Business-as-usual Emission Scenarios

Case Study
San Francisco del Rincón, Mexico

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Water and Wastewater Companies for Climate Mitigation

WaCCliM

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Development of BAU emission scenarios for San Francisco del Rincón, Mexico

San Francisco del Rincón is located in western state of Guanajuato, north-central Mexico. It lies in the valley of the upper Turbio river at an elevation of 1762 masl. The availability of surface water in some regions is zero and groundwater has been exploited by 35% beyond its natural recharge[1], putting pressure on water utilities to fulfil growing water demands. Low tariffs, high water consumption and an intricate legal framework have led to unsustainable water abstraction, high-energy costs, high water losses, and inadequate wastewater treatment. As a result, high amounts of greenhouse gas (GHG) emissions are released.[2]

Water and wastewater services

The water supply system, from source to distribution and the wastewater drainage system are managed by SAPAF (Sistema de Agua Potable y Alcantarillado de San Francisco). The water is locally pumped and chlorinated for each respective water distribution sectors. The topography of the urban water supply system is flat; the maximum elevation difference between nodes is 78 m. All consumers are metered, including SAPAF's consumption and the portion of schools' consumption that is not paid for. Significant investments in meter replacement have been made in recent years.

Building of the SAPAF water company ©SAPAF

SITRATA (Sistema Intermunicipal para los servicios de tratamiento y disposición de aguas residuales para los municipios del Rincón) operates the "San Jerónimo" intermunicipal treatment plant, which receives wastewater from the municipalities of San Francisco and La Purísima

The wastewater treatment is the activated sludge (AS) containing the following stages: pre-treatment for large solid waste; primary settler; AS reactor, secondary settler, and final disinfection through U.V. (chlorine for water for internal use). There is a sludge thickener for the secondary settler, and with the sludge from the primary settler, pre-heating of sludge, anaerobic digestion, and dewatering.

The utility has a cogeneration system was designed primarily to make use of the production of biogas to generate electricity for wastewater processes, with the purpose of consuming as little energy as possible and reduce greenhouse gas emissions

The project Water and Wastewater Companies for Climate Mitigation -WaCCliM supports the water companies in the look of opportunities to reduce their carbon footprints. Developing a Business-as-Usual (BAU) emission scenarios for the utilities can help to understand the impact of adopting a low carbon policy. Analysing the behaviour of future and past greenhouse gas emissions levels in the absence of mitigation efforts can serve as a technical component to inform/decide strategic planning on climate change, emissions mitigation goal setting and long-term climate policy design.

The following case study analyses the GHG emissions of the utilities SAPAF & SITRATA in San Francisco del Rincón under BAU conditions and applies the 'Methodology to establish baseline scenarios' developed by the WaCCliM project based on the Energy Performance and Carbon Emission Assessment tool- ECAM.

Building of the SITRATA water company ©SITRATA

[1] https://agua.org.mx/tag/guanajuato/

[2] For more information, please visit https://wacclim.org/wp-content/uploads/2018/12/CaseStudy_Mexico2018.pdf.

Methodology

The following steps are a summary of the 'Methodology to Develop Baseline Scenarios in the Urban Water Sector with ECAM' developed by the WaCCliM. A more complete overview of concepts and related theory can be found in the mentioned study.

Step 1: Definition of boundaries and time horizon

Developing a BAU emission scenario begins with defining the type of systems to be analysed, the limitations within the systems, and type of facilities and stages to which it applies. Additionally, it is important to define the time period over which the scenario will be projected.

Step 2: Identification of the key parameters and driving factors that affect the GHG emission trajectory

There are several factors to consider while developing a BAU scenario, such as the nature and composition of BAU activities, parameters and how this composition may change over time due to legal, economic, or physical factors. To establish a BAU scenario, it is important to identify the most relevant parameters or key parameters that drive the emissions of GHGs in the systems to be analysed. For this, resources that could give insights into past and future BAU trends need to be investigated, which are important for the data projection, i.e., official population and sanitation statistical databases.

Step 3: Data collection & projection

This step varies and adjusts according to each local context and the time frame decided for the scenario establishment. A robust and representative set of data must be collected for the year chosen as the starting point for the BAU scenarios. Preferably, the data must come directly from the utility. The initial data will then be projected considering the trends analysed in the previous step. To facilitate this, a tool to Project ECAM Inputs for GHG Emissions as BAU Scenarios (PEIGE) was developed, which projects the data based on fixed BAU trends, nevertheless, the tool need be adjusted and fit to local or utility BAU trends.

Step 4: Development of BAU scenarios using ECAM

One of the advantages of developing BAU emission scenarios in the urban water sector and in the context of the project WaCCliM is that the ECAM tool can be used to determine GHG emissions. Once the chosen data is properly projected, these will be the input source in ECAM to determine the GHG emissions in any desired time frame. This will then give us the past and future trajectory of GHG emissions to be considered as the BAU scenario.

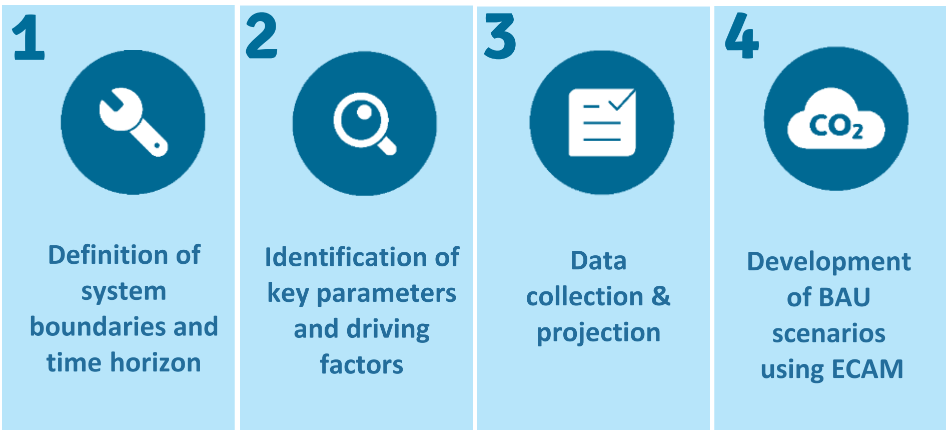

Figure 1. *Steps to develop BAU scenarios*

Scope and time period

The starting point to develop BAU emission scenarios for SAPAF & SITRATA is the year 2015 in accordance to the implementation of the measures of the WaCCliM project. The baseline scenario will be projected until the year 2040 and will analyse the following stages according to the characteristics of the utility and data availability:

- Water supply: Abstraction
- Wastewater: Treatment and Discharge/Reuse (biogas production and co-generation systems were not considered)

Key parameters and data to adjust BAU trends

This section evaluates the historical development of the parameters based on reliable statistics and projection data. To have a robust comprehension of historical BAU trends, deep literature review was conducted on the evolution of the parameters up to 15 years before the starting year of the BAU scenario. This analysis is used to obtain the Compound Annual Growth Rate (CAGR) which will be used in the next section to project the data. The CAGR values were adjusted accordingly in the PEIGE tool.

Resident population

The population of Mexico was analysed based on data obtained form the UN Department of Economic and Social Affairs (UNDESA), which updates comprehensive reviews of global prospects of demography and urbanisation to guide decision-makers in achieving the new Sustainable Development Goals. The results are regularly published in the form of the “World Population Prospects” and “World Urbanisation Prospects”. Country-specific data related to the national population are projected up until 2100 [UNDESA, 2017a] and those regarding the urban population up to 2050 [UNDESA, 2018]. The calculated future growth rates show the increase of population until the end of the BAU scenario, a slight decrease from the year 2030 is observed. The figures are presented in Annex A and introduced in PEIGE.

Population with access to water and sanitation services

Data on the connection degree to public water supply and sewer system were obtained from the Statistics on Water in Mexico (Estadisticas del Agua en México, EAM) published by the National Water Commission of Mexico (Comisión Nacional del Agua, CONAGUA) [2018]. The JMP data are used to mark the coverage degree of WWTPs that provides at least secondary treatment

Generally, projects with greater cost-effectiveness as “low hanging fruits” are preferred in investment decision-making. Those that are less favoured and delayed encounter more substantial difficulties in the implementation, meaning that infrastructure expansion will most likely be accomplished at a declining speed on the decadal time scale. This is especially the case if the service level has reached a relatively high degree. Consequently, the improvement of Mexico’s water supply and sewer system will occur at a much slower pace towards 2040.

In terms of wastewater treatment services, the budget constraints of Mexico’s municipalities as well as the high expenditures for operation, maintenance and training that are associated with the typical systems used in urban areas, for instance, activated sludge, trickling filters, rotating biological contractors and aerated lagoons, are most likely to impede the enhancement of the service level. In rural areas, the coverage of WWTPs remains at a low degree, which is partly due to nearly one-third of the national population residing in villages with a density of fewer than 15 000 inhabitants. The significant gap in knowledge and competencies to construct and operate suitable and economically feasible treatment systems, as well as the government’s focus on urban areas, have hampered the development of sanitation services [Zurita et al., 2012] and are expected to remain the major barriers in rural areas. As a result, it is suggested to adopt 0.8 percentage point as the BAU change rate of wastewater treatment services at the national level up to 2040, and a higher rate of 1.0 percentage points for urban areas (Table 1).

Table 1. *The BAU trend of the coverage of water and sanitation services in Mexico.*

Mexico	2005 (%)	2015 (%)	Past average ann. change over 2005-2015 (percentage points)	BAU annual change (percentage points)
% with public water supply, national [C]	89.2	95.3	0.6	0.2
% with sewer connection, national [C]	85.6	92.8	0.7	0.2
% with wastewater safely treated, national [B]	18.5	36.8	1.8	0.8
% with public water supply, urban [C]	95.0	97.8	0.3	0.1
% with sewer connection, urban [C]	94.5	97.4	0.3	0.1
% with wastewater safely treated, urban [B]	22.3	42.3	2.0	1.0

Sources and remarks:
[B] WHO/UNICEF [2017b]. WASH (JMP) database.
[C] CONAGUA [2018]. *Estadisticas del Agua en México* (EAM) (Statistics on Water in Mexico). Figure 4.4, 4.5, 4.7, 4.8.

Water and wastewater volume

The data on public water supply is from EAM [CONAGUA, 2014; 2018], calculated as the sum of ground and surface water volume used for public water supply, while the data on collected wastewater is from the Situation of the Potable Water, Drainage and Sanitation Sector (Situación del Subsector Agua Potable, Drenaje y Saneamiento, DSAPAS) of CONAGUA [2016].

The ratio of water reuse can be calculated from the AQUASTAT of FAO [2016].

at 0.5 kWh/m³. Other sub-stages are supposed to have the typical values suggested by [IEA, 2016c] (for more information refer to the 'Methodology for Establishing Baseline Scenarios in the Urban Water Sector with ECAM' of the WaCCliM Project).

As for the future trend in the BAU scenarios, it is expected that the regional overexploitation of underground aquifers or water withdrawal from distant sources [IEA, 2016b; Valek et al., 2017] will lead to a higher rate of increase in the energy-intensity of the water supply than the average level in the developing world (Table 3).

Table 2. *The BAU trend of per capita water supply and treated wastewater in Mexico*

Mexico national	Units	2005	2015	CAGR 2005-2015 BAU CAGR (%)
Gross public water supply [C]	m m³/year	10 700	12 480	
Population with public water supply *	1 000 persons	96 757	119 974	
Per capita gross drinking water supply	m³/person/year	110.6	104.0	-0.6%
Volume of collected wastewater [F]	m m³/year	6 465	6 686	
Population connected to sewers *	1 000 persons	92 852	116 827	
Per capita collected wastewater volume	m³/person/year	69.6	57.2	-1.9%
Ratio of water reuse in the treated WW [G]	%		26	

Sources and remarks:
[C] Calculated from CONAGUA [2018], EAM, Figure 3.6.
[F] Calculated according to CONAGUA [2016], *Situación del Subsector Agua Potable, Drenaje y Saneamiento* (DSAPAS) (the Situation of the Potable Water, Drainage and Sanitation Sector). Table 3.10.
[G] Data refer to 2011, from FAO [2016], AQUASTAT. Online query, select "water use", "wastewater".
* Calculated from UNDESA and CONAGUA EAM data.

Energy consumption

According to the WWAP [2014], providing one m³ of groundwater for human consumption requires 0.48 kWh, about 33% higher than the energy needed for surface water withdrawal. Currently, groundwater resources make up 60% of the national municipal water supply in Mexico [CONAGUA, 2018].[3] The average energy intensity can be estimated for water abstraction at 0.5 kWh/m³, while for treatment at 0.1 kWh/m³,[4] and distribution at 0.3 kWh/m³. These values were obtained from the IEA's projection is established on the grounds of the typical range of energy intensity for various processes [IEA, 2016c].

In the wastewater sector, Noyola [2016] provided the typical electricity consumption for the municipal wastewater technologies applied in Mexico. According to DSAPAS [CONAGUA, 2016], the major treatment types used are activated sludge (62%), followed by stabilisation ponds (13%) and the dual system of trickling filter plus activated sludge (13%). Thus, the average energy intensity can be estimated

Table 3. *The BAU trend of the energy intensity*

Water Supply		
	Abstraction	
2015 (kWh/m³)	2.8	
BAU CAGR	0.8%	
CAGR due to aging and deterioration of equipment	1.25	
Total	2.1%	
Wastewater		
	Treatment	Discharge
2015 (kWh/m³)	0.5	0.1
BAU CAGR	0.6%	0.1%

Emission factors of grid electricity

From 2012 on, the IEA updated the country-specific electricity-only emission factors, providing a sound basis for the

[3] The ratio estimated in the WWAP (2014) is 95%.

[4] According to Valek, et al. (2017), drinking water treatment is generally lacking in Mexico.

examination of the development path. Based on analyses of different IEA reports [2014, 2015, 2016a, 2017, 2018a, 2018b], the emission factor for grid electricity in Mexico exhibited a declining trend due to the shift to natural gas as the fossil fuel with the lowest carbon intensity, although the fossil fuels' share in electricity generation remained steady at 90%.

Table 4. *The BAU trend of the grid emission factor*

	Unit	Value
2005	$kgCO_2/kWh$	0.538
2015 / National current states (2015)	$kgCO_2/kWh$	0.460
BAU CAGR	%	-1.3

The IEA's special report "Mexico Energy Outlook" [IEA, 2016b] projected the future trend of Mexico's energy sector in different scenarios. According to its outcome, the emission factor in 2040 in the current policy pattern can be estimated at 0.328 kgCO2/kWh. This corresponds to a CAGR of -1.3% and is adopted in PEIGE (Table 5).

Per capita per year protein generation

In line with the ECAM tool, the national average protein intake is used for BAU projections without the consideration of regional divergence. Due to potential errors in the recording of stock variations [FAO, 2014], there is significant uncertainty in the data. In the case of Mexico, the CAGR over the period 2000-2013 was calculated at only 0.1%, which didn't fit in with the picture of the steady income increase and a taste preference for meat protein in this country. Thus, a more extended period of 1990-2013 was chosen as the reference to the past trend in Mexico.

Table 5. *The BAU trend of the per capita protein generation quantity*

	Unit	Value
1990	g/capita/day	77.79
2013°	g/capita/day	87.63
BAU CAGR	%	0.5
° FAO [2017], FAOSTAT, Food Balance Sheets. Online available: http://www.fao.org/faostat/en/#data/FBS		

Per capita BOD_5 generation

The IPCC 2006 Guideline widely adopted the per capita BOD_5 values estimated by the US Environmental Protection Agency (EPA) [Doorn & Liles, 1999]. The typical value for this parameter is 40 grams BOD_5 per capita per day for developing countries. As Mexico fits in this category this value is used in ECAM.

Due to the data gap the fact that the existing literature concentrates mainly on the contemporary situation rather than future development, a reliable projection is not applicable. As such, the current figure of 40 g BOD5 per capita per day will be used for the BAU estimations as a constant level towards 2040.

CH_4 emission factors

The CH_4 emission factor of the treatment can be assigned to the respective technology according to the recommendations of the IPCC 2006 Guideline, which is specified in detail in the ECAM tool and its methodology. The values are assumed to remain constant under BAU conditions for this case study.

BOD_5 loads

In BAU scenarios, it is assumed that the removal efficiency will remain at the current level. As such, BOD_5 loads don't exhibit endogenous variations and will be determined by the evolution of the serviced population and their per capita BOD_5 generation quantity (for more information about the calculations, please refer to the 'Methodology for Establishing baseline scenarios')

Nitrogen concentration in the effluent

The nitrogen concentration in the effluent will be calculated based on the IPCC quantification standards and comprises loads in the collected but untreated sewage as well as the remaining nitrogen in the treated wastewater. Therefore, there is no specipific BAU trend for this parameter. For a more detailed explanation please refer to the 'Methodology for Establishing Baseline Scenarios in the Urban Water Sector with ECAM'.

Sludge management

Disposal of sludge contributes significantly to the emission of greenhouse gases. The ECAM tool considers the different disposal pathways of dry sludge. For this case study, the development of sludge management will be calculated obtaining the ratio of sludge produced per wastewater volume, and dry sludge produced per amount of sludge. The ratios obtained for year 2015 will be constant in BAU scenarios. The values and parameter were added to PEIGE and the total dry sludge was calculated on a yearly basis.

Data Collection and projection

Establishing BAU scenarios requires the collection of representative data as initial values which will be projected taking the considerations from the previous step. The initial data for this case study was obtained directly from the operators in charge at SAPAF and SITRATA. The data was later projected using the PEIGE tool which adds the respective CAGR value for each parameter to each year analysed under BAU conditions.

The initial values used and final values of the parameters that were projected with PEIGE and further inputted into ECAM to analyse the GHG emissions to establish the BAU scenarios can be seen in Table 6.

Table 6. *Initial and final data to establish BAU scenarios*

Stages	Parameter	Unit	Initial value (2015)	BAU final value (2040)
General Information	Emission factor for electricity	$kgCO_2/kWh$	0.452	0.326
	Protein generation	kg/capita/year	33.58	38.043
	BOD_5 generation	kg/capita/year	0.04	0.04
	Water Supply System			
Population	Resident population	persons	128 000	173 822
	Serviced population	persons	128.000	171 214
Abstraction	Electricity consumed for water abstraction	kWh	3 428 016	5 605 796
	Volume of abstracted water	m^3	73 575 103	8 819 614
	Wastewater system			
Population	Resident population	persons	200 000	271 596
	Population connected to sewers	persons	128 200	180 883
	Population serviced by WWTP	persons	128 200	180 883
Treatment	Electricity consumed for wastewater treatment	kWh	1 481 895	1 360 648.5
	Volume of treated wastewater	m^3	4 444 028	3 881 613.4
	Type of treatment	-	Activated Sludge – well managed	Activated Sludge - well managed
	Influent BOD_5 load	kg	1 266 768.8	1 858 835.7
	Effluent BOD_5 load	kg	112 849.8	159 224.9
	BOD removed as sludge	kg	539 000	760 499.7
	Sludge Production	kg	3 628 000	3 168 857.9
	Dry Sludge Production	m^3	725 600	633 77.59
	Disposal type	-	Land application	Land application
Discharge/Reuse	Volume of discharged wastewater		4 268 600	3 728 386.74
	Energy consumed from the grid	kWh	5 518	4 941.61
	Total Nitrogen at discharge	mg/l	17.1	44.4
	Volume of reused effluent	m^3	24 414	21 324.28

BAU scenarios

GHG emission scenarios

Figure 2 shows the possible development of GHG emissions since the starting point of the study in 2015 until 2040. More than 3 000 tons of CO_2e of GHG emissions were generated by the water supply and wastewater utilities of San Francisco del Rincón in 2015. On general terms, the BAU scenarios show that emissions are likely to follow a linear growing pattern for the water supply system, and, on the contrary, the emissions of the wastewater system will increase until 2030 and slightly decline towards 2040.

The future trajectory of emissions under BAU conditions for SAPAF following BAU trends are more likely to increase by almost 940 tons of CO_2e in 2040 or an equivalent increase of 58%. (Figure 2). This value can be directly attributed to the indirect emissions from energy consumption required to abstract water and fulfil demands.

Within the operational boundary of the SITRATA utility, the treatment of wastewater will contribute to most of the total emissions produced. Nevertheless, the overall tendency of the emission trajectory has a slight tendency to decrease from 2019 until 2040. It is important to highlight the jump in the emission values in the year 2019 compared to the previous years. A closer inspection to the data per stage provides a better understanding of the emission development.

The GHG emissions of the wastewater treatment stage will decrease towards 2040 by around 8% or 124 tons CO_2e. This behaviour can be explained by the following:

- Even though the population growth will increase towards 2040, the growth rate is expected to slow down from 2025 onwards (see Annex 1).
- The amount of treated wastewater in the future according to the BAU trends analysed for this study, based on the time frame of 2005-2015, is negative. This means that the progress being made in sanitation services cannot keep pace with population growth, leading to considerable increases in the absolute numbers of inhabitants who are not connected to sewers.

Regardless this behaviour, the overall GHGs emitted in treatment stage will still be higher as the initial values from 2015, due to the emissions coming from treatment processes and disposal of sludge.

Let us now focus on the behaviour of the emission of GHGs form the Discharge/Reuse stage. By observing and analysing the utility data from the years 2015-2019 with the company's operators, a higher nitrogen concentration in the effluent was observed (17 to 40 mg/l respectively). This fluctuation was attributed to the settlement of an industry in the utility's service area that changed the wastewater composition and affected directly to the emissions from the Discharge/Reuse stage. The present BAU methodology does not consider punctual events as this one, therefore, this data was introduced in PEIGE for the year 2019 and the following years were projected based on this value.

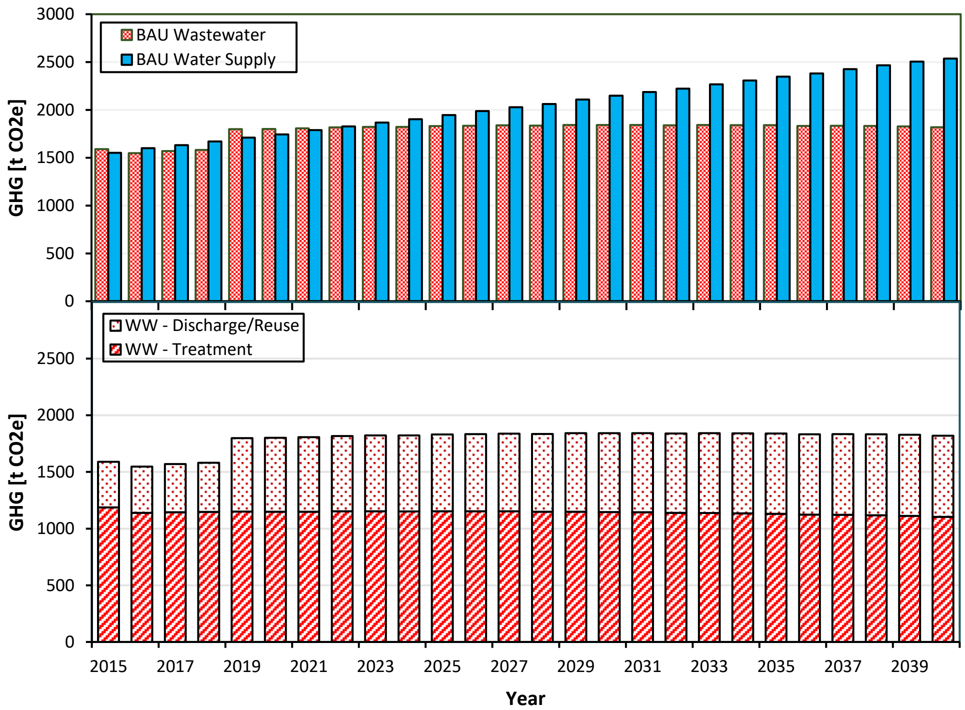

Figure 2. GHG emissions as BAU scenarios for the water and wastewater systems of San Francisco del Rincón. Top: Total GHG emissions per systems. Bottom: GHG emissions distributed per stage of the wastewater system

Energy consumption

Figure 3 shows the possible development of energy consumption in MWh until 2040. Energy consumption is one of the main parameters that drives GHG emissions due to intensive requirements for water infrastructure.

Energy demand in BAU scenarios is proportional to the GHG emissions in the water supply system. The abstraction of water will require to keep up with water demands which are more likely to increase due to population growth. Nevertheless, other factors such as pump aging, loss efficiency and increase in energy will also increase the energy intensity of the system. In precise numbers, however, energy consumption is more likely to grow by up to 60% or slightly more than 2 000 MWh higher in 2040 than 2015.

The wastewater system will have a decrease of energy demands for the stages of treatment and discharge, due to what was explained in the previous section: volume of treated and discharged water is going to decrease in the future according to the analysed data for BAU trends, decreasing energy demands.

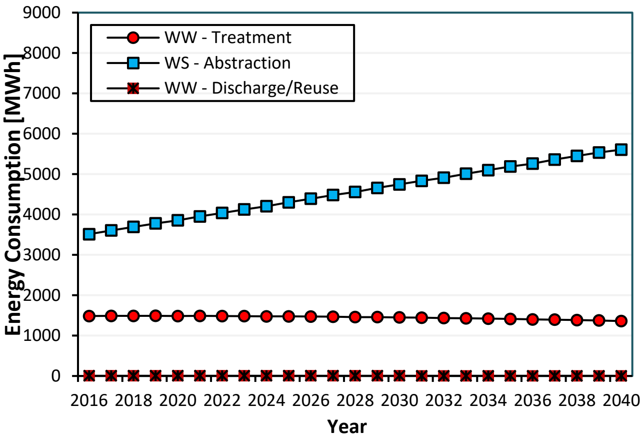

Figure 3. The future trend of energy consumption per stage for the water supply and wastewater systems of San Francisco del Rincón

Mitigation impacts – the WaCCliM project

The project WaCCliM supports SAPAF and SITRATA to reduce their carbon footprint since 2014. Until now, WaCCliM has been using and monitoring the results of their approach and the implemented measures considering the initial baseline as static in time.

The initial baseline assessment of San Francisco del Rincón analysed measures to implement to reduce GHG emissions most effectively. Increasing wastewater treatment coverage, energy optimisation on pumps and treatment processes were the most promising measures that could mitigate emissions (Mexico Case Stuy, WaCCliM, 2018).

Comparing the projection of the baseline under BAU conditions showed that implementing energy efficiency measures in the water supply system reduced more emissions as it was initially believed, achieving a reduction of around 192 tons of CO_2e in 2019 (Figure 6).

The increase in wastewater treatment coverage contributed significantly to the reduction of GHG emissions if the baseline is analysed under BAU conditions (around 230 tons of CO_2e reduced in 2019). At the same time, SITRATA, improved the biogas and energy production in the plant, which also could have an impact of reduction of GHGs, but an increase if not handled effectively. The before-mentioned statement can also explain the increase in GHG emissions between 2015 and 2016.

Implementing the before-mentioned measures had an impact that could not be measured if we used the initial baseline as a comparison point, as it can be seen in Figure 6.

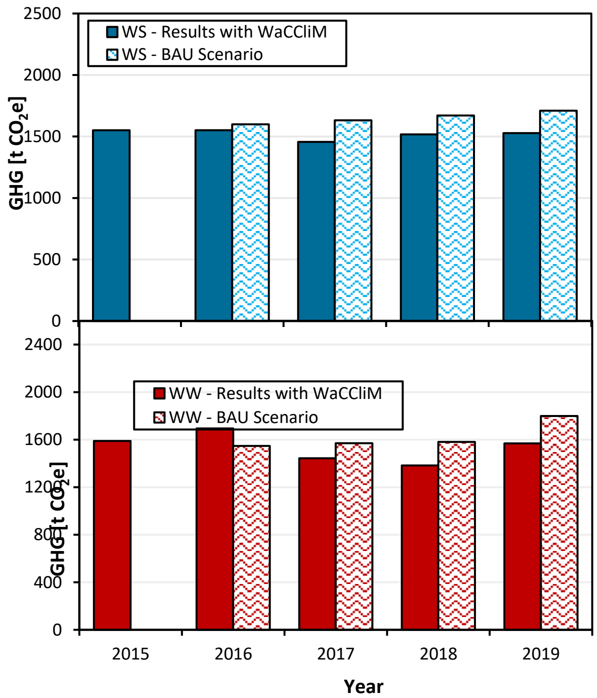

Figure 4. Comparison between BAU scenarios and WaCCliM results. Top: Water supply system. Bottom: Wastewater system

Conclusions

This case study aimed at understanding the possible trajectory of GHG emissions of the water and wastewater utilities SAPAF and SITRATA of San Francisco del Rincón, Mexico under BAU conditions. The scenarios show that the direct and indirect GHGs emitted by the utilities can increase by up to 58% for the water supply, while the wastewater system will decrease 8% if the utility continues with the same BAU trends as it was until 2015.

The analysis of comparing the results of the mitigation measures with the BAU scenarios showed significant reductions for both utilities and highlighted some underestimation of the results if BAU conditions were not analysed.

Increasing the efficiency of the water supply system resulted in the reduction of around 192 tons of CO_2e in 2019 and the increase of treatment coverage plus the use of the electricity cogeneration in SITRATA reduced up to 230 tons CO_2e in 2019.

The results obtained with the establishment of BAU scenarios helped to estimate the reduction of the utilities' carbon footprints, the status of achievement of mitigation efforts and can serve as a strong technical component for further implementation of climate policies if all uncertainties are considered.

Considering uncertainties

Although this document aims to deliver a reliable analysis of the evolution of GHG emissions, the uncertainty resulting from different source must be analysed.

First, the GHG inventory method of the IPCC involves uncertainty related to default parameters, emission factors, and other metrics used [WaCCliM, 2019]. Since the IPCC guideline and ECAM lays the groundwork for the BAU scenario development, this uncertainty must also be considered in this document.

Second, the application of a country-wide development trend on single utilities does not consider individual performances in multiple aspects.

Third, the statistical method used to determine the past trend (mostly used as CAGR values) only consider the start and end values of the reference period which are sensitive to the choice of the two data points.

Finally, the question of data quality also arises, as the last aspect leading to uncertainty. The coverage of water and sanitation access, the per capita water and wastewater volume and the energy intensity, are main sources of uncertainty with BAU scenarios. The values presented as energy intensity are estimations based on typical values of techniques and processes as well as analyses of the specific stress points faced by the respective country. Since the electricity consumption of the public water sector is often summarised under the same position as public lighting, it is hardly possible to calibrate the calculated energy consumption values with real statistics.

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Annex A
BAU CAGR for resident population growth

Annex D-2 Annual growth rate of national and urban population (PO-01, PO-02) 2015-2040

Year	BAU CAGR
2015	1.7%
2016	1.7%
2017	1.6%
2018	1.6%
2019	1.6%
2020	1.5%
2021	1.5%
2022	1.4%
2023	1.4%
2024	1.4%
2025	1.3%
2026	1.3%
2027	1.3%
2028	1.2%
2029	1.2%
2030	1.1%
2031	1.1%
2032	1.1%
2033	1.0%
2034	1.0%
2035	1.0%
2036	0.9%
2037	0.9%
2038	0.9%
2039	0.8%
2040	0.8%

Sources:
The national growth rate is calculated from the total population data from UNDESA [2017].
Online: *https://population.un.org/wpp/Download/Standard/Population/*, File "Total Population – Both Sexes".

The urban growth rate is calculated from the urban population projection of UNDESA [2018].
Online: *https://population.un.org/wup/download*, File 19 "Annual Urban Population at Mid-Year by region, subregion and country, 1950-2050".

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