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Carbon Footprint Estimation at the National University of Rosario, Argentina: Evaluation and Perspective

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Abstract. The National University of Rosario (UNR) is in the city of Rosario, Argentina. Its current building structure is formed of 12 faculties, 3 high schools and the Centre for Interdisciplinary Studies. The built infrastructure is more than 180,000 square meters and in 2009 the university population was around 107,000 people including students, professors, and technical and administrative staff. The campus policies include sustainability as one of its main objectives. To assess and eventually reduce the campus environmental impact, its greenhouse gas (GHG) inventory was analysed, and its carbon footprint was calculated, using ISO 14064 standard and series. In 2019, the campus produced around 3610 tonnes of CO2 equivalent; corresponding to Category 2 (Indirect GHG emissions caused by imported energy) generating electricity, 2937 tonCO2eq and natural gas, 673 tonCO2eq. As this is a preliminary report corresponding to 2019 (several years prior to the present) and because the information necessary to calculate GHG emissions has not been systematised, the results are more indeterminate than expected, estimated at between 10% and 20%. Neither were minor contributions estimated (with respect to the sources with the highest contribution: Stationary Energy and Mobility), due to sources such as Waste, Fugitive Emissions, etc. Furthermore, it was not possible to obtain information for this First Report on the number of trees that are planted on the entire land area of the UNR (mainly in the Faculties of Agricultural Sciences and Veterinary Science), to estimate the removals of the main greenhouse gas, Carbon Dioxide (CO2). Given that in the Mobility Sector it was not possible to obtain direct information on GHG emitting sources (as only indirect data is available through the purchase of fuel in 2019 by the UNR), no data is presented for this sector. Consequently, the results presented in this Preliminary Report should be considered as minimum values for UNR emissions. However, considering the extensive experience from other reports and preliminary estimates, it is considered that the results of the UNR GHG emissions incorporate most of the emissions. The inventory will assist in the establishing policies for GHG reduction and mitigation, resulting in potential environmental and economic benefits. Having completed the preliminary UNR Carbon Footprint (CF) Report, it is now time to move forward on a Greenhouse Gases (GHG) Emission Reduction Target and a Climate Action Plan to take this target forward. Consequently, and as part of the strategy to promote the development of sustainable campuses, the UNR decided to set a reduction horizon by the end of the year 2023 of 10% of the value calculated in the First Report for the year 2019.

Keywords: Carbon footprint, ISO 14064, greenhouse gas, university

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INTRODUCTION

The biggest current challenge worldwide is climate change because its impact has a great influence on human beings and the environment (made up of air, water, soil, flora and fauna). In 1972, the United Nations Environment Program [1] is established. In 1983, the World Commission on Environment and Development (WCED) [2] was appointed with the mission of uniting countries to jointly pursue sustainable development and popularised the term "Sustainable Development", introduced in the Brundtland Report [3]. In 2015, the UN General Assembly proposed the 2030 Agenda for Sustainable Development, which sets out 17 Goals (SDGs) to be achieved by 2030. More recently, the European Commission drafted communication 640/2019 where it presents a European Green Deal as a new growth strategy, aimed at transforming the European Union in which there will be no net GHG emissions by 2050 and the economic growth will be decoupled from the use of resources.

Global warming is the main contributing factor in exacerbating climate change. Global warming is directly related to the concentration of GHG emissions released into the atmosphere.

An effective and progressive response to the urgent threat of climate change is necessary, based on the best existing scientific knowledge, such as that synthesised in the reports on Climate Change of the United Nations Intergovernmental Panel of Experts on Climate Change (see www.ipcc.ch). Therefore, it is of fundamental importance to know the Carbon footprint, HC (the emissions of Greenhouse gases thrown into the atmosphere each year) of the National University of Rosario (UNR), since it allows knowing in greater detail the activities inherent to the GHG emission. In this way, it is feasible to make decisions for a more efficient and effective management of the energy consumption of the UNR, related to mobility, lighting, air conditioning, information technology, etc.

One of the most recognized regulatory frameworks for accounting for emissions is ISO 14.064-1 (2018) and other Standards in the same series. To organise the identification of emission sources, they must be disaggregated into six categories at the organisation level, for GHG accounting and reporting purposes.

There are numerous publications on HC measurement studies in universities, for example that of the Polytechnic University of Valencia, which in 2018 obtained values of *0.31 tCO2eq per student* and *2.69 TCO2eq* for teaching and non-teaching staff [4], Duquesne University with an average of *3.1 tCO2eq per student* in 2015 [5], and the University of Talca, Chile where in 2016 the mobility of students and teaching and non-teaching staff emitted 0.41tCO2eq per person [6].

Universities, such as the UNR, can contribute to achieving the objective of climate neutrality by knowing how their environmental performance is through the Carbon Footprint (HC). The HC "represents the amount of greenhouse gas emissions that were emitted annually into the atmosphere by means of some human activity, which can be a product or a service, or by the daily action of an inhabitant" [7]. Subsequently, universities can propose action plans and reduction targets to reduce and/or offset their emissions.

MATERIALS AND METHODS

Description of the UNR

The National University of Rosario (UNR) [8] was created in 1968 through Law 17,987. Its founding structure was a detachment from the Universidad Nacional del Litoral, from which it took its first academic and administrative bodies, which at that time consisted of the faculties of: Medical Sciences, Engineering Sciences and Architecture, Economic Sciences, Philosophy, Law and Political Sciences, Dentistry, Agrarian Sciences and the Teaching Hospitals and Secondary Schools that depended on it, in addition to the Superior Institute of Music of Rosario.

Since its inception, the National University of Rosario began an active relationship with the Rosario society from which it was generating projects that were expressed in sustained growth, according to the demands of the region. At present, its structure is made up of *12 faculties, 3 institutes of secondary education and 1 centre for interdisciplinary studies*. It has a building area of more than 180,000 square meters, where an academic offer is provided, consisting of 219 postgraduate courses, 121 undergraduate degrees, 17 technical degrees, 53 intermediate degrees, 26 titles for articulation with the non-university higher education system and 32 post titles.

In recent years, the virtual Campus has been added to this academic offer, where courses are offered in the distance modality and using the Web support as a teaching environment.

ISO 14.064

The UNR began measuring the HC for the first time in 2022, taking 2019 as the base year. This environmental management tool allows to find the possibility of increasing the energy performance of the university, with the aim that the activities carried out have a minimum environmental impact. It has followed the methodological recommendations of the ISO/TR 14064 standards and the ISO/TR 14065 and ISO/TR 14069 series [9].

ISO 14064 is an international standard developed by the International Organization for Standardization (ISO) that deals with accounting and reporting of greenhouse gas (GHG) emissions and verification of related reports. This standard is made up of three parts [9]:

1. *ISO 14064-1: Specifications for the quantification and reporting of greenhouse gas emissions and removals*. This part establishes the requirements and guidelines for organisations to quantify and report their direct and indirect GHG emissions, as well as related removals. Defines the principles and criteria for the preparation of GHG inventories, including aspects such as organisational scope, operational limits, geographic and temporal limits and the emission and removal factors used for the calculation.
2. *ISO 14064-2: Specifications for the verification and validation of greenhouse gases* [10]. This part establishes the requirements for the verification and validation of GHG emissions reports. It provides guidelines for the design, planning and execution of the verification, including the criteria for the selection of verifiers and the required competence. It also focuses on the review and evaluation of the information, the identification and correction of deficiencies and the issuance of a verification report.
3. *ISO 14064-3: Specifications for the validation and verification of greenhouse gas projects*. This part focuses on the validation and verification of specific projects aimed at reducing GHG emissions or increasing removals. It establishes the requirements for the design and implementation of emission reduction or carbon sequestration projects, including the evaluation of the baseline, the monitoring of reductions or removals and the determination of additional benefits. Aspects such as stakeholder participation and transparency in the documentation and communication of results, are also addressed.

ISO 14064 is widely used by organisations in various sectors to quantify and reliably and consistently report their GHG emissions, and to obtain independent verification and validation of their reports. Additionally, it helps organisations demonstrate their commitment to reducing GHG emissions and mitigating climate change.

Data and Information Included in the Report

CO2 emission factor

For the assignment of the numerical value of the CO2 emission factor, the Calculation of the CO2 Emission Factor of the Argentine Electricity Network of the Ministry of Energy [11], of the year 2019 was considered.

TABLE 1. Operating, Construction and Combined Margins

Operating Margins (W_{OM})	0,4282 tCO2/MWh
Construction Margins (W_{BM})	0,3440 tCO2/MWh
Combined Margins W_{OM}= 0,5; W_{BM}= 0,5	0,3861 tCO2/MWh

Note: Weighted Average Combined Margin was used

The formula used is the following:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \, x \, W_{OM} + EF_{grid,BM,y} \, x \, W_{BM}$$

Where:

$EF_{grid,CM,y}$ CO2 emission factor of the Combined Margin in the year y (tCO2/MWh)
$EF_{grid,OM,y}$ CO2 emission factor of the Operating Margin in the year y (tCO2/MWh)
$EF_{grid,BM,y}$ CO2 factor of the Construction Margin in the year y (tCO2 /MWh)
W_{OM} Operating margin emission factor weighting
W_{BM} Construction Margin Emission Factor Weighting

The CO2 Emission Factor adopted is: *0,3861 tCO2/MWh.*

Warming potential

Table 2 presents the Global Warming Potential (GWP) [12] of the most important GHGs [13]. It is a measure used to compare the relative impact of different greenhouse gases on global warming. This measure is expressed as a ratio between the warming caused by a specific gas and the warming caused by an equivalent amount of carbon dioxide (CO2) over a specific period. These values correspond to those detailed in the Fifth Assessment Report of the IPCC: Climate Change 2013. The Physical Basis [14].

TABLE 2. The most important Global Warming Potentials (GWP).

Name	*Formula*	*GWP Values*[a]
Carbon dioxide	*CO2*	*1*
Methane	*CH4*	*28*
Nitrous oxide	*N2O*	*265*
Sulphur Hexafluoride	*SF6*	*23.500*
Carbon tetrafluoride	*CF4*	*6.630*
Hexafluoroethane	*C2F6*	*11.100*

[a] *IPCC Fifth Assessment Report on CO2 (IPCC, 2013).*

GHG emission sources

GHG emissions from UNR activities are classified into six main sectors, which include:

i. Stationary energy
ii. Transport and mobility
iii. Waste
iv. Industrial processes and product use, IPPU
v. Agriculture, forestry, and other land use, AFOLU
vi. Any other emission that occurs outside the geographical limit as a result of university activities.

Stationary energy

In the present study, the greenhouse gas emissions that emanate from the combustion for the use of energy in buildings and facilities are considered. They are those that contribute the most to the UNR GHG emissions, as shown in the results presented in item 3.

Transport and mobility

Mobile sources produce direct GE emissions, the most important are *Carbon dioxide* (CO2), *Methane* (CH4) and *Nitrous oxide* (N2O), as well as various other contaminants such as Carbon monoxide (CO), Volatile organic gases other than methane, Sulphur dioxide (SO2), Particulate matter (PM) and nitrogen oxides (NOx), that also contribute to local or regional air pollution. As direct information was not available, the analysis of this type of surface contamination was not carried out.

Waste (and sewage)

The UNR produces solid waste and wastewater (collectively referred to as "waste") that can be disposed of and/or treated at facilities within the city limits or transported to other cities for treatment. Waste disposal and treatment produce GHG emissions through aerobic or anaerobic decomposition, or incineration.

The available data on UNR water consumption is based on information provided by the company Aguas Santafesinas, which is an estimate of consumption and the corresponding cost, and there is normally no own measuring equipment that provides detailed information on said consumption. In addition, the UNR does not have sewage (or grey) water purification equipment, most of which goes to the Paraná River. A point in favour is that this river is one of the largest and mightiest on the planet, with a delta of islands in front of Rosario, with a width of about 60 Km to the opposite coast in front of the city of Rosario, extending to 2 km wide downstream. Consequently, it has not been possible to estimate the emissions due to wastewater from the UNR, in this First Work.

Industrial processes and product use, IPPU

The attribution of emissions from the use of fossil fuels to the Energy Sector or the IPPU Sector is often a complex task. Uses of process feed substances and fuel reducers (additives) frequently produce gases that can be combusted to provide power to such processes. This can lead to uncertainties and ambiguities in reporting. The emissions referring to this sector are not included in this report.

Agriculture, forestry, and other land use (AFOLU)

The Agriculture, Forestry, and Other Land Use (AFOLU) sector produces GHG emissions through a variety of pathways, including land-use changes that alter soil composition, methane produced in the digestive processes of farm animals, and nutrient management for agricultural purposes.

For this First report, it has not been possible to make estimates of the corresponding emissions and removals, since the data that allows such calculations is not available. It should be noted that a qualitative analysis tends to show that the emissions will be (at least partially) offset by the removals due to the more than 50 Ha of forests in the Villarino Experimental Field, Zavalla, of the Faculty of Agrarian Sciences of the UNR and the quite large number of trees of the Faculty of Veterinary, placed at Casilda city.

Emission Factors

Table 3 and Table 4 show the CO2 emission factors for electricity (Kg/KWh) and those of fuel and biofuel emissions of N20 (KgN2O/TJ), CH4 (KgCH4/TJ) y CO2 (tCO2/TJ) fuels [15].

TABLE 3. Electricity emission factor of Argentina.

Emission source	*CO2 emission factor (Kg/KWh)*	*Quality*
Electricity	*0,3861*	*Medium*

TABLA 4. Fuel and biofuel emisión factors. The quality of the data is also detailed.

Emission source	*Emission factor*			*Quality*
Fuel	***N2O*** *(KgN2O/TJ)*	***CH4*** *(KgCH4/TJ)*	***CO2*** *(tCO2/TJ)*	
Road diesel	*3.9*	*3.9*	*74.1*	*Medium*
Compressed Natural Gas	*3*	*92*	*56.1*	*Medium*
Gasoline	*8*	*25*	*69.3*	*Medium*
Biodiesel	*3.9*	*3.9*	*74.1*	*Medium*
Bioethanol	*8*	*25*	*70.8*	*Medium*

RESULTS AND DISCUSSION

Data Results Quantified by Emission Category

Table 5 summarizes the preliminary partial information collected at the time of writing this paper [16].

TABLE 5. Quantification of CO2eq emissions according to ISO 14064.

	COMPANY THAT INFORMS	**National University of Rosario (Argentina)**									
	PERSON OR ENTITY RESPONSIBLE FOR THE REPORT	Interdisciplinary Studies Center, National University of Rosario									
	RECORDED REPORTING PERIOD	from	1/1/2019	to	1/1/2020						
	LIMITS OF THE ORGANIZATION	attached document									
	REPORT LIMITS	attached document									
	EMISSIONS	**Notes**	**2019 Co2e TOTA**	Carbon dioxide (CO2)	Methane (CH4)	Nitrous oxide (N2O)	Sulfur hexafluoride (SF6)	PFC-14 (CF4)	Hexafluoroethane (C2F6)	quantitative uncertainty	qualitative uncertainty
	GWP			1	28	265	23.500	6.630	11.100		
1	**Category 1: Direct GHG emissions and removals in Tons of CO2e (1)**										
1.1	Direct emissions from stationary combustion		0	0	0	0	0	0	0		
1.2	Direct emissions from mobile combustion		0	0	0	0	0	0	0		
1.3	Direct processes of emissions and removals arising from industrial processes		0	0	0	0	0	0	0		
1.4	Direct fugitive emissions caused by GHG release in anthropogenic systems		0	0	0	0	0	0	0		
1.5	Direct Emissions and Removals from Land Use, Land Use Change, and Agriculture		0	0	0	0	0	0	0		
2	**Category 2: Indirect GHG emissions caused by imported energy (3)**		***3610***								
2.1	Indirect emissions from imported electricity		2937	2937	0	0	0	0	0		
2.2	Indirect emissions caused by imported energy, including GHG emissions related to the production of energy consumed by the organization through a physical network, (steam, heating, cooling and compressed air), excluding electricity.		673	673	0	0	0	0	0		

Emissions by Area or Sector of the UNR

Figure 1 shows the total emissions of the UNR for the year 2019. The Centre area emits 1276 t CO2 eq, CUAS 883 tCO2 eq, CUR 723 tCO2 eq, Zavalla 526 tCO2 eq and Casilda 202 tCO2 eq, all data per year.

Emissions per Constructed Area (m^2) of Each Area or Sector of the UNR

Figure 2 shows the CO2eq emissions per built area, for each area comprising the UNR. The units are in $KgCO2eq/m^2$. For the Central area, emissions are 17 $KgCO2eq/m^2$, the CUAS 39 $KgCO2eq/m^2$ (higher emission), the CUR 15 $KgCO2eq/m^2$, for Zavalla the value is 32 $KgCO2eq/m^2$ and 13 $KgCO2eq/m^2$ for Casilda (lower emission).

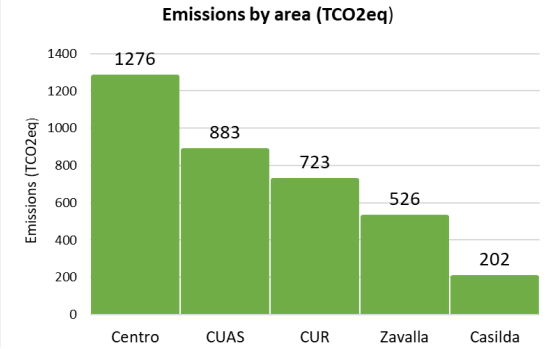

FIGURE 1. Total emissions by area (tCO2eq).

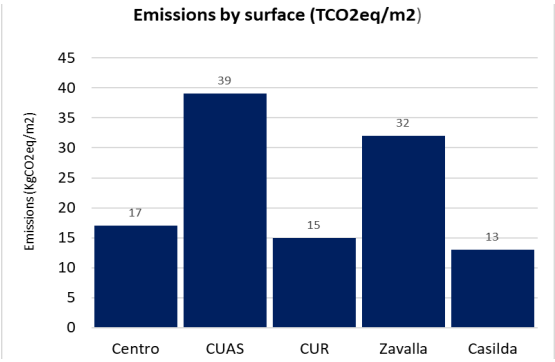

FIGURE 2. CO2eq emissions in relation to the constructed area for UNR areas ($KgCO2eq/m^2$).

Emissions by Staff (Teaching & Administrative) & Students for Each Area or Sector of UNR

Figure 3 reports on emissions by staff (teachers and non-teachers) and students, per area. For Casilda the corresponding GHG emissions are 98 Kg CO2eq/person, Zavalla 262 Kg CO2eq/person (higher emission), CUR 24 Kg CO2eq/person (lower emission), CUAS 33 Kg CO2eq/person and the Center area 27 Kg CO2eq/ person.

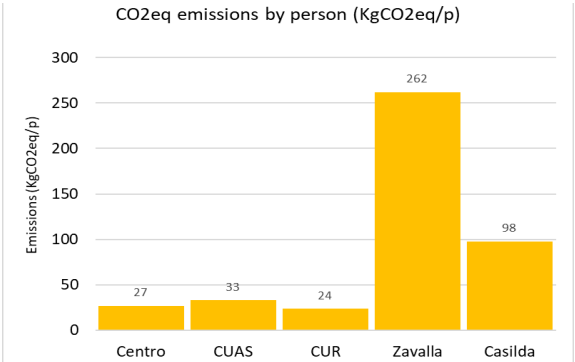

FIGURE 3. CO2eq emissions by teaching and administrative staff and students for the areas of the UNR (Kg CO2eq/person).

Percentage Emissions from the Consumption of Electricity and Natural Gas

Figure 4 shows the percentage and total contributions of GHG emissions that were generated in different faculties, institutes and centres of the UNR, during the year 2019, corresponding to electricity (81%) and natural gas (19%).

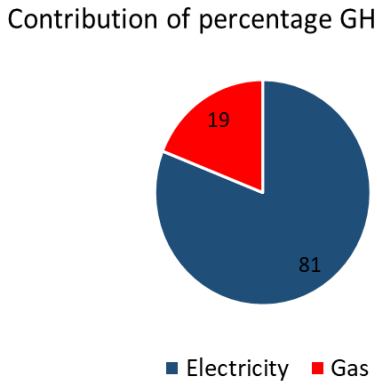

FIGURE 4. Contribution of percentage GHG emissions due to electricity and gas from the UNR in 2019.

CONCLUSION

At the close of this work, the sources of greatest contributions, Stationary Energy and Mobility, were estimated. No minor contributions were estimated, such as Waste, Furtive Emissions, etc. In addition, it was not possible to obtain information, for this First Work, on the number of trees that are planted in the entire land area of the UNR (mainly in the Faculties of Agricultural Sciences and Veterinary Medicine), to estimate the absorption of the main greenhouse gas, Carbon Dioxide (CO2).

Consequently, the results presented in this Preliminary Report should be considered minimum values of the UNR emissions. However, considering the great experience of other Reports carried out and preliminary estimates, it is considered that the results of the GHG emissions of the UNR, incorporate most of the emissions.

The UNR proposes to establish a program to obtain the most reliable data that will serve not only to establish GHG emissions and the way to reduce them, but also to achieve greater efficiency in the use of energy and natural resources. So, it is suggested to train the different related sectors in these issues and in energy management.

It is proposed to set an energy and emissions reduction goal, based on an action plan for that purpose. It is necessary to address these initiatives through an energy diagnosis, to obtain knowledge about the energy consumption of the UNR, to understand the energy variables and to identify opportunities for improvement and efficient use of energy.

Implementing energy saving and efficiency measures means:

- Reduce demand and energy cost.
- Improve competitiveness.
- Improve the production process.
- Reduce equipment maintenance costs.
- Reduce C02 emissions.
- Increase production by consuming the same amount of energy.

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