



CARBON FOOTPRINT OF THE GROUNDWATER CATCHMENT

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ABSTRACT

The Carbon Footprint is one of the measurements of the impact caused by the human activities in the environment. It is estimated by the amount of Greenhouse Gases (GHG), measured in Carbon Dioxide (CO₂) units.

The calculation of Carbon Footprint allows to establish policies towards its reduction. Monte Hermoso, located on the maritime coast of the Southwest of the Province of Buenos Aires (Argentina), is a touristic town. During summer time the water demand increases because the population becomes ten times greater than the stable one.

In this season, the 49 underground catchment wells operate simultaneously 24 hours a day. This causes greater generation of GHG due to the increase of electric energy used for the water extraction.

The purpose of this paper is to estimate the Carbon Footprint of the water extraction well park and introduce a methodology to do it. This may be of general application in similar water supply services. The collection and analysis of information from the consumptions that arise on the pump energy service invoices are used to calculate the Carbon Footprint.

The annual Carbon Footprint generated during the process of capturing ground water in Monte Hermoso is 562 tons CO₂/year. This, represents 1% of the one generated by the stable population.

KEYWORDS: CARBON FOOTPRINT, UNDERGROUND WATER CATCHMENT, TOURISM.

1. INTRODUCTION

In Monte Hermoso town, located on the maritime coast of the Southwest of the Province of Buenos Aires, Argentina (Figure 1), during the summer, the number of inhabitants usually exceeds more than 10 times the stable population. This situation causes severe imbalances in public services, particularly in sanitary services. The greater water demand causes an increment of the energy used for the pumping, increasing this way, the generation of Greenhouse Gases (GHG).

The Carbon Footprint is one of the measurements of the human impact in the environment and is estimated according to the amount of GHG produced, measured in units of Carbon Dioxide (CO₂). It serves to quantify direct or indirect emissions sources, in this case the indirect ones produced by the groundwater catchment. This measurement allows the implementations of actions to reduce them, creation of awareness to minimize global warming, and decrease energy costs due to activity. The energy consumption of the catchment pumps is used. These values are obtained from the billing of the service of the year 2017. The purpose is to estimate the annual and monthly Carbon Footprint, generated by the Monte Hermoso drilling park. A methodology for the collection and analysis of information is presented, which may be applicable in other water services. The guidelines of ISO 14064-1 are used as reference.



FIGURE 1: MONTE HERMOSO LOCATION, BUENOS AIRES PROVINCE, REPÚBLICA ARGENTINA.

2. CARBON FOOTPRINT

Carbon Footprint is the set of direct and indirect emissions of Greenhouse Gas (GHG) of an individual, organization, event or product [1]. It is also, a GHG inventory, measured in tons of CO₂ equivalent and considers the gases included in the Kyoto Protocol (CO₂, CH₄, N₂O, PFCs, HFCs y SF₆) [2]. It is a global environmental indicator of the activity that is being developed. It is useful to take measures to reduce energy consumption and to choose resources and materials with better environmental performance.

To calculate the Carbon Footprint of an organization emission sources are identified. These are analyzed according to its operational limit:

- **Scope 1:** Direct emissions. These are from sources that are owned or controlled by the organization, released in the place where the activity occurs. For example, boilers, furnaces, vehicles, etc. It also includes fugitive emissions (air conditioning leaks, CH₄ leaks from ducts, others).

- **Scope 2:** Indirect emissions. They are a consequence of the activities of the organization, but they occur in sources that are owned or controlled by another. Emissions produced by a third party, to generate the energy consumed by the entity.

- **Scope 3:** Other indirect emissions. Some examples are the extraction and production of materials purchased by the organization; business travel with external resources; raw materials, fuel and product transport (logistic activities) carried out by third parties; use of products or services offered by others [1].

To calculate the Carbon Footprint, the following Equation is applied (1):

$$Carbon\ Footprint = Activity\ Data \times Emission\ Factor \quad [1] \quad (1)$$

- **Activity Data:** Indicates degree of the activity generating GHG emissions. [1]

- **Emission Factor:** amount of GHG emitted by each unit of Activity Data. They vary depending on the activity in question. [1]

For this paper, only Scope 2 emissions were evaluated. The water extraction wells Carbon Footprint due the pumps electrical energy acquired and consumed, is calculated. These emissions are produced in the place where electricity is generated.

3. OBJETIVES, METHOD AND WORK DEVELOPMENT

The purpose of this paper is:

- To estimate the annual and monthly Carbon Footprint, generated by the park of extraction wells for water supply of a touristic town.

- To introduce a methodology for collecting and analyzing the information to calculate the Carbon Footprint. The procedure could be applied to similar water services.

For the groundwater pumping wells Carbon Footprint estimation, the emission sources of the activity are identified. Therefore, the information to be collected

(Activity Data) is the electricity consumption of the pumps.

In this case, the activity Emission Factor is the amount of CO₂ generated per MWh of electricity used (in ton CO₂ / MWh). For Argentina, this value is provided by the Energy and Mining Ministry [3].

Replacing in (1):

$$Carbon\ Footprint \left[\frac{tCO_2}{period} \right] = Pump\ electricy\ consumption \ [MWh] \times Emission\ Factor \left[\frac{tCO_2}{MWh} \right]$$

Information from the 49 catchment wells, for Monte Hermoso water supply, is collected. The existing data is updated through interviews with qualified officials of the Sanitary Services Administration Department and technical staff of the Municipality. Also, the electric energy invoices of the pumps, for the year 2017, are requested. The wells are geographically located and visualized in a Geographic Information System (GIS), to link the billing and power consumption to each one of them.

The Carbon Footprint estimation is made based on the consumption of electricity. This data is taken from the invoice data of each pump and / or group of collection pumps.

The Emission Factor obtained from [3] is 0.486 tCO₂ / MW.h.

Figure 2 shows the perforation distribution on the urban area. They are located in 3 zones, named: Water Plant, Urban Plant and Pinar Plant.

A Table is made for each well and / or group of wells. The information is loaded, indicating type of invoice, well number, billing period and electrical consumption [kW.h]. Multiplying this latter value by the Emission Factor, the Carbon Footprint of each period is obtained.

As an example, in Table 1, the data of the group of wells of the Pinar Plant is shown (Wells 1P to 10P). The pump consumption is unified in a single value per period. In Figure 2, you can see the location of this group of wells.

Table 1: Carbon Footprint for Pinar Plant wells - Period 2017

Invoice type	Well N°	Data				Estimate	
		Month ⁽¹⁾	Period	Month Consumption		Emission Factor [tCO ₂ / MW.h]	Carbon Footprint [tCO ₂ / month]
				[kW.h / month]	[MW.h / month]		
T3BT ⁽²⁾	1P-10P (Pinar Plant)	January	1	36800	36,800	0,486	18
		February	2	23920	23,920	0,486	12
		March	3	5080	5,080	0,486	2
		April	4	3200	3,200	0,486	2
		May	5	120	0,120	0,486	0
		June	6	0	0,000	0,486	0
		July	7	0	0,000	0,486	0
		August	8	5320	5,320	0,486	3
		September	9	6040	6,040	0,486	3
		October	10	160	0,160	0,486	0
		November	11	45840	45,840	0,486	22
		December	12	17520	17,520	0,486	9

Note:
 (1) According to the electricity bill, each period may contain 1 or 2 days corresponding to the previous and / or subsequent month.
 (2) T3: energy and power consumption for any use when the maximum power demand is equal or greater than 50 kW; BT (Low voltage): 0.38 kV supply voltage.

Table 1 shows that for the wells of the Pinar Plant, the consumption was zero in months 6 and 7. This happened because in those months, it was not necessary to use these pumps to supply water to the stable population. Furthermore, months 1, 2 and 11 are highlighted as those with higher energy consumption and, therefore, the highest GHG emissions. This corresponds to the high season of tourism.

The emission factor is given in units of active power (tCO₂ / MW.h). In the calculations, this unit is chosen for energy obtained from the billings. In this case, a minimum Carbon Footprint is estimated. The lost energy in driving lines, transformers, etc. is not considered.

Table 2 contains the summary of energy consumption in each period and the associated Carbon Footprint. The consumption corresponds to the pumps used for the water supply. This table shows that the total annual electricity consumption (1156932 kWh) generated a Carbon Footprint of 562 tCO₂ / year for the 12 months of 2017.

From Table 2, Figure 3 is elaborated. This shows the HC generated by the water collection pumps, for each period of the year 2017. The periods of highest HC correspond to the summer season, which involve January, February, November and December (periods 1, 2, 11 and 12). GHG emissions during these months represent 45% of the total generated throughout the year.

From the comparison of Table 1 and Table 2, it appears that the totality of the wells does not follow the same consumption pattern. The highest energy consumption of all the wells corresponds to the months of January and February. For the Pinar Plant wells, the maximum values are given in November.

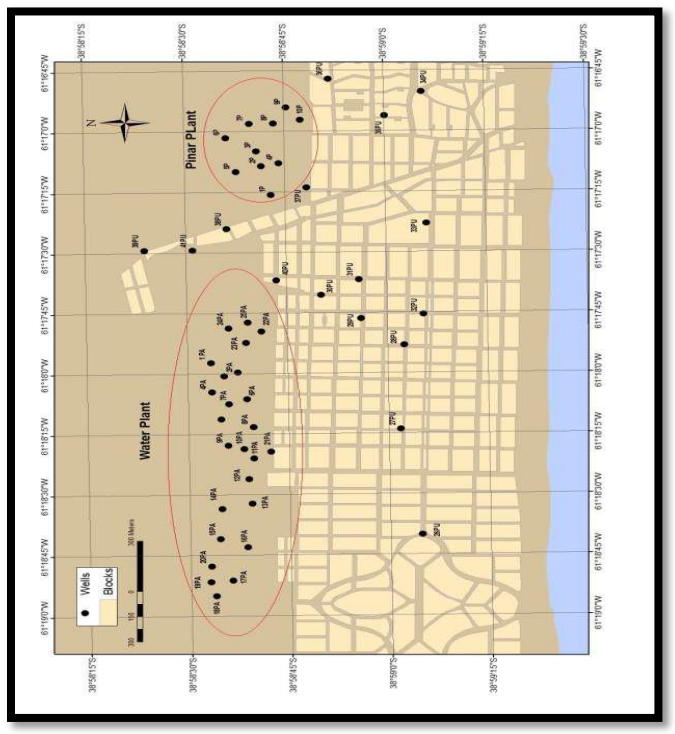


FIGURE 2. WATER WELLS LOCATION.

Table 2: Consumption summary and HC estimates (2017)

Month	Period	Energy Consumption		Carbon Footprint
		$\frac{kW.h}{month}$	$\frac{MW.h}{month}$	$\frac{tCO_2}{month}$
January	1	178251	178,25	86,63
February	2	129297	129,29	62,84
March	3	92752	92,75	45,08
April	4	84555	84,55	41,09
May	5	61986	61,98	30,13
June	6	65794	65,79	31,98
July	7	72818	72,81	35,39
August	8	80464	80,46	39,11
September	9	86805	86,80	42,19
October	10	86612	86,61	42,09
November	11	99985	99,98	48,59
December	12	117613	117,61	57,16
Annual Total		1156932	1156,93	562,27

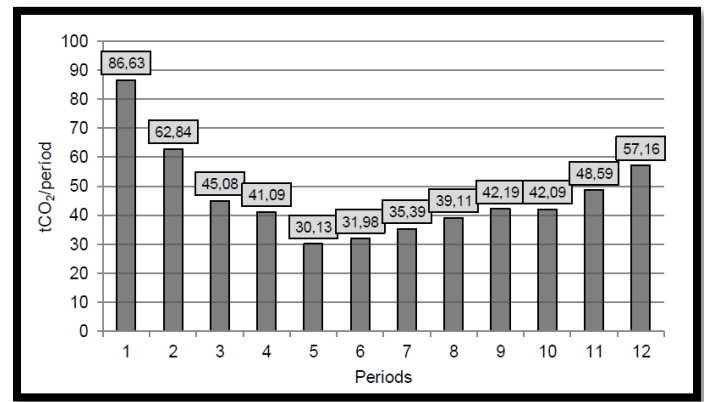


FIGURE 3. CARBON FOOTPRINT BY PERIOD, YEAR 2017.

The inventory of GHG emissions for all sectors of the Argentine Republic, prepared in 2014 by the Secretary of Environment and Sustainable Development, states that the annual carbon footprint for an average inhabitant was 8.1 tCO₂ / inhabitant [4]. It is not possible to access a more up-to-date national bibliography for this value.

The population equivalent to the CO₂ emitted by the use of all water extraction pumps is calculated. For this, Equation (2) is used:

$$\text{Equivalent population[inhabitants]} = \frac{\text{Annual Carbon Footprint of well park}}{\text{Average Carbon Footprint by inhabitant}} \quad (2)$$

$$\text{Equivalent population[inhabitants]} = \frac{562 \frac{tCO_2}{año}}{8,1 \frac{tCO_2}{hab. año}} = 70 \text{ inhabitants}$$

This means that the carbon footprint generated by the annual energy consumption of the water pumps is roughly equivalent to that produced in one year by 70 Argentine inhabitants. Bearing in mind that the stable population of the town of Monte Hermoso is about 7,000 inhabitants, and that the peak population in the summer season reaches about 70,000 inhabitants, the equivalent population value would represent 1% and 0.1% respectively.

The replacement of the pumping equipment to achieve greater energy efficiency in Monte Hermoso has already

been carried out. Therefore, to reduce the Carbon Footprint it would be necessary to implement other alternatives, such as reducing water consumption to lower the associated energy expense. To achieve this objective, awareness and education policies on the rational use of water should be applied.

1. FINAL CONSIDERATIONS

The calculation of the Carbon Footprint produced by the energy consumed in the pumping of groundwater catchment for the supply service, constitutes a double opportunity for the service provider. Considering that this calculation is a first step for the reduction and / or compensation of its emissions the following opportunities apply. In first place, it is an instrument to reduce the costs implied by the consumption of energy for pumping. Secondly, it contributes to the reduction of GHG emissions, providing an environmental care concern. Therefore, the importance of interaction with the staff of the Municipality of Monte Hermoso is highlighted, enabling access to information.

The study shows that, due to the marked tourist affluence in the summer period, the highest energy consumption, and consequently the greatest Carbon Footprint, occurs during the months of January, February, November and December. In these months 45% of the annual Carbon Footprint is generated. In addition, the annual carbon footprint for the well park expressed in equivalent inhabitants represents 1% of the stable population and 0.1% of the peak population in the summer season.

It is recommended for all water services, the need to have statistically representative data. It is suggested to record the dates of construction of the wells, installation, maintenance and replacement of the pumps, as well as characteristics and / or brands of them, associating the data with the electric billing. If in the case of the study this information was counted, estimates could also have been made according to the operating conditions of the pumps, which would have made it possible to verify the results.

As for the maintenance of the pumping equipment, it should be carried out periodically and in the need of replacement, opting for those with high energy efficiency, to minimize costs for electricity consumption and to minimize GHG emissions.

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