub> load <code>wvt_bod_infl</code>	Estimation: 1,460,000 kg <b>3</b> 1,460,000 kg
Effluent BOD <sub>5</sub> load <code>wvt_bod_effl</code>	219,000 kg <b>3</b> 219,000 kg
Total Nitrogen load in the influent <code>wvt_tn_infl</code>	Estimation: 743,562 kg <b>4</b> 743,562 kg
Total Nitrogen load in the effluent <code>wvt_tn_effl</code>	446,137 kg <b>4</b> 446,137 kg
CH <sub>4</sub> emission factor (treatment) <code>wvt_ch4_efac_tre</code>	0.12 kgCH <sub>4</sub> /kgBOD
Anaerobic shallow lagoon and facultative lagoons (<2m depth) (0.12) <code>wvt_n2o_efac_tre</code>	0.016 kgN <sub>2</sub> O-N/kgN
N <sub>2</sub> O emission factor (treatment) <code>wvt_n2o_efac_tre</code>	Centralised, aerobic, treatment plant (0.016)
CH <sub>4</sub> emission factor (discharge) <code>wvt_ch4_efac_dis</code>	0.068 kgCH <sub>4</sub> /kgBOD
Discharge to aquatic environments (Tier 1) (0.068) <code>wvt_n2o_efac_dis</code>	0.005 kgN <sub>2</sub> O-N/kgN
N <sub>2</sub> O emission factor (discharge) <code>wvt_n2o_efac_dis</code>	Freshwater, estuarine, and marine discharge (Tier 1) (0.005)
Energy consumed from the grid <code>wvt_nrg_cons</code>	<b>8</b> 30,000 kWh
Emission factor for grid electricity <code>wvt_conv_kwh</code>	Estimation: 0.45 kgCO <sub>2</sub> eq/kWh <b>9</b> 0.45 kgCO <sub>2</sub> eq/kWh
Sludge removed from wastewater treatment (dry weight) <code>wvt_mass_slu</code>	0 kg
Type of treatment undefined → [0 gSS/inhabitant/day] → (0 kg)	0 kg
BOD <sub>5</sub> removed as sludge <code>wvt_bod_slu</code>	0 kg
Mechanical treatment plants (primary sedimentation sludge) → [0.5 kgBOD/kg dry mass sludge] → (0 kg)	0 kg

The Outputs section shows the results of the calculations.

Resident population **8** 0  
Population connected to sewers **8** 0  
↳ Serviced population 200,000  
Population with onsite sanitation 0  
Population with open defecation 0

Pump Efficiency (0) Sludge Management (41) Energy Performance (14) Costs (2)

show outputs

Highlight mode people

**Click to open the Output section**

In the image below, we can see the result for the emissions referring to **Total GHG wastewater treatment (11,901,057 kg CO<sub>2</sub>eq)**.

OUTPUTS — <a href="#">hide outputs</a>	Value	$\Sigma$ sum (1 substages) Unit
GHG emissions		
kgCO <sub>2</sub> eq	13,500	13,500 kgCO <sub>2</sub> eq
kgCO <sub>2</sub> eq/year	10,336,631	10,336,631 kgCO <sub>2</sub> eq
kgCO <sub>2</sub> eq/year/serv.pop.	0	0 kgCO <sub>2</sub> eq
Electricity (indirect) <a href="#">www_KPI_GHG_elec</a>	13,500	13,500 kgCO <sub>2</sub> eq
Treatment process <a href="#">www_KPI_GHG_tre</a>	10,336,631	10,336,631 kgCO <sub>2</sub> eq
Biogas (anaerobic digestion of sludge) <a href="#">www_KPI_GHG_bio</a>	0	0 kgCO <sub>2</sub> eq
Fuel (digester) <a href="#">www_KPI_GHG_dig_fuel</a>	0	0 kgCO <sub>2</sub> eq
Sludge management <a href="#">www_KPI_GHG_slu</a>	0	0 kgCO <sub>2</sub> eq
Discharged water <a href="#">www_KPI_GHG_disc</a>	1,550,926	1,550,926 kgCO <sub>2</sub> eq
Total GHG wastewater treatment <a href="#">www_KPI_GHG</a>	11,901,057	11,901,057 kgCO <sub>2</sub> eq

## Sludge Anaerobic Digester vs Landfilling

This case presents a proposal for calculating avoided GHG emissions in recent years, considering that a utility makes a switch from **Landfilling** sludge to **Anaerobic Digestion** at the Wastewater Treatment Plant.

We will consider:

- The analysis will be between **01/01/2016 to 01/01/2021**.
- The amount of sludge produced during this entire period was **23,675 tons in dry weight**. This data was obtained by operational monitoring.

Start by performing the General Setup on the Configuration tab:

1. Let's use the GWP Report IPCC 5th AR CCF.
2. Select the entire evaluation period.
3. Select the country where the facility is located, which is Peru.
4. There is no local data for the general factors, so we will use the ECAM suggestions based on the IPCC.

**Configuration**

- ▶ Load and save file
- ▼ List of assessments

Select Global Warming Potential																										
Assessment period	GHG (kgCO <sub>2</sub> eq)	Energy (kWh)	Substages	Options																						
Landfilling	2016-01-01 2021-01-01 (1.827 days)	99,267,834	0	1	<a href="#">settings</a> <a href="#">duplicate</a>																					
<a href="#">change assessment name</a>																										
<b>Assessment period</b> From: 01/01/2016 To: 01/01/2021 1.827 days																										
<b>Country</b> Select Peru																										
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">Currency (3 letters code)</td> <td style="width: 10%;">PEN</td> <td style="width: 10%;">Currency</td> </tr> <tr> <td>more info</td> <td>0.424</td> <td>kgCO<sub>2</sub>/kWh</td> </tr> <tr> <td>more info</td> <td>26,128598</td> <td>kg/person/year</td> </tr> <tr> <td>more info</td> <td>40</td> <td>g/person/day</td> </tr> <tr> <td>more info</td> <td>1,25</td> <td>kgN/kgN</td> </tr> <tr> <td>more info</td> <td>1,1</td> <td>kgN/kgN</td> </tr> <tr> <td>more info</td> <td>1,1</td> <td>kgN/kgN</td> </tr> </table>						Currency (3 letters code)	PEN	Currency	more info	0.424	kgCO <sub>2</sub> /kWh	more info	26,128598	kg/person/year	more info	40	g/person/day	more info	1,25	kgN/kgN	more info	1,1	kgN/kgN	more info	1,1	kgN/kgN
Currency (3 letters code)	PEN	Currency																								
more info	0.424	kgCO <sub>2</sub> /kWh																								
more info	26,128598	kg/person/year																								
more info	40	g/person/day																								
more info	1,25	kgN/kgN																								
more info	1,1	kgN/kgN																								
more info	1,1	kgN/kgN																								
<a href="#">Access inventory</a>																										
<b>Comments</b> Comments																										
<a href="#">+ create new assessment</a>																										

## Landfill

First, we are going to generate an assessment (scenario) considering that **there is no anaerobic sludge digester**. For this, it is also important to indicate the methane emission factor of the wastewater treatment, because a reduction in the organic load due to the removal of BOD<sub>5</sub> must be considered.

In this case, the sludge management will consider that undigested sludge is sent to a sanitary landfill, where there is no recovery or burning of biogas, which is emitted directly into the atmosphere.

Initially you must:

1. Fill in the CH<sub>4</sub> emission factor from wastewater treatment.
2. Fill in the amount of sludge produced in the WWTP (dry weight).

3. Select the option “aerobic treatment plants with primary treatment (mixed primary and secondary sludge, untreated or treated aerobically).”

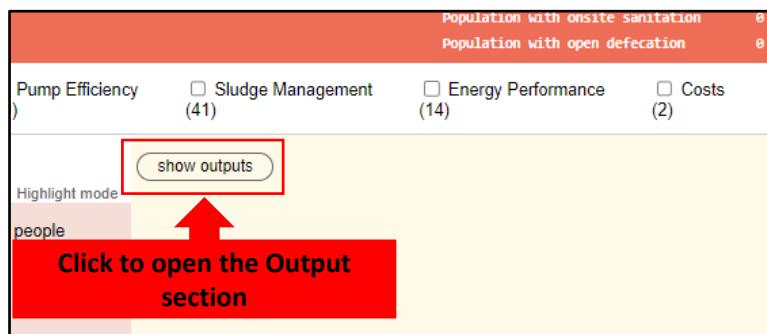
Serviced population wwt_serv_pop	0 people	N <sub>2</sub> O emission factor (treatment) wwt_n2o_efac_tre	0 kgN <sub>2</sub> O-N/kgN
Volume of treated wastewater wwt_vol_trea	0 m <sup>3</sup>	Type of treatment undefined (0)	
Volume of discharged effluent to water body Estimation: 0 m <sup>3</sup> wwt_vol_disc	0 m <sup>3</sup>	CH <sub>4</sub> emission factor (discharge) wwt_ch4_efac_dis	0 kgCH <sub>4</sub> /kgBOD
Influent BOD <sub>5</sub> load wwt_bod_infl	0 kg	Discharge undefined (0)	
Effluent BOD <sub>5</sub> load wwt_bod_effl	0 kg	N <sub>2</sub> O emission factor (discharge) wwt_n2o_efac_dis	0 kgN <sub>2</sub> O-N/kgN
Untreated systems [100 %] (0 kg)	0 kg	Discharge undefined (0)	
Total Nitrogen load in the influent wwt_tn_infl	0 kg	Energy consumed from the grid wwt_nrg_cons	0 kWh
Total Nitrogen load in the effluent wwt_tn_effl	0 kg	Emission factor for grid electricity Estimation: 0.16 kgCO <sub>2</sub> eq/kWh wwt_conv_kwh	0.16 kgCO <sub>2</sub> eq/kWh
Untreated systems [100 %] (0 kg)	0 kg	Sludge removed from wastewater treatment (dry weight) wwt_mass_slu	
CH <sub>4</sub> emission factor (treatment) wwt_ch4_efac_tre	0.018 kgCH <sub>4</sub> /kgBOD	Custom value	
Centralised, aerobic, treatment plant (0.018)		BOD <sub>5</sub> removed as sludge wwt_bod_slu	18,940,000 kg
		Aerobic treatment plants with primary treatment (r... 3	

Then, in the question “Evaluate sludge management?” choose “Yes”, and in the question “Is sludge sent to landfilling?” choose “Yes”.

1. Enter the same amount of sludge generated in the field “sludge sent to a landfill (dry weight)”
2. Choose the “Non-digested” option in “Total Volatile Solids (%)” and “N content of sludge (% dry weight)”.
3. In "Methane correction for anaerobically managed landfills", select "Sanitary Landfill" option.

▼ [SM] Is sludge sent to landfilling? <input checked="" type="radio"/> No <input type="radio"/> Yes	
Sludge sent to landfilling (dry weight) wwt_mass_slu_land	1 23,675 t
Total Volatile Solids (TVS) content of sludge sent to landfilling wwt_slu_if_TVS	70 %
Non-digested (70) 2	
Uncertainty factor (UNFCCC/CCNUC, 2008) wwt_slu_if_uncertainty	0.9 adimensional
CH <sub>4</sub> in landfill gas wwt_slu_if_CH4_in_gas	50 %
Decomposable organic fraction of raw wastewater solids wwt_slu_if_DOCf	80 %
Percentage decomposed in first 3 years wwt_slu_if_decomp_3yr	69.9 %
Methane correction for anaerobic managed landfills (default=1) wwt_slu_if_MCF	1 ratio
Landfill (1) 3	
N content of sludge sent to landfilling (% of dry weight) wwt_slu_if_N_cont	3 %
Non-digested (3) 2	
N <sub>2</sub> O emission factor for low C:N ratio	0.015 kgN <sub>2</sub> O-N/kgN

The Outputs section shows the results of the requested calculations.



In the image below, we can see the result for the emissions referring to **Total GHG wastewater treatment (99,267,834 kg CO<sub>2</sub>eq).**

<b>Sludge management</b> www_KPI_GHG_slu	110,859,114	110,859,114 kgCO <sub>2</sub> eq
<b>Discharged water</b> www_KPI_GHG_disc	0	0 kgCO <sub>2</sub> eq
<b>Total GHG wastewater treatment</b> www_KPI_GHG	99,267,834	99,267,834 kgCO <sub>2</sub> eq

## Sludge Digester

Additional information about the Sludge Digester include:

- The amount of sludge sent to the landfill is reduced by treatment in the anaerobic digester. According to the operational reports we can assume a reduction of the total solids of **26.24%**. Therefore, we are now going to consider sending only **17,464 tons of digested sludge** to the landfill instead of the 23,675 tons in the previous assessment/scenario.
- Since the anaerobic sludge digester produces biogas with a **methane concentration of 67%**, we also need to determine the GHG emissions from losses to the atmosphere. We can assume a biogas production of **5,819,342 Nm<sup>3</sup>**, at normal conditions (N) of pressure (P = 1 atm.) and temperature (T = 0°C), during the 5 years; and that 98% of the production is burned and 2% is lost or released into the atmosphere.

To make the comparison, we are going to duplicate the evaluation/scenario (without anaerobic digester) generated above.

You are editing Landfilling  
99,267,834 kgCO<sub>2</sub>eq 1,827 days 0.4

## Configuration

- ▶ Load and save file
- ▼ List of assessments

Select Global Warming Potential Report IPCC 5th AR (2014/2013) CCF ▾ More info

	Assessment period	GHG (kgCO <sub>2</sub> eq)	Energy (kWh)	Substages	Options
Landfilling	2016-01-01 2021-01-01 (1,827 days)	99,267,834	0	1	

[change assessment name](#)

1. Keep the methane emission factor from the wastewater treatment and the amount of sludge produced in the WWTP (dry weight).
2. Change the BOD<sub>5</sub> removed as sludge to “aerobic treatment plants with primary treatment and anaerobic digestion of sludge (mixed primary and secondary sludge, treated anaerobically)”.

<b>CH<sub>4</sub> emission factor (treatment)</b> <code>wwt_ch4_efac_tre</code>	0.018 kgCH <sub>4</sub> /kgBOD
Centralised, aerobic, treatment plan	<b>1</b>
<b>N<sub>2</sub>O emission factor (treatment)</b> <code>wwt_n2o_efac_tre</code>	0 kgN <sub>2</sub> O-N/kgN
Type of treatment undefined (0)	
<b>CH<sub>4</sub> emission factor (discharge)</b> <code>wwt_ch4_efac_dis</code>	0 kgCH <sub>4</sub> /kgBOD
Discharge undefined (0)	<b>2</b>
<b>N<sub>2</sub>O emission factor (discharge)</b> <code>wwt_n2o_efac_dis</code>	0 kgN <sub>2</sub> O-N/kgN
Discharge undefined (0)	<b>2</b>
<b>Energy consumed from the grid</b> <code>wwt_nrg_cons</code>	0 kWh
<b>Emission factor for grid electricity</b> Estimation: 0.42 kgCO <sub>2</sub> eq/kWh <code>wwt_conv_kwh</code>	0.42 kgCO <sub>2</sub> eq/kWh
<b>Sludge removed from wastewater treatment (dry weight)</b> <code>wwt_mass_slu</code>	23,675 t
Custom value	<b>2</b>
<b>BOD<sub>5</sub> removed as sludge</b> <code>wwt_bod_slud</code>	23,675,000 kg
Aerobic treatment plants with prima	<b>2</b>

1. In relation to biogas production, fill in the amount of **5,819,342 Nm<sup>3</sup>** for the 5 years.
2. Keep the percentages of biogas burned, biogas released into the atmosphere and change the percentage of methane in the biogas to 67%.

▼ Are you producing biogas from anaerobic digestion?  No  Yes

Biogas produced (volume) Estimation: 9,091,200 Nm <sup>3</sup>	<b>1</b> 5,819,342	Nm <sup>3</sup> <input type="button" value="▼"/>
Biogas flared (% volume) Estimation: 98 %	98	%
Biogas valorised as heat and/or electricity (% volume) Estimation: 0 %	0	%
Biogas leaked to the atmosphere (% volume) Estimation: 2 %	2	%
Biogas sold (% volume) Estimation: 0 %	0	%
Percentage of methane in the biogas (% volume) wwt_ch4_biog	<b>2</b> 67	%
Fuel type (digester) wwt_dige_typ	(0) Diesel	<input type="button" value="▼"/>
Fuel consumed for the digester wwt_fuel_dig	0	L <input type="button" value="▼"/>
Energy efficiency for biogas valorization with respect to the theoretical maximum wwt_nrg_biog_eff	43	%
Electrical energy produced from biogas valorization Estimation: 0 kWh	0	kWh <input type="button" value="▼"/>

1. Enter the new amount of digested sludge in the “sludge sent to landfilling (dry weight)” field
2. Choose the “Digested” option in “Total Volatile Solids (% dry weight)” and “N content”.
3. In the “Methane correction for anaerobically managed landfills” field, select the “Landfill” option.

▼ [SM] Is sludge sent to landfilling?		<input type="radio"/> No <input checked="" type="radio"/> Yes
Sludge sent to landfilling (dry weight) wvt_mass_slu_land	1	17,464 t
Total Volatile Solids (TVS) content of sludge sent to landfilling wvt_slu_if_TVS	51	%
Digested (51)	2	
Uncertainty factor (UNFCCC/CCNUC, 2008) wvt_slu_if_uncertainty	0.9	adimensional
CH <sub>4</sub> in landfill gas wvt_slu_if_CH4_in_gas	50	%
Decomposable organic fraction of raw wastewater solids wvt_slu_if_DOCf	80	%
Percentage decomposed in first 3 years wvt_slu_if_decomp_3yr	69.9	%
Methane correction for anaerobic managed landfills (default=1) wvt_slu_if_MCF	1	ratio
Landfill (1)	3	
N content of sludge sent to landfilling (% of dry weight) wvt_slu_if_N_cont	4	%
Digested (4)	2	
N <sub>2</sub> O emission factor for low C:N ratio wvt_slu_if_low_CN_EF	0.015	kgN <sub>2</sub> O-N/kgN

The emission results can also be displayed at the Output Section. In the image below, we can see the result for the emissions referring to **Total GHG wastewater treatment (49,208,213 kg CO<sub>2</sub>eq).**

Sludge management wvt_KPI_GHG_slu	61,805,180	61,805,180 kgCO <sub>2</sub> eq
Discharged water wvt_KPI_GHG_disc	0	0 kgCO <sub>2</sub> eq
<b>Total GHG wastewater treatment wvt_KPI_GHG</b>	<b>49,208,213</b>	<b>49,208,213 kgCO<sub>2</sub>eq</b>

As a conclusion, we know that without an anaerobic sludge digester, the sludge management system generated 99,267,834 kgCO<sub>2</sub>eq. With the implementation of the anaerobic sludge digester, the system generates 49,208,213 kgCO<sub>2</sub>eq. **There is a reduction of 50,059,621 kgCO<sub>2</sub>eq.**

## Section 6: Putting into practice: proposed case exercises

### Calculate emissions from a water pumping facility in the Distribution Stage

The management of an Urban Water Utility in Guatemala saw your results obtained on the emissions from the Water Abstraction (refer to *Calculate emissions from a water pumping facility in the Abstraction Stage*) stage when you were working at the Water Utility “Hope”.

There is now also interest in assessing the GHG emissions from the **Water Distribution stage** pumping system located in another city: the **Memory City, in Guatemala**.

### Types of emissions that will be considered in this exercise:

- Electricity (indirect).
- Fuel Engines.

After consulting the database, the technicians found the following information:

- The pump system consumed **1,500,000 kWh/year** from the grid.
- The backup power supply system for the distribution pumps is made up of **onsite diesel engines**. These engines operated a few days throughout the year due to grid failures or scheduled maintenance. In total, **20,000 liters of diesel** were consumed in 2021.

Start by performing the General Setup on the Configuration tab:

5. Select the entire year of 2021 as the evaluation period.
6. Let's use the GWP Report IPCC 5th AR CCF.
7. Select the country where the facility is located.
8. There is no local data for the general factors, so we will use the ECAM suggestions based on the IPCC.

### Answer the following questions:

- A. How much GHGs are generated in **Electricity (indirect)**, **Fuel engines**, and **Total GHG water distribution** in CO<sub>2eq</sub>?
- B. The utility would also like to know how many **kg of CO equivalent** are generated **per year by each inhabitant** served by the distribution system. This result will be used for benchmarking with other utilities. The population serviced is 50,000 inhab.

### Calculate emissions from a WWTP

In this exercise, the proposal is to calculate the **GHG emissions of a WWTP** that uses a process composed of an **anaerobic lagoon** followed by a **facultative lagoon** in the treatment of wastewater.

### Types of emissions that will be considered in this exercise:

- Emissions from Electricity (indirect).
- Emissions from Treatment.
- Emissions from Discharged Water.

Relevant information about the process includes:

- The population serviced by the wastewater treatment system is **200,000 people**.
- The WWTP electricity consumption is entirely from the grid, with a total of **140,000 kWh** in 2021.
- Considering the technological composition of the treatment process (anaerobic + facultative lagoons) a methane emission factor of **0.540 kgCH<sub>4</sub>/kgBOD** should be assumed. The average nitrous oxide emission factor for the treatment is **0.013 kgN<sub>2</sub>O-N/kgN**. Check the topic "**How to choose an emission factor for treatment if my WWTP has two or more technologies**" to understand this choice.
- We will **not consider removing sludge** from processes.
- The treated effluent is **discharged into a river**.

Start by performing the General Setup on the Configuration tab:

1. Let's use the GWP Report IPCC 5th AR CCF.
2. The assessment period will be the full year of 2021.
3. The assessment will take place at a facility in the United States.
4. In the USA around 50% of the food waste is disposed of in sewers through the sinks, so the Non consumed protein added to the wastewater is higher. Let's consider a value of 1.13, according to IPCC table 6.10A (Volume 5, 2009).
5. For the other General factors, we will keep the values suggested by ECAM, since we don't have local or official factors to replace them.

### Answer the following questions:

- A. How much is the **total GHG emissions** generated in the Wastewater Treatment Stage (**treatment + discharge + electricity**)?
- B. How much is the GHG emission of the Wastewater Treatment Stage **per serviced population** (**treatment + discharge + electricity**)?
- C. Which of the considered gases - **carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O)** - generate **the most significant GHG emissions** and how much is their **corresponding emission** in CO<sub>2eq</sub> (**treatment + discharge + electricity**)?

## Conduct a complete assessment of an Urban Water Utility

The Urban Water Utility "Visionary Water (VW)" is preparing an inventory of greenhouse gas emissions from the systems it operates, which include water and sanitation facilities. VW must therefore assess its main sources of GHG emissions.

### Types of emissions that will be considered in this exercise:

- Water Abstraction, Treatment, and Distribution:
  - Emissions from Electricity (indirect) and Fuel engines.
- Sanitation Collection:
  - Emissions from Discharge to water body (untreated)
- Sanitation Treatment:
  - Emissions from Electricity (indirect).
  - Emissions from Treatment process and from Discharged water.
  - Emissions from Biogas (anaerobic digestion of sludge)

Relevant information was accessed in the urban water utility database. They were organized according to each stage of the ECAM tool:

- Water Abstraction:
  - The system is composed of pumps and equipment transporting water from a river using energy from the grid. In the year 2019, the system consumed **3,200,000 kWh** of electrical energy. The backup power supply system consists of **gasoline engines** and consumed **65,000 liters** in the year 2019.
- Water Treatment:
  - The drinking water treatment system consumed **850,000 kWh** of electrical energy from the grid in the year 2019. The backup system is also composed of gasoline engines and consumed **10,000 liters** in the same year.
- Water Distribution:
  - The system is composed of boosters that supply additional pressure when necessary. It consumed 3,800,000 kWh in the year 2019. The backup power supply system consists of **diesel engines** and consumed **22,000 liters** in the year 2019.
- Sanitation Collection:
  - The population connected to the sewer system is **150,000 people**.
  - VW wants to include in the scope the emissions related to the **Discharge to water body (untreated)**, since part of the collection system is not yet connected to a wastewater treatment plant. **15% of the volume of collected wastewater** is not yet being treated and is being discharged into water bodies about which the utility has no information.

- The sanitation collection system is **100% gravitational**. Electricity consumption will not be considered.
- Sanitation Treatment:
  - **85% of the 150,000 people** connected to the sewer system **are being serviced** by the WWTP.
  - The **technology** adopted at the WWTP is activated sludge, a **centralized aerobic treatment system composed of primary + secondary treatment**.
  - The WWTP electricity consumption is entirely from the grid, with a total of **4,100,000 kWh** in 2019.
  - The treated wastewater is discharged to River Melbourne.
  - The operational control shows that the system **produced 3,000 tonnes of sludge (dry weight) in 2019**.
  - The sludge is treated anaerobically in a **sludge digester** that produces biogas with **65% metered (measured) methane concentration**, where **98% of the production is flared** and approximately **2% is lost or released to the atmosphere**. The digested sludge is sent to landfilling.
  - Sludge emissions that occur OUTSIDE of the WWTP, ie, those related to the final disposal of the digested sludge, will not be considered. This decision refers to the scope defined by the utility.

Start by performing the General Setup on the Configuration tab:

1. Let's use the GWP Report IPCC 5th AR CCF.
2. The assessment period will be the full year of 2019.
3. The assessment will take place in Australia.
4. For the General factors, we will keep the values suggested by ECAM, since we don't have local or official factors to replace them.

### **Answer the following questions:**

- A. How much GHG emissions are generated for each of the emissions requested by the exercise ( $\text{CO}_{2\text{eq}}$ )?

Water Abstraction	Electricity (indirect)	
	Fuel engines	
Water Treatment	Electricity (indirect)	
	Fuel engines	
Water Distribution	Electricity (indirect)	
	Fuel engines	
Sanitation Collection	Discharge to water body (untreated)	
	Electricity (indirect)	
	Treatment process	
Sanitation Treatment	Biogas (anaerobic digestion of sludge)	
	Discharged water	

- B. Is the greater consumption of electrical energy associated with the Utility's Water supply or Sanitation systems? Rank the stages according to the highest energy consumption (in  $\text{CO}_{2\text{eq}}$ ) in the reference year.
- C. Which gas has the greatest absolute representation of emissions for the utility (in  $\text{CO}_{2\text{eq}}$ )? And which gas has the highest unitary generation and in which stage (in  $\text{CO}_{2\text{eq}}$ )?

# Results for the proposed exercises

## Calculate emissions from a water pumping facility in the Distribution Stage

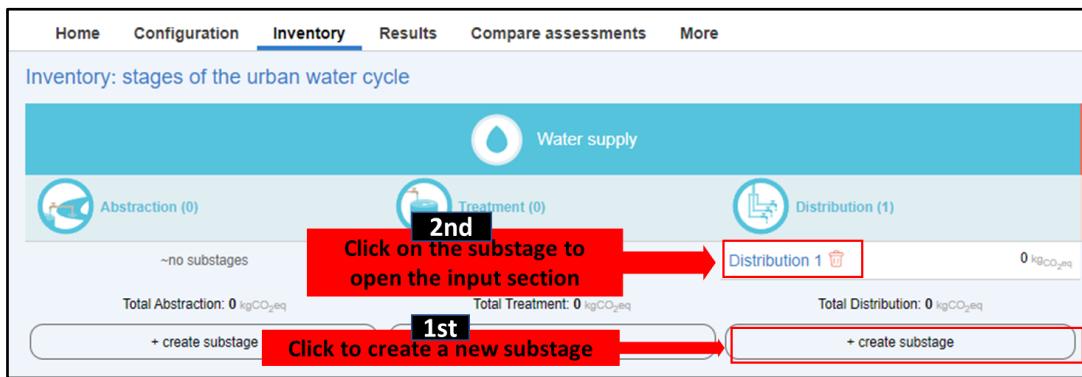
The first thing to do is to prepare the Configuration tab according to the specifications.

1. Select the GWP Report IPCC 5th AR CCF.
2. Select the name of your assessment.
3. Select the assessment period to consider the full complete year of 2021. Remember to choose it from the 1<sup>st</sup> of January to the 1<sup>st</sup> of January.
4. Select the country where the facility is located (Guatemala)
5. There is no local data for the general factors, so we will use the ECAM suggestions.

The screenshot shows the 'Configuration' tab of the WaCCliM software. Step 1 highlights the 'Select Global Warming Potential Report' dropdown set to 'IPCC 5th AR (2014/2013) CCF'. Step 2 highlights the 'Assessment period' section with 'Memory city' selected. Step 3 highlights the date range 'From: 01/01/2021 To: 01/01/2022 365 days'. Step 4 highlights the 'Country' dropdown set to 'Guatemala'. Step 5 highlights the 'ECAM suggestions' table for GTQ currency, showing values for various factors like Emission factor for grid electricity (0,564 kgCO<sub>2</sub>/kWh), Annual protein consumption per capita (23,166.842 kg/person/year), and BOD<sub>5</sub> generation (40 g/person/day). A blue button at the bottom right says 'Access inventory'.

Factor	Value	Unit
Emission factor for grid electricity	0,564	kgCO <sub>2</sub> /kWh
Annual protein consumption per capita	23,166.842	kg/person/year
BOD <sub>5</sub> generation (wastewater)	40	g/person/day
Industrial and commercial co-discharged protein into the sewer	1,25	kgN/kgN
Non consumed protein added to the wastewater	1	kgN/kgN
Additional Nitrogen from household products added to the wastewater	1,1	kgN/kgN

As a next step, let's access the Inventory tab and create a substage in the Distribution stage.



Within the created substage, it will be necessary to fill in the information:

1. The pump system consumed **1,500,000 kWh/year from the grid**.
2. The backup power supply system for the distribution pumps is made up of **onsite diesel engines**.
3. These engines operated a few days throughout the year due to grid failures or scheduled maintenance. In total, **20,000 liters of diesel** were consumed in 2021.

INPUTS	
Enter the values for this stage	
<input type="checkbox"/> Highlight mode	
Serviced population wsd_serv_pop	0 people
Volume of water injected to distribution wsd_vol_dist	0 m <sup>3</sup>
Energy consumed from the grid wsd_nrg_cons	1 1,500,000 kWh
Emission factor for grid electricity wsd_conv_kwh	0.56 kgCO <sub>2</sub> eq/kWh
<b>▼ Do you have fuel engines?</b> <input type="radio"/> No <input checked="" type="radio"/> Yes	
Fuel type (engines) wsd_fuel_typ	2 (0) Diesel
Volume of fuel consumed (engines) wsd_vol_fuel	3 20,000 L

Now answer the following questions.

- A. How much GHGs are generated in **Electricity (indirect)**, **Fuel engines**, and **Total GHG water distribution** in CO<sub>2</sub>eq?

Distribution (1)

Total Distribution: 899,733 kgCO<sub>2</sub>eq

~no substages

+ create substage

Collection (0)

Total Collection: 0 kgCO<sub>2</sub>eq

+ create substage

Substage name:

(11)  Energy Performance (14)  Costs (2)

Highlight mode

0 people

0 m<sup>3</sup>

1,500,000 kWh

show outputs

Click to open the Output section

The Outputs section shows the results of the requested calculations. In the image below, we can see the result for the emissions referring to **Electricity from the grid (846,000 kg CO<sub>2</sub>eq)**, **Fuel Engines 53,733 CO<sub>2</sub>eq**, and **Total Emissions in Water Abstraction (899,733 CO<sub>2</sub>eq)**.

OUTPUTS — <input type="button" value="hide outputs"/>		Value	Σ sum (1 substages)	Unit
<b>Electricity (indirect)</b> wsd_KPI_GHG_elec	kgCO <sub>2</sub> eq	846,000	846,000	kgCO <sub>2</sub> eq
<b>Fuel engines</b> wsd_KPI_GHG_fuel	kgCO <sub>2</sub> eq/year	53,733	53,733	kgCO <sub>2</sub> eq
<b>Total GHG water distribution</b> wsd_KPI_GHG	kgCO <sub>2</sub> eq/year/serv.pop.	899,733	899,733	kgCO <sub>2</sub> eq

- B. The utility would also like to know how many **kg of CO equivalent** are generated **per year by each inhabitant** served by the distribution system. This result will be used for benchmarking with other utilities. The population serviced is 50,000 inhab.

Fill in the population data and change the unit shown in the Output section.

**Water supply > Distribution > Distribution 1**

**Change the unit for the outputs**

INPUTS	OUTPUTS
Enter the values for this stage	GHG emissions
Serviced population wsd_serv_pop	<b>kgCO<sub>2</sub>eq</b> <b>kgCO<sub>2</sub>eq/year</b> <b>kgCO<sub>2</sub>eq/year/serv.pop.</b>
Volume of water injected to distribution wsd_vol_dist	Value   Σ sum (1 substages) Unit
Energy consumed from the grid wsd_nrg_cons	Electricity (indirect) wsd_KPI_GHG_elec   846,000   846,000 kgCO <sub>2</sub> eq
Emission factor for grid electricity Estimation: 0.56 kgCO <sub>2</sub> eq/kWh wsd_conv_kwh	Fuel engines wsd_KPI_GHG_fuel   53,733   53,733 kgCO <sub>2</sub> eq
<b>Fill in population data</b>	Total GHG water distribution wsd_KPI_GHG   899,733   899,733 kgCO <sub>2</sub> eq
<b>Do you have fuel engines?</b>	Energy consumption per volume injected to distribution wsd_KPI_nrg_per_vd   ~Missing_inputs   kWh/m <sup>3</sup>
Fuel type (engines) wsd_fuel_typ	(0) Diesel
Volume of fuel consumed (engines) wsd_vol_fuel	20,000 L

Once you have changed the units, you can check the updated results in the Outputs section. In the image below, we can see the result for the emissions (**kgCO<sub>2</sub>eq/year/serv.pop.**) referring to **Electricity from the grid (16.92)**, **Fuel Engines (1.07)**, and **Total Emissions in Water Abstraction (17.99)**.

OUTPUTS	Value	Σ sum (1 substages)	Unit
GHG emissions			
<b>kgCO<sub>2</sub>eq</b> <b>kgCO<sub>2</sub>eq/year</b> <b>kgCO<sub>2</sub>eq/year/serv.pop.</b>			
Electricity (indirect) wsd_KPI_GHG_elec	16.92	16.92	kgCO <sub>2</sub> eq/year/serv.pop.
Fuel engines wsd_KPI_GHG_fuel	1.07	1.07	kgCO <sub>2</sub> eq/year/serv.pop.
<b>Total GHG water distribution</b> wsd_KPI_GHG	17.99	17.99	kgCO <sub>2</sub> eq/year/serv.pop.

## Calculate emissions from a WWTP

In this exercise, the proposal was to calculate the **GHG emissions of a WWTP** that uses a process composed of an **anaerobic lagoon** followed by a  **facultative lagoon** in the treatment of wastewater.

First, start your assessment, or create a new one under the Configuration tab.

Now you will need to prepare the Configuration tab considering the following information:

1. Let's use the GWP Report IPCC 5th AR CCF.
2. The assessment period will be the full year of 2021.
3. The assessment will take place at a facility in the United States.

- In the USA around 50% of the food waste is disposed of in sewers through the sinks, so the Non consumed protein added to the wastewater is higher. Let's consider a value of 1.13, according to IPCC table 6.10A (Volume 5, 2009).
- For the other General factors, we will keep the values suggested by ECAM, since we don't have local or official factors to replace them.

**Configuration**

- Load and save file
- List of assessments

Select Global Warming Report: **1** IPCC 5th AR (2014/2013) CCF

Assessment period	GHG (kgCO <sub>2</sub> eq)	Energy (kWh)	Substages	Options
2021-01-01 2022-01-01 (365 days)	0	0	0	<a href="#">settings</a> <a href="#">duplicate</a>

change assessment name

Assessment period: From: 01.01.2021 To: 01.01.2022 **2**

Currency: Select **3** United States of America

Emission factor for grid electricity  
Annual protein consumption per capita  
BOD<sub>5</sub> generation (wastewater)  
Industrial and commercial co-discharged protein into the sewer  
Non consumed protein added to the wastewater **4** 1.13  
Additional Nitrogen from household products added to the wastewater

USD

Currency	Value
kgCO <sub>2</sub> /kWh	0,418
kg/person/year	33.21208
g/person/day	85
kgN/kgN	1,25
kgN/kgN	1,13
kgN/kgN	1,1

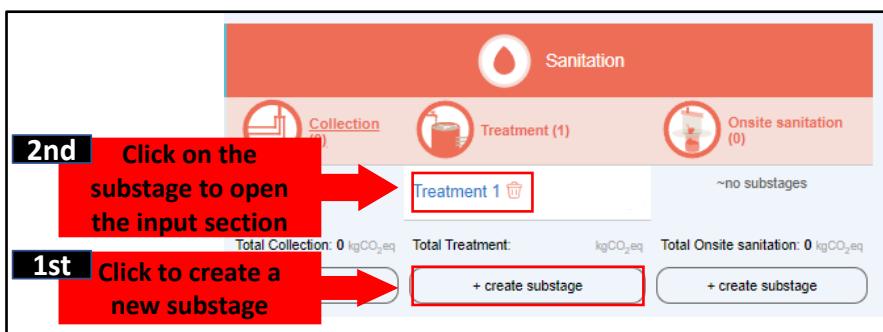
Access inventory

Comments

+ create new assessment

+ Load assessment from Excel file

The next step will be to create a substage within the Wastewater Treatment stage.



Now you must fill in the Input Section according to the data provided by the exercise.

- The population serviced by the wastewater treatment system is **200,000 people**.
- When filling in the serviced population, ECAM will suggest some **estimates** for the inputs (**green squares**). These values are also calculated based on the General Factors selected in the

Configuration tab (for example, from the BOD generated per capita it is possible to calculate the Load of Influent BOD to the WWTP<sup>21</sup>). **To use estimates, click on the suggested value.**

3. We do not have information about the BOD load in the effluent (there is no monitoring in the WWTP). It would be possible to calculate it from the efficiency of our process, but we are not sure about this data either. In this sense, we are going to use the **dropdown menu** offered by ECAM, selecting the technology we have. The system of lagoons is a primary + secondary process. **The software also calculates the value in kg/year.**
4. If you don't have WWTP affluent monitoring data, you should also use estimation for the Nitrogen load in the influent. **To use estimates, click on the suggested value.**
5. Like step 3, we can calculate the Total Nitrogen load in the effluent from the dropdown menu. **Select the "primary + secondary process" option.**
6. Considering the technological composition of the treatment process (anaerobic + facultative lagoons) a methane emission factor of **0.540 kgCH<sub>4</sub>/kgBOD** should be assumed. The average nitrous oxide emission factor for the treatment is **0.013 kgN<sub>2</sub>O-N/kgN**. Check the topic "**How to choose an emission factor for treatment if my WWTP has two or more technologies**" to understand this choice. **To choose these factors, you have to fill them in directly.**
7. The discharge emission factor is defined based on the type of discharge and the level of information that we have:
  - For CH<sub>4</sub> emission factor (discharge):
    - We have information about the water body of discharge, we know it is a specific river (Level 2).
    - The BOD load data used are estimated by ECAM from the efficiency of our process, also based on an influent BOD estimate (Level 1).
    - Based on this, **choose the factor 0.068.**
  - For the N<sub>2</sub>O emission factor (discharge):
    - There is information about the water body, but there is no measurement of nutrients (Level 2).
    - Based on this, **choose the factor 0.005.**
8. The WWTP electricity consumption is entirely from the grid, with a total of **140,000 kWh** in 2021.
9. The emission factor for grid electricity comes from the General factors in the Configuration tab.

---

<sup>21</sup> Check more about that in the Methodology Guide.

INPUTS		Outputs	
Enter the values for this stage		<input type="checkbox"/> Highlight mode	
Serviced population wwt_serv_pop		<b>1</b>	200,000 people
Volume of treated wastewater wwt_vol_trea		<b>2</b>	Estimation: 14,600,000 m <sup>3</sup>
Volume of discharged effluent to water body wwt_vol_disc		<b>2</b>	Estimation: 14,600,000 m <sup>3</sup>
Influent BOD <sub>5</sub> load wwt_bod_infl		<b>2</b>	Estimation: 6,205,000 kg
Effluent BOD <sub>5</sub> load wwt_bod_eff		<b>2</b>	930,750 kg
<b>3</b>	Primary + Secondary (biological treatment plants) [15 %] (930,750 kg)	<b>4</b>	14,600,000 m <sup>3</sup>
Total Nitrogen load in the influent wwt_tn_infl		<b>4</b>	14,600,000 m <sup>3</sup>
Total Nitrogen load in the effluent wwt_tn_eff		<b>4</b>	6,205,000 kg
<b>5</b>	Primary + Secondary (biological treatment plants) [60 %] (990,783 kg)	<b>4</b>	930,750 kg
CH <sub>4</sub> emission factor (treatment) wwt_ch4_efac_tre		<b>6</b>	1,651,305 kg
Custom value		<b>6</b>	990,783 kg
N <sub>2</sub> O emission factor (treatment) wwt_n2o_efac_tre		<b>6</b>	kgCH <sub>4</sub> /kgBOD
Custom value		<b>6</b>	0.013 kgN <sub>2</sub> O-N/kgN
CH <sub>4</sub> emission factor (discharge) wwt_ch4_efac_dis		<b>6</b>	0.068 kgCH <sub>4</sub> /kgBOD
<b>7</b>	Discharge to aquatic environments (Tier 1) (0.068)	<b>6</b>	0.005 kgN <sub>2</sub> O-N/kgN
N <sub>2</sub> O emission factor (discharge) wwt_n2o_efac_dis		<b>8</b>	kgCH <sub>4</sub> /kgBOD
Freshwater, estuarine, and marine discharge (Tier 1) (0.005)		<b>8</b>	0.005 kgN <sub>2</sub> O-N/kgN
Energy consumed from the grid wwt_nrg_cons		<b>8</b>	140,000 kWh
Emission factor for grid electricity wwt_conv_kwh		<b>9</b>	kgCO <sub>2</sub> eq/kWh
Sludge removed from wastewater treatment (dry weight) wwt_mass_slu		<b>9</b>	0.42 kgCO <sub>2</sub> eq/kWh
Type of treatment undefined → [0 gSS/inhabitant/day] → (0 kg)		<b>9</b>	0 kg
BOD <sub>5</sub> removed as sludge wwt_bod_slu		<b>9</b>	0 kg
Mechanical treatment plants (primary sedimentation sludge) → [0.5 kgBOD/kg dry mass sludge] → (0 kg)		<b>9</b>	0 kg

Now answer the questions:

- A. How much is the total GHG emission generated in the Wastewater Treatment Stage (treatment + discharge + electricity)?

The Outputs section shows the results of the requested calculations.

Population with open defecation				
Solutions	<input type="checkbox"/> Pump Efficiency (10)	<input type="checkbox"/> Sludge Management (41)	<input type="checkbox"/> Energy Performance (14)	<input type="checkbox"/> Costs (2)
<input type="checkbox"/> Highlight mode				
<input type="button" value="show outputs"/> <div style="background-color: red; color: white; padding: 5px; text-align: center;"> <b>Click to open the Output section</b> </div>				
200,000 people 14,600,000				

In the image below, we can see the result for the emissions referring to **Total GHG wastewater treatment (128,506,732 kg CO<sub>2</sub>eq)**.

OUTPUTS — <a href="#">hide outputs</a>		Value	$\Sigma$ sum (1 substages)	Unit
GHG emissions	<a href="#">kgCO<sub>2</sub>eq</a> <a href="#">kgCO<sub>2</sub>eq/year</a> <a href="#">kgCO<sub>2</sub>eq/year/serv.pop.</a>			
<b>Electricity (indirect)</b> <a href="#">wwt_KPI_GHG_elec</a>		58,520	58,520	kgCO <sub>2</sub> eq
<b>Treatment process</b> <a href="#">wwt_KPI_GHG_tre</a>		123,976,471	123,976,471	kgCO <sub>2</sub> eq
<b>Sludge management</b> <a href="#">wwt_KPI_GHG_slu</a>		0	0	kgCO <sub>2</sub> eq
<b>Discharged water</b> <a href="#">wwt_KPI_GHG_disc</a>		4,471,741	4,471,741	kgCO <sub>2</sub> eq
<b>Total GHG wastewater treatment</b> <a href="#">wwt_KPI_GHG</a>		128,506,732	128,506,732	kgCO <sub>2</sub> eq

B. How much is the GHG emission of the Wastewater Treatment stage per capita (treatment + discharge + electricity)

To answer this question, select the unit kg CO<sub>2</sub>eq/year/pob.serv. The result is **642.5 kg CO<sub>2</sub>eq/year/pob.serv.**

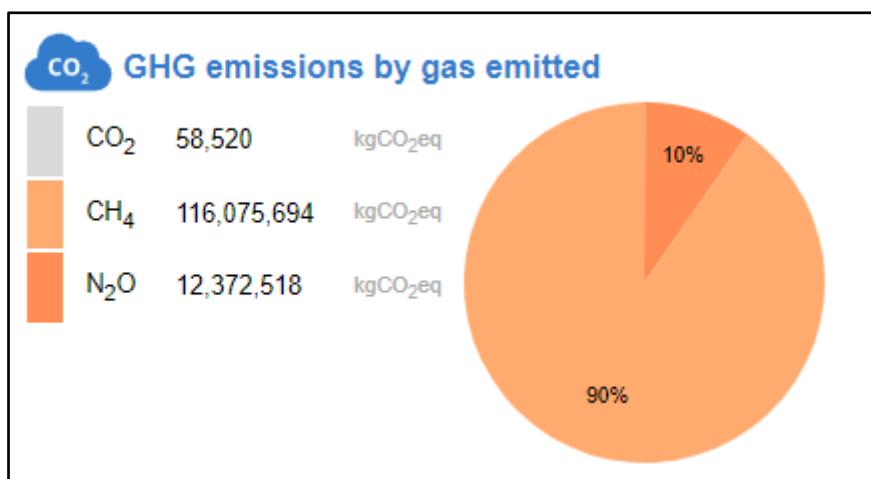
OUTPUTS — <a href="#">hide outputs</a>		Value	$\Sigma$ sum (1 substages)	Unit
GHG emissions	<a href="#">kgCO<sub>2</sub>eq</a> <a href="#">kgCO<sub>2</sub>eq/year</a> <a href="#">kgCO<sub>2</sub>eq/year/serv.pop.</a>			
<b>Electricity (indirect)</b> <a href="#">wwt_KPI_GHG_elec</a>		0.29	0.29	kgCO <sub>2</sub> eq/year/serv.pop.
<b>Treatment process</b> <a href="#">wwt_KPI_GHG_tre</a>		619.9	619.9	kgCO <sub>2</sub> eq/year/serv.pop.
<b>Sludge management</b> <a href="#">wwt_KPI_GHG_slu</a>		0	0	kgCO <sub>2</sub> eq/year/serv.pop.
<b>Discharged water</b> <a href="#">wwt_KPI_GHG_disc</a>		22.36	22.36	kgCO <sub>2</sub> eq/year/serv.pop.
<b>Total GHG wastewater treatment</b> <a href="#">wwt_KPI_GHG</a>		642.5	642.5	kgCO <sub>2</sub> eq/year/serv.pop.

C. Which of the gases considered - carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) - generate the most significant GHG emissions and how much is their corresponding emission in CO<sub>2</sub>eq (treatment + discharge + electricity)?

To answer this question, click on the tab **Results**, and in **Summary** you should click on “**Charts GHG**”.

The screenshot shows the ECAM software interface. At the top, there's a blue header bar with the text "ECAM Energy Performance and Carbon Emissions Assessment and Monitoring Tool v3.0.0 EN". Below the header, there's a navigation bar with tabs: Home, Configuration, Inventory, Results (which is highlighted with a red box), Compare assessments, More, and a status message: "You are editing USA WWTP assessment 128,506,732 kgCO<sub>2</sub>eq 365 days 0.42 kgCO<sub>2</sub>/kWh". Under the Results tab, there are three sub-tabs: Summary (highlighted with a red box), Sankey diagram, and Report. Below these tabs, the text "Summary: GHG emissions and energy consumption" is displayed. At the bottom of the interface, there are buttons for Table, Charts GHG (highlighted with a red box), Charts Energy, and Charts Serviced population, along with a "Select units" dropdown menu set to "kgCO<sub>2</sub>eq".

The third graph will show the emissions by GHG.



## Conduct a complete assessment of an Urban Water Utility

In this exercise, the proposal was to calculate the **GHG emissions of an Urban Water Utility**, "**Visionary Water (VW)**", which was preparing an inventory of greenhouse gas emissions from its water and sanitation facilities.

First, start your assessment, or create a new one under the Configuration tab.

Now you will need to prepare the Configuration tab considering the following information:

1. Let's use the GWP Report IPCC 5th AR CCF.
2. The assessment period will be the full year of 2019.
3. The assessment will take place in Australia.
4. For the General factors, we will keep the values suggested by ECAM, since we don't have local or official factors to replace them.

**Configuration**

- ▶ Load and save file
- ▼ List of assessments

		Assessment period	GHG (kgCO <sub>2</sub> eq)	Energy (kWh)	Substages	Options
	Visionary Water	2019-01-01 2020-01-01 (365 days)	20,620,735	11,950,000	5	<a href="#">settings</a> <a href="#">duplicate</a>

[change assessment name](#)

**Assessment period**

2 From: 01/01/2019 To: 01/01/2020 365 days

**Country**

Select Australia [More info](#) 3

Currency	kgCO <sub>2</sub> /kWh
AUD	0,646
30,934480000000004	kg/person/year
60	g/person/day
1,25	kgN/kgN
1,1	kgN/kgN
1,1	kgN/kgN

[Access inventory](#)

[Comments](#)

The next step will be to create a substage within each one of the stages (Water Abstraction, Water Distribution, Water Treatment, Sanitation Collection, and Sanitation Treatment).

Inventory: stages of the urban water cycle [Save file](#)

Water supply		Sanitation	
	Abstraction (1)		Treatment (1)
	Distribution (1)		Collection (1)
	Treatment (1)		Onsite sanitation (0)

Click on the substage to open the input section 2nd

Click to create a new substage 1st

Abstraction 1 [Delete](#) 0 kgCO<sub>2</sub>eq Treatment 1 [Delete](#) 0 kgCO<sub>2</sub>eq Distribution 1 [Delete](#) 0 kgCO<sub>2</sub>eq Collection 1 [Delete](#) 0 kgCO<sub>2</sub>eq Treatment 1 [Delete](#) 0 kgCO<sub>2</sub>eq ~no substages

Total Abstraction: 0 kgCO<sub>2</sub>eq Total Treatment: 0 kgCO<sub>2</sub>eq Total Distribution: 0 kgCO<sub>2</sub>eq Total Collection: 0 kgCO<sub>2</sub>eq Total Treatment: 0 kgCO<sub>2</sub>eq Total Onsite sanitation: 0 kgCO<sub>2</sub>eq

[+ create substage](#) [+ create substage](#)

Now you must fill in the Input Section according to the data provided by the exercise.

## Water Abstraction

1. The energy consumption is **3,200,000 kWh**.
2. The fuel is **gasoline**.
3. Fuel consumption is **65,000 liters**.

**INPUTS**  
Enter the values for this stage  Highlight mode

Volume of abstracted water <i>wsa_vol_conv</i>	0 <input type="button" value="m3"/>
Energy consumed from the grid <i>wsa_nrg_cons</i>	1 3,200,000 <input type="button" value="kWh"/>
Emission factor for grid electricity Estimation: 0.65 kgCO <sub>2</sub> eq/kWh <i>wsa_conv_kwh</i>	0.65 kgCO <sub>2</sub> eq/kWh
<b>▼ Do you have fuel engines?</b> <input checked="" type="radio"/> No <input type="radio"/> Yes	
Fuel type (engines) <i>wsa_fuel_typ</i>	2 (1) Gasoline/Petrol
Volume of fuel consumed <i>wsa_vol_fuel</i>	3 65,000 <input type="button" value="L"/>

## Water Treatment

1. The energy consumption is **850,000 kWh**.
2. The fuel is **gasoline**.
3. Fuel consumption is **10,000 liters**.

**INPUTS**  
Enter the values for this stage  Highlight mode

Volume of treated water <i>wst_vol_trea</i>	0 <input type="button" value="m3"/>
Treatment type (potabilization chain) <i>wst_treatment</i>	(0) None
Energy consumed from the grid <i>wst_nrg_cons</i>	1 850,000 <input type="button" value="kWh"/>
Emission factor for grid electricity Estimation: 0.65 kgCO <sub>2</sub> eq/kWh <i>wst_conv_kwh</i>	0.65 kgCO <sub>2</sub> eq/kWh
<b>▼ Do you have fuel engines?</b> <input checked="" type="radio"/> No <input type="radio"/> Yes	
Fuel type (engines) <i>wst_fuel_typ</i>	2 (1) Gasoline/Petrol
Volume of fuel consumed <i>wst_vol_fuel</i>	3 10,000 <input type="button" value="L"/>

## Water Distribution

1. The energy consumption is **3,800,000 kWh**.
2. The fuel is **diesel**.
3. Fuel consumption is **22,000 liters**.

**INPUTS**

Enter the values for this stage  Highlight mode

Serviced population wsd_serv_pop	0 people
Volume of water injected to distribution wsd_vol_dist	0 <input type="text" value="m³"/> m³
Energy consumed from the grid wsd_nrg_cons	<b>1</b> <input type="text" value="3,800,000"/> kWh
Emission factor for grid electricity Estimation: 0.65 kgCO <sub>2</sub> eq/kWh wsd_conv_kwh	0.65 kgCO <sub>2</sub> eq/kWh
<b>▼ Do you have fuel engines?</b> <input checked="" type="radio"/> No <input type="radio"/> Yes	
Fuel type (engines) wsd_fuel_typ	<b>2</b> <input type="text" value="(0) Diesel"/>
Volume of fuel consumed (engines) wsd_vol_fuel	<b>3</b> <input type="text" value="22,000"/> L

## Sanitation Collection

1. The Population connected to sewers is **150,000 people**.
2. When filling in the population, ECAM will suggest some **estimates** for the inputs (**green squares**). These values are also calculated based on the General Factors selected in the Configuration tab (for example, from the BOD generated per capita it is possible to calculate the Load of Influent BOD to the WWTP<sup>22</sup>). **To use estimates, click on the suggested value.**
3. Volume of collected wastewater untreated is 15% of our total volume of collected water. 15% of 10,950,000. **Fill in 1,642,500 m<sup>3</sup>.**
4. Use the estimation tool to calculate the next data.
5. The discharge emission factor is defined based on the [type of discharge](#) and the [level of information](#) that we have (To recall the criteria of this analysis, access topic "**How to choose an emission factor for discharge (using Tiers)**")
  - For CH<sub>4</sub> emission factor (untreated collected wastewater):
    - We do not have information on the water body of discharge (Level 1)
    - The BOD load data used are estimated by the ECAM from the General Factors (per capita generation averages) (Level 1).
    - Based on this, **choose the factor 0.068**.
  - For the N<sub>2</sub>O emission factor (untreated collected wastewater):
    - There is no information about the water body (Level 1).
    - Based on this, **choose the factor 0.005**.
6. **There is no CH<sub>4</sub> emission factor for collected water** since the collection is made by **flowing closed sewers**.

<sup>22</sup> Check more about that in the Methodology Guide.

INPUTS	
Enter the values for this stage	
<input type="checkbox"/> Highlight mode	
Population connected to sewers wwc_conn_pop	<b>1</b> 150,000 people
Volume of collected wastewater Estimation: 10,950,000 m <sup>3</sup> wwc_vol_coll	<b>2</b> 10,950,000 m <sup>3</sup> ▾
Volume of collected wastewater untreated (e.g. CSO) Estimation: 1,642,500 m <sup>3</sup> wwc_vol_coll_unt	<b>3</b> 1,642,500 m <sup>3</sup> ▾
Volume of collected wastewater conveyed to treatment Estimation: 9,307,500 m <sup>3</sup> wwc_vol_coll_tre	<b>4</b> 9,307,500 m <sup>3</sup> ▾
BOD <sub>5</sub> load collected Estimation: 3,285,000 kg wwc_bod	<b>4</b> 3,285,000 kg ▾
Total Nitrogen load collected Estimation: 1,122,922 kg wwc_ln	<b>4</b> 1,122,922 kg ▾
CH <sub>4</sub> emission factor (untreated collected wastewater) wwc_ch4_efac_cso	0.068 kgCH <sub>4</sub> /kgBOD
Discharge to aquatic environments (Tie ▾)	<b>5</b>
CH <sub>4</sub> emission factor (collected wastewater) wwc_ch4_efac_col	0 kgCH <sub>4</sub> /kgBOD
(Flowing sewer (open or closed) (0) ▾)	<b>6</b>
N <sub>2</sub> O emission factor (untreated collected wastewater) wwc_n2o_efac_cso	0.005 kgN <sub>2</sub> O-N/kgN
Freshwater, estuarine, and marine disch ▾	<b>5</b>
N <sub>2</sub> O emission factor (collected wastewater) (default: 0) wwc_n2o_efac_col	0 kgN <sub>2</sub> O-N/kgN
Energy consumed from the grid wwc_nrg_cons	0 kWh ▾
Emission factor for grid electricity Estimation: 0.65 kgCO <sub>2</sub> eq/kWh wwc_conv_kwh	0.65 kgCO <sub>2</sub> eq/kWh

## Sanitation Treatment

1. The population serviced by the wastewater treatment system is 127,500 **people**.
2. When filling in the serviced population, ECAM will suggest some **estimates** for the inputs (**green squares**). These values are also calculated based on the General Factors selected in the Configuration tab (for example, from the BOD generated per capita it is possible to calculate the Load of Influent BOD to the WWTP<sup>23</sup>). **To use estimates, click on the suggested value**.
3. We do not have information about the BOD load in the effluent (there is no monitoring in the WWTP). It would be possible to calculate it from the efficiency of our process, but we are not sure about this data either. In this sense, we are going to use the **dropdown menu** offered by

<sup>23</sup> Check more about that in the Methodology Guide.

ECAM, selecting the technology we have. **Choose the “Primary + Secondary biological treatment plants”.**

4. Since you don't have Nitrogen influent monitoring data, you should also use estimation for the Nitrogen load in the influent. **To use estimates, click on the suggested value.**
5. Like step 3, we can calculate the Total Nitrogen load in the effluent from the dropdown menu. **Select the " Primary + Secondary biological treatment plants " option.**
6. Choose the centralized aerobic treatment plant option in the dropdown menus since we have activated sludge as our technology.
7. The discharge emission factor is defined based on the type of discharge and the level of information that we have:
  - For CH<sub>4</sub> emission factor (discharge):
    - We have information about the water body of discharge, we know it is a specific river (Level 2).
    - The BOD load data used are estimated by ECAM from the efficiency of our process, also based on an influent BOD estimate (Level 1).
    - Based on this, **choose the factor 0.068.**
  - For the N<sub>2</sub>O emission factor (discharge):
    - There is information about the water body, but there is no measurement of nutrients (Level 2).
    - Based on this, **choose the factor 0.005.**
8. We have our own data for sludge removed from the treatment. **Fill in with 3,000 tones.**
9. Since our sludge is digested in an anaerobic digester, **choose the option “Aerobic treatment plants with primary treatment and anaerobic sludge digestion”.**

**INPUTS**  
Enter the values for this stage

Highlight mode

Serviced population <code>wwt_serv_pop</code>	<b>1</b> 127,500 people
Volume of treated wastewater <code>wwt.vol_trea</code>	Estimation: 9,307,500 m <sup>3</sup>
Volume of discharged effluent to water body <code>wwt.vol_disc</code>	Estimation: 9,307,500 m <sup>3</sup>
Influent BOD <sub>5</sub> load <code>wwt.bod_infl</code>	Estimation: 2,792,250 kg
Effluent BOD <sub>5</sub> load <code>wwt.bod_effl</code>	2,792,250 kg
Primary + Secondary (biological treatment plants) [15 %] (418,838 kg)	<b>3</b> 418,838 kg
Total Nitrogen load in the influent <code>wwt.tn_infl</code>	Estimation: 954,483 kg
Total Nitrogen load in the effluent <code>wwt.tn_effl</code>	572,690 kg
Primary + Secondary (biological treatment plants) [60 %] (572,690 kg)	<b>4</b> 572,690 kg
CH <sub>4</sub> emission factor (treatment) <code>wwt.ch4_efac_tre</code>	0.018 kgCH <sub>4</sub> /kgBOD
Centralised, aerobic, treatment plant (0.018)	
N <sub>2</sub> O emission factor (treatment) <code>wwt.n2o_efac_tre</code>	0.016 kgN <sub>2</sub> O-N/kgN
Centralised, aerobic, treatment plant (0.016)	
CH <sub>4</sub> emission factor (discharge) <code>wwt.ch4_efac_dis</code>	0.068 kgCH <sub>4</sub> /kgBOD
Discharge to aquatic environments (Tier 1) (0.068)	
N <sub>2</sub> O emission factor (discharge) <code>wwt.n2o_efac_dis</code>	0.005 kgN <sub>2</sub> O-N/kgN
Freshwater, estuarine, and marine discharge (Tier 1) (0.005)	
Energy consumed from the grid <code>wwt.nrg_cons</code>	4,100,000 kWh
Emission factor for grid electricity <code>wwt.conv_kwh</code>	Estimation: 0.65 kgCO <sub>2</sub> eq/kWh
Sludge removed from wastewater treatment (dry weight) <code>wwt.mass_slu</code>	0.65 kgCO <sub>2</sub> eq/kWh
Custom value	
BOD <sub>5</sub> removed as sludge <code>wwt.bod_slu</code>	<b>8</b> 3,000 t
Aerobic treatment plants with primary treatment and anaerobic sludge digestion (mixed primary and secondary sludge, treated anaerobically)	<b>9</b> 3,000 t

Since we are also accounting for the biogas emissions within the anaerobic digestion, you have to activate the option “Are you producing biogas from anaerobic digestion”.

Once you did that, you have to:

1. Use the estimation option to estimate the production of biogas (**1,152,000 Nm<sup>3</sup>**). We also know that our case follows the ECAM suggestion when it comes to the percentage of biogas flared (**98%**) and leaked to the atmosphere (**2%**).
2. Since we monitor ao biogas, we know **it has 65% of methane**. Fill in this information.

▼ Are you producing biogas from anaerobic digestion?

No  Yes

Biogas produced (volume) www.biog_pro	Estimation: 1,152,000 Nm <sup>3</sup>	1,152,000 Nm <sup>3</sup>
Biogas flared (% volume) www.biog_fla	Estimation: 98 %	98 %
Biogas valorised as heat and/or electricity (% volume) www.biog_val	Estimation: 0 %	0 %
Biogas leaked to the atmosphere (% volume) www.biog_lkd	Estimation: 2 %	2 %
Biogas sold (% volume) www.biog_sold	Estimation: 0 %	0 %
Percentage of methane in the biogas (% volume) www.ch4_biog	65 %	65 %
Fuel type (digester) www.dige_typ	(0) Diesel	L
Fuel consumed for the digester www.fuel_dig	0 L	0 L
Energy efficiency for biogas valorization with respect to the theoretical maximum www.nrg_biog_eff	43 %	43 %
Electrical energy produced from biogas valorization www.nrg_biog	Estimation: 0 kWh	0 kWh

Now answer the questions:

- A. How much GHG emissions are generated for each of the emissions requested by the exercise (CO<sub>2</sub>eq)?

The emissions generated by each stage can be displayed in the Results -> Summary -> Table tab.

Home Configuration Inventory **Results** Compare assessments More

Summary Sankey diagram Report

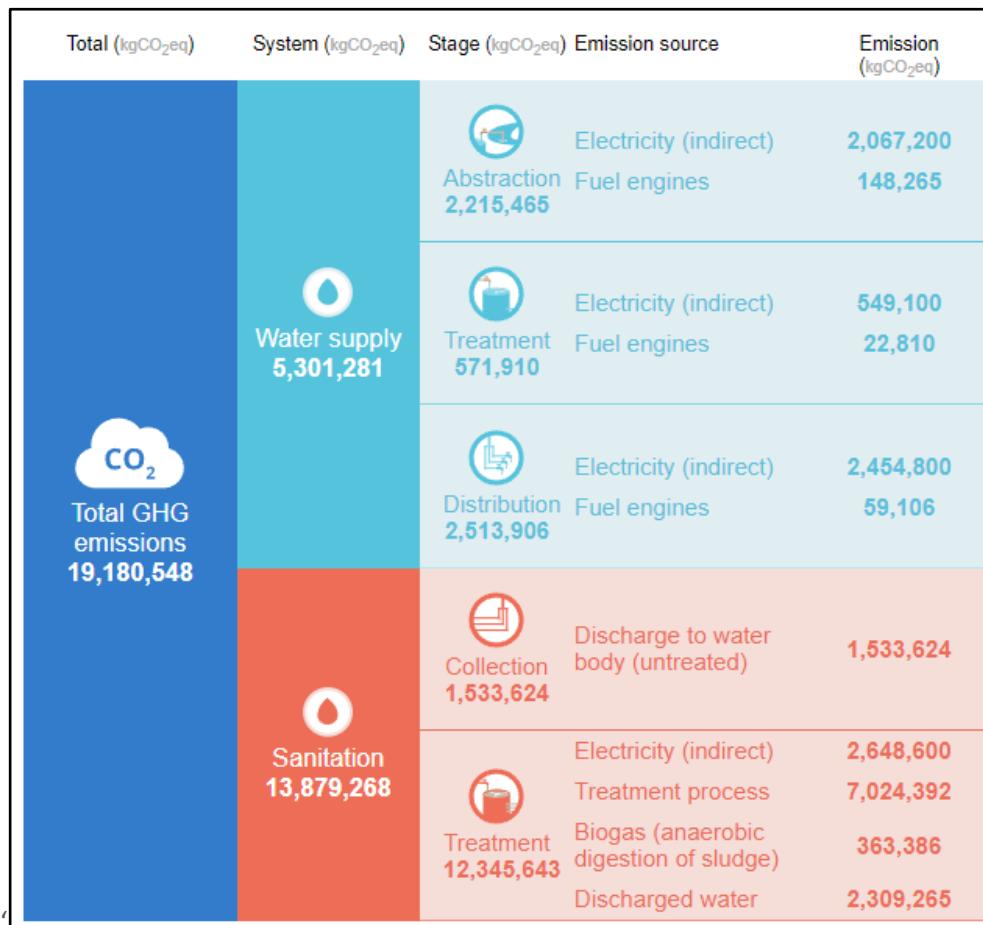
Summary: GHG emissions and energy consumption

**Table** Charts GHG Charts Energy Charts Serviced population

Select summary table  GHG  Energy

Select units kgCO<sub>2</sub>eq kWh

Show emissions in CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O  Yes  No

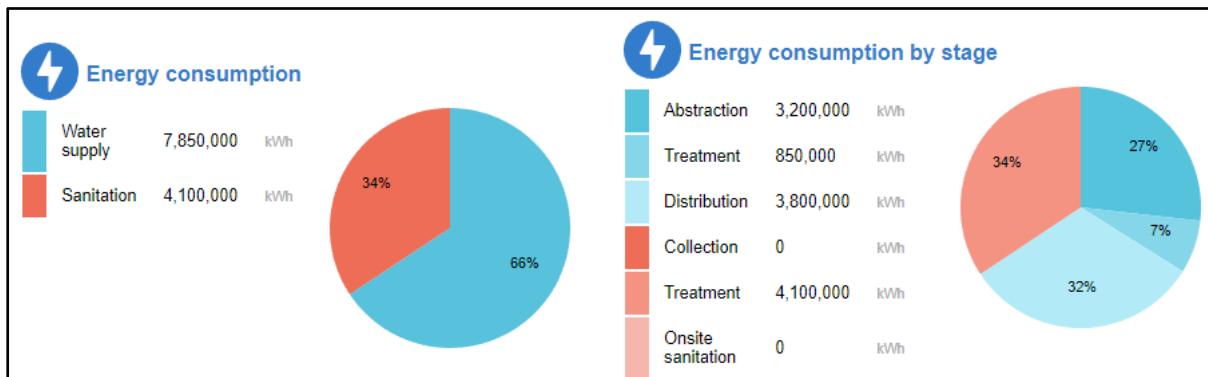


- B. Is the greater consumption of electrical energy associated with the Utility's Water supply or Sanitation systems? Rank the stages according to the highest energy consumption (in CO<sub>2</sub>eq) in the reference year.

You can check data about electricity still in the Results -> Summary tab but choosing to show the Energy Charts.

In the charts we see that the greater consumption of electricity is related to the Water supply (7,850,000 kWh). The rank for energy consumption is: Sanitation treatment > Water Distribution > Water Abstraction > Water treatment.

This approach can be interesting to initiate investigations that lead to the prioritization of actions for energy management.

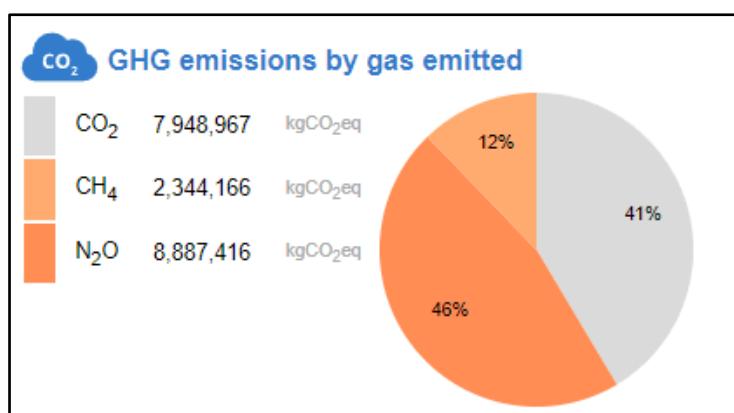


- C. Which gas has the greatest absolute representation of emissions for the utility (in CO<sub>2</sub>eq)? And which gas has the highest unitary generation and in which stage (in CO<sub>2</sub>eq)?

To check information about specific gases, go to the Charts GHG option within the Results -> Summary tab.

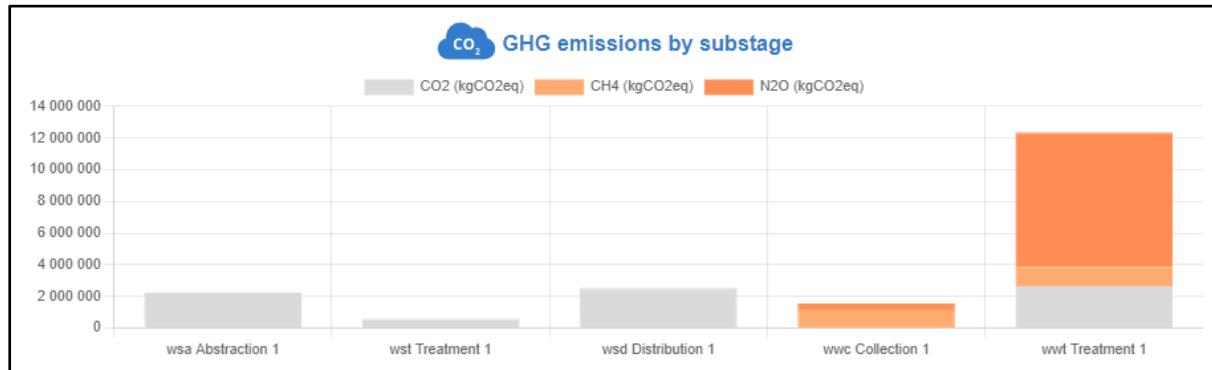


The third chart will show information about each specific GHG within the whole assessment. N<sub>2</sub>O represents the biggest absolute emission in this case (**8,887,416 kg CO<sub>2</sub>eq**).



To display the unitary emissions per gas, which is, per gas per stage, access the bar chart below the pie charts.

From this graph it will be possible to see that the largest representative of unitary emission is the N<sub>2</sub>O in the Sanitation Treatment Stage (“wwt Treatment 1”). It is interesting to note that N<sub>2</sub>O emissions, often less representative when in the unit of the gas itself, become extremely relevant when converted to equivalent CO<sub>2</sub> due to their high Global Warming Potential.



# Troubleshooting

## **What happens if I have negative emissions?**

It is important that the users consider the source of their activity data when evaluating the results in the ECAM tool. Negative results could happen when the user uses two different sources for data that compose the same equation.

To traceback a negative result, use highlight mode (topic “[How to traceback a result using the highlight function](#)”).

## **What happens if I upload data from Excel and they are not recognized by the tool?**

The reason for this is because you probably didn't follow the template suggested by the tool. Check more about it in the topic “[How to load data from excel files](#)”.

## **The .Json file that I uploaded is damaged, what do I do?**

JSON is a plain text file that can be opened in a text editor. You can easily check it and modify/save it back without any special software.

## **I want to change the emission factors given in ECAM, how do I change them?**

To change an emission factor suggested by the tool, just click on the numerical value, and fill in with your own EF.

Further information about the calculation of emission factors by ECAM is given in the [Methodology Guide](#).

## **Can I rearrange the order of my assessments in ECAM?**

You can rearrange the order in which assessments appear in your report when comparing them. To do this, follow the steps outlined in the topic “[Comparing assessments](#)”.

## **Does ECAM consider leap years?**

Yes. The ECAM tool considers leap years, but for this it will be necessary to select the assessment period properly. Check the topic “[How to start and configure a new assessment](#)”.

## Where to learn more

ECAM has a series of complementary materials for the use and understanding of the tool. They include:

- **Methodology Guide:** which presents the conceptual framework of the tool, as well as the equations and sources behind the calculations and estimates.
- **E-learning modules:** to learn interactively what was also presented in the User Manual.
- **Tutorial Video Collection:** series of videos on how to use the ECAM tool, organized by topics.
- **Factsheets, cases, and more.** To access, visit the [WaCCliM project webpage](#).

## References

- Alegre, H., Melo Baptista, K., Cabrera, E., Cubillo, F., Duarte, P., Hirner, W., . Parena, R. (2006). Performance indicator for water supply services (2 ed.). London: IWA Publishing.
- Cabrera, Enrique; Dane, Peter; Haskins, Scott; Theuretzbacher-Fritz, Heimo (2011). Benchmarking Water Services. *Water Intelligence Online*, 10(), 9781780400877–. doi:10.2166/9781780400877
- Chernicharo, C. A. L. (2015). Anaerobic Reactors. In *Water Intelligence Online* (Vol. 6, Issue 0, pp. 9781780402116–9781780402116). IWA Publishing. <https://doi.org/10.2166/9781780402116>
- European Investment Bank. (2020). EIB project carbon footprint methodologies: methodologies for the assessment of project GHG emissions and emission variations: July 2020. Publications Office.
- FAO. (2022). Food Balances. Retrieved June 22, 2022, from <https://www.fao.org/faostat/en/#data/FBS/visualize>
- IPCC (2006), 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.
- IPCC (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize, S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.
- Silva, C., & Rosa, M. (2014). Energy performance indicators of wastewater treatment: a field study with 17 Portuguese plants. *IWA World Water Congress*. Lisbon: IWA Publishing.
- UNFCCC. (2022). List of harmonized GHG accounting standards/approaches and guidelines developed. Unfccc.int. Retrieved June 22, 2022, from <https://unfccc.int/climate-action/sectoral-engagement/ifis-harmonization-of-standards-for-ghg-accounting/ifi-twg-list-of-methodologies>
- Sperling, M. V. (2015). Basic Principles of Wastewater Treatment. In *Water Intelligence Online* (Vol. 6, Issue 0, pp. 9781780402093–9781780402093). IWA Publishing. <https://doi.org/10.2166/9781780402093>

**This project is part of the International Climate Initiative (IKI):**  
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On behalf of:



Federal Ministry  
for the Environment, Nature Conservation,  
Nuclear Safety and Consumer Protection

of the Federal Republic of Germany

Implemented by:

