International Journal of Advanced Engineering Research and Science (IJAERS)
Peer-Reviewed Journal
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-8, Issue-11; Nov, 2021
Journal Home Page Available: https://ijaers.com/
Article DOI: https://dx.doi.org/10.22161/ijaers.811.29

Analysis of the Greenhouse Gas Emissions Inventory in a Photographic Paper Finishing Industry in the Manaus city

Edfran da Cruz Magalhães[1], Simone da Silva[2]

[1]Student of the Professional Master's in engineering, Process Management, System and Environmental at the Instituto de Tecnologia e Educação Galileo da Amazônia – ITEGAM, Brazil
[2]Professor and researcher of the Professional Master's in Engineering, Process Management, System and Environmental at the Instituto de Tecnologia e Educação Galileo da Amazônia – ITEGAM, Brazil

Received: 16 Sept 2021,

Received in revised form: 09 Nov 2021,

Accepted: 19 Nov 2021,

Available online: 26 Nov 2021

***Keywords*— Gas emissions, greenhouse effect, photo paper, chemical industries.**

***Abstract*—** *In the Manaus Free Zone, the processing industry of photographic paper is poorly representative and, is classified as a Chemical Industry. This type of photographic industry has environmental aspects in all its production processes, including those that only benefit the already emulsified photographic papers, transforming them into sizes and formats necessary for later use in photo printing laboratories. From this perspective, the problem to be investigated in this dissertation was limited to emissions of greenhouse gases (GHG) in scope 1 and 2, using the protocol of the Brazilian GHG Protocol Program (PBGHGP) thus enabling the inventory of data and the estimation of the total GHG emission in a native industry of photographic paper processing. As a result of the analysis, it was found that the main source of GHG comes from the cooling system in the consumption of refrigerant R410A and that the control and/or management of these gases are possible to be adopted, because the industry has an implemented environmental management system capable of managing this environmental aspect.*

I. INTRODUCTION

The emission of greenhouse gases (GHG) has a direct effect on our climate and the environment. Climate change, its consequences, and agreements to reduce and/or stabilize emissions of these gases have been debated by major world leaders for centuries. In the year 2021, the United Nations (UN) brought together the world's largest conference on climate change, COP26, in the Scottish city of Glasgow. This conference brought together approximately 200 countries to promote actions aimed at achieving the objectives of the Paris Agreement and the United Nations Framework Convention on Climate Change.

The way industries see the minimization of environmental pollution has changed in recent years. Until the 1980s, the focus was the end-of-pipe treatment, that is, the impact was allowed for the subsequent treatment of effluent, waste or emission. The Management of Greenhouse Gases (GHG) has become an increasingly important topic in global corporate agendas, due to the repercussions that have shown the issues of climate and environment. Companies have invested in actions that aim to reduce greenhouse gas emissions and disseminate results to promote sustainable consumer-oriented marketing, as well as to help understand the climate study.

The greenhouse gases inventory is an instrument that allows companies to assess and account for GHG emissions from all sources defined in groups of activities associated with the company. The inventory is fundamental for the formulation of business policies adapted to the new trends of the global market and aims to analyze the degree of emission and, with this, plan its

reduction or compensation, mitigating the environmental impact.

The problem to be investigated will be limited to GHG emissions in scope 1 and 2, through the use of tool of the Brazilian GHG Protocol Program (PBGHGP) thus enabling the inventory of data and the estimation of the total GHG emission in a native industry of photographic paper processing. Although the statistical data show a low percentage of GHG emissions in the industrial sector, the emission of GHG in the state grew alarmingly, making it necessary to analyze in a factual way the context of emissions from industrial processes.

II. LITERATURE REVISION

2.1 Greenhouse Gas Inventory

The unbridled emission of GHG into the atmosphere, particularly the emission of carbon dioxide, ends up exacerbating the greenhouse effect and thereby triggering a series of problems affecting the entire planet, such as global warming itself and the compromise of atmospheric air, can trigger a few respiratory diseases. For (Fernandes; Nogueira & Jimenez, 2020), the impacts caused by the emission of GHGs affect not only the place where such emission occurs, but the commitment is worldwide.

According to Monzoni (2008) participants of the PBGHGP must include in their inventory of emissions all GHG regulated by the Kyoto Protocol. They are: Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Perfluorocarbons (Pfcs) Hidrofluorcarbon (Hfcs), Trifluoreto de Nitrogênio (NF3) and Hexafluoride de Enxofre (SF6). These gases are from anthropogenic sources, the first three being considered the most abundant.

In addition, methane (CH4) takes less time in the atmosphere than carbon dioxide (CO2). However, CH4 is much more efficient when it comes to trapping radiation than CO2, and CH4 has an estimated global warming potential of 21 times greater than CO2 in a 100-year time span. However, in relation to CO2, its time of permanence in the atmosphere is measured in about 150 years Fernandes *et al.* (2020).

According to Dutra *et al.* (2019) to be able to measure the air quality of a given region, it is necessary to monitor the emission of the group of pollutants, either by their occurrence or by the adverse effects caused. Also according to the authors, in addition to the subsequent control, it is of paramount importance that the emission of GHGs is continuously controlled, in order to verify the possible levels of GHGs that a given industry is emitting in a given location (Dutra e*t al*., 2019).

A balance is sought between GHG emissions and their removals, to find a level of sustainability between human actions and the environment. In this sense, it can be said that among the sources of GHG emissions are: industrial activities; fuel burning and deforestation. While from the perspective of the removals of such emissions are forests to help the preservation of the environment (Dutra *et al*., 2019).

In the context of what is mentioned by Dutra *et al*. (2019), it is of paramount importance to have the cooperation of the industries of a given region so that there is efficient monitoring of GHG emissions. Thus, one realizes the importance of the application of this case study, in the face of the verification of emission control GHGs, conducted in the industry that will be the target of the analysis of this research, given that it is in the region of Manaus/AM, where the state of Amazonas itself has been considered a major emitter of GHGs nationwide.

According to the PBGHGP tool, Scopes 1 and 2 contain the type of GHGs emissions, where Scope 1 includes emissions derived from the derived combustion categories, mobile combustion and fungible emissions and Scope 2 including emissions derived from the energy purchase category. The GHG Protocol (Greenhouse Gas Protocol) of the Brazilian program defines the aspects inherent to scopes 1 and 2, to calculate the emission of GHGs. Thus, the case study applied to the target industry of this research will investigate the data presented by Scope 1 (direct emissions) and Scope 2 (indirect and mandatory emissions from the acquired energy consumption). The development of the case study was guided by the survey of the gases emission inventory, contemplating the steps shown below by Fig. 1.

Fig. 1: Steps for the survey of GHG emissions

Source: IPCC, (2006).

According to Brazil, De Souza, & De Carvalho (2009) the emission factor is an expression of the emission associated with a unit of activity of the source. Emission factors report the amount of equivalent CO2 emitted per unit of activity. Thus, they express how intensive a given activity is.

Table 1 shows the emission factors in kilogram of gas per unit of measurement, performed after identifying the activity of scope 1 or 2 and its respective quantitative.

Table 1 - Examples of emission factors.

Activity	**Activity data**	**Emission factor**
Consumption of ectric power	Quantity in kWh	kgCO2/kWh
Burning of natural gas in boiler	Quantity of natural gas (m3)	kgCH4/m3
Power generation in generator set (diesel cycle)	Diesel consumption (liter)	kgN2O/liter

Source: Authors, (2021).

When detailed information is not available, there is the option of using emission factors available in the literature. In this case, it is important to be careful to employ factors that are as close to reality and, if possible, conservative. Conservative factors are those that overestimate some emission, due to the ignorance of some information. For example, if the alcohol content in petrol is unknown and should be considered as the lowest possible value, as this results in the highest GHG emission possible. This way, a price is paid for ignorance, without prejudice to the scenario of the company's emission with stakeholders (BRASIL *et al.*, 2009).

Also, according to the Fundação Getúlio Vargas [FGV] (2011, p. 8) the carbon dioxide equivalent (CO2e) is the unit of measurement used to compare the radiation intensity of a given GHG to that of carbon dioxide. Thus, CO2e should be used to calculate the mass of a given GHG, which should be multiplied by its global warming potential (GWP). In the same sense, it should be emphasized that greenhouse gas emissions can be measured by the total mass of a GHG released into the atmosphere (FGV, 2011, p. 8). Fig. 2 gives the sequence of the operations to be performed, to obtain the result of carbon dioxide equivalent.

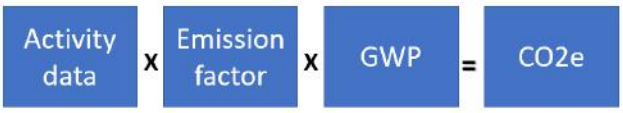


Fig. 2: Steps for the survey of GHG emissions

Source: Authors, (2021).

The emissions of each GHG (CO2, CH4, N2O etc.) are calculated separately and subsequently converted to carbon dioxide (CO2) equivalence based on its global warming potential. As regards GWP, this is the factor that will describe the impact deferred by the radiative force of a unit, which is based on the mass of a given GHG, relative to the CO2 equivalent unit in each period (FGV, 2011).

The elaboration of inventories is the first step for an institution or company to contribute to the fight against climate change, a critical phenomenon that afflicts humanity at the beginning of this century. Knowing the emission profile, from the diagnosis guaranteed by the inventory, any organization can take the following step: to establish strategies, plans and targets for reducing and managing greenhouse gas emissions, engaging in solving this huge challenge to global sustainability (Monzoni, 2008).

The GHG Protocol tool, with a version adapted to the Brazilian reality, launched by PBGHGP, has a methodology compatible with the standards of the International Organization for Standardization (ISO), thus allowing and facilitating the management of their GHG.

Part 1 of the technical standard of the Brazilian Association of Technical Standards [ABNT] NBR ISO 14.064-1: 2007 "Specification and guidance to organizations for quantification and reporting of emissions and removals of greenhouse gases" details principles and requirements', aiming at the planning, development, management and communication of inventories.

2.2 Environment and legal aspects

Based on economic growth and technological development, the great benefits of this evolution are notorious. However, this development has resulted in a series of negative side effects which arise directly on the environment, causing its degradation and, consequently, reducing the quality of human life, as well as deteriorating the legal prospects for environmental preservation (Rolim, 2000).

Thus, the environment became the object of protection and several discussions on its preservation. In this context, it is of paramount importance to highlight the conceptualization of the environment, permeating by the legal concept established by Law N. 6.938, promulgated

on August 31st, 1981, which deals exactly with the National Environment Policy (NEP). In its art. 3, item I, the said legal act establishes the concept of the environment, this being: "the set of conditions, laws, influences and interactions of a physical, chemical and biological order, which allows, houses and governs life in all its forms" (Lei n. 6938, 1981).

In the same sense, NBR ISO 14001:2015 also presented a conceptualization of the environment, stating that this is a "neighborhood in which an organization operates, including air, water, soil, natural resources, flora, fauna, human beings and their interrelationship" (ABNT, 2015). However, in Brazil, the legal definition of the environment positive by art 3, item I, of NEP, as already highlighted above (Lei n. 6938, 1981). Given that such a concept is broad and contemplates the whole set of man-made goods that can affect their existence, whether natural or not (Krzsczak, 2016).

Since 1981, through the promulgation of the NEP, with the advent of Law No 6.938, the actions applied to the environment have gained a preventive conception, from the perspective of adopting measures that anticipate human actions, to mitigate the negative effects on the environment, rather than just to correct them. In addition, NEP itself began to consider the environment as a public asset, and it should receive greater security and protection, considering its collective use in a past, present and future vision (Lei n. 6938, 1981).

By adopting a new concept on environmental preservation, the NEP has paved the way for new legal aspects applied to environmental issues at the national level. These aspects gained – in 1988-a normative force of constitutional order, with the advent of the Federal Constitution of 1988 NEP (Constituição da República Federativa do Brasil, 1988).

Thus, the 1988 Law cited above inserted in its normative body explicit rules on environmental preservation, directing legal responsibility to the Legislator to develop infraconstitutional norms that encompass the preservation and maintenance of the environment in the face of human actions, thus contemplating the objectives of the NEP and adopting a civil responsibility-legal for harmful practices NEP (Lei n. 6938, 1981; Constituição da República Federativa do Brasil, 1988).

Thus, when speaking about the environment, it is irrefutable to analyze the legal aspects that fall on the protection of the same, because this has been considered a social and collective right since the promulgation of the Citizen Constitution of 1988 which, He also defined environmental balance as a condition for achieving a dignified life in society, in conjunction with the legal principles of NEP (Lei n. 6938, 1981; Constituição da República Federativa do Brasil, 1988).

The Federal Constitution of 1988 was the first to adopt environmental standards, previously these norms were only included in the infraconstitutional legislation by the NEP in 1981. The Magna Carta of 1988 is recognized for encompassing a series of social and fundamental rights, popularly known for valuing social welfare and also named the Green Constitution, precisely because it has a strong framework of environmental guidelines. Thus, it is known that the environment is indispensable for a balanced human life and thus, the legal act has inserted into its normative body aspects that seek environmental preservation (Constituição da República Federativa do Brasil, 1988).

This constitutional law contains a list of principles that are adopted by environmental law. Such principles appear both explicitly and implicitly and should be observed as guiding principles for balanced human, political and economic development. The principle of the dignity of the human person; the principle of responsibility; the precautionary principle; the principle of sustainable development; the principle of the polluter- the principle of community participation and the principle of the social function of property (Constituição da República Federativa do Brasil, 1988; Fiorillo, 2018).

It is worth highlighting here the National Policy on Climate Change (NEP), instituted by Law n. 12,187 of 2009, which formalized a voluntary commitment made by Brazil, before the United Nations and its Convention-Framework on climate change and reduction of GHG emissions. In its article 12, this law formalizes the commitment to have actions to mitigate GHG emissions in favor of the reduction of 36.1% to 38.9% of their greenhouse gas emissions.

Thus, the 2015 Paris Agreement was an extremely important point for the climate change regime caused by GHG emissions and managed by the United Nations. Thus, this agreement brings a global approach, allowing several countries to voluntarily adhere to the aforementioned global agreement (Peixer, 2019). However, through Decree n. 9,073 of June 5th, 2017, Brazil became the consignee of this agreement, assuming the reduction of GHG emissions progressively until 2030.

According to Dal Forno (2017), the legal framework linked to the environment has conceived a new perception about the need for environmental preservation to maintain a balanced environment. After the advent of the Federal Constitution of 1988, more specifically from the 1990s, originated the concept that companies started to do a certain "homework" thus fulfilling all the requirements

imposed by environmental legislation in force in the country (Dal Forno, 2017).

Such legal conception awakened the need for the application of Environmental Management in the face of the materialization of legal objectives linked to environmental preservation. It was precisely this set of legal requirements that gave rise to the so-called Environmental Management System (EMS), a system that articulates directly with the perception of the environmental impacts that can be degenerated by the commercial activities practiced by a given enterprise and that start to be managed through the use of Environmental Management (Dal Forno, 2017).

The EMS is managed through ABNT NBR ISO 14001:2015, which has a few requirements with guidelines for the use and implementation of an Environmental Management System. This standard has an international character, included directly in the ISO 14000 series of standards, bringing a branch of requirements for organizations to implement EMS in their industrial operations (ABNT, 2015).

In this context, it should be noted that the atmospheric imbalance caused by GHG emissions is a global concern and causes a great impact on public interests based on the preservation of the environment. Thus, it is essential for the present study a brief analysis on the emission of GHGs in the context of environmental preservation.

2.3 Emissions of greenhouse gases

Climate change has been the subject of global discussions that seek to protect the climate system for the sake of its preservation for present and future generations. Thus, there is a clear concern about human activities that corroborates the substantial increase in greenhouse gas (GHG) concentrations in the atmosphere (Torres; Ferman & Sbragia, 2016).

The GHGs are gaseous compounds that have the absorption capacity of high frequency radiation of infrared origin, causing the accumulation of this radiation in the atmosphere, which directly contributes to the increase of temperature. The high concentration of GHG in the atmosphere ends up increasing the amount of heat retained, which is aggravated by the unbridled increase in the emission of these gases due to human actions and activities, thus raising the problem of global warming (Aguiar; Fortes & Martins, 2016).

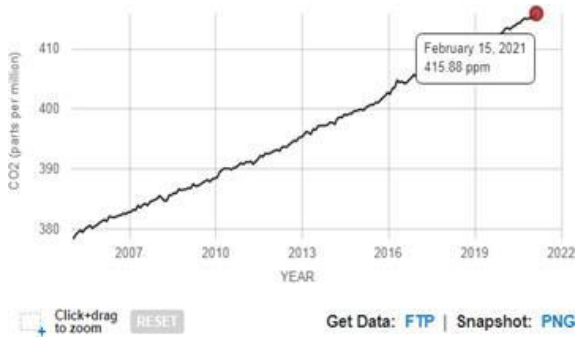
It is worth noting that of all the infrared radiation that falls on the earth, about 70% is absorbed by the oceans and the soil, 30% is reflected into space, while a residual fraction is absorbed by the atmosphere. With the increase of GHG emission the atmosphere amplifies its absorption capacity of infrared radiation, due to the accumulation of GHG on the surface that ends up increasing this absorption condition, degenerating a series of damages to the biome of the environment (Torres; Ferman & Sbragia, 2016).

Among the existing GHGs, the ones with the greatest relevance in relation to their high harmful power for the increase of the greenhouse effect: carbon dioxide (CO2); methane (CH4); nitrous oxide (N2O) and water vapor (H2O).

For Aguiar *et al.* (2016), given the data presented by the reports released by the IPCC, it can be confirmed that the largest responsible for GHG emissions is human activity. The data in the fourth report exposed this statement with about 90% certainty, pointing to human actions as the major cause of the intensification of the greenhouse effect by the large GHG emissions.

The report also pointed out in the middle of this century the unbridled rise in temperature, together with the reduction of soil moisture caused by the scarcity of rainfall, may gradually replace the Amazon rainforest - characterized by a tropical climate - by savannas, as well as the vegetation of the semi-arid region by a vegetation typical of arid lands (Aguiar *et al.*, 2016).

The global report presented by the National Aeronautics and Space Administration (NASA) of 2021, clearly shows that GHG emissions have been growing wildly over the years, going against the objectives of maintaining the climatic conditions of the planet. According to the report, at the beginning of the 20th century the concentration of GHG in the Earth's atmosphere was 300 ppm (parts per million), while the data verified in 2021 already denoted a concentration percentage of approximately 416 ppm by the month of February of that year (National Aeronautics and Space Administration, 2021). Such data can be contacted through representative analysis of graph 1 below.

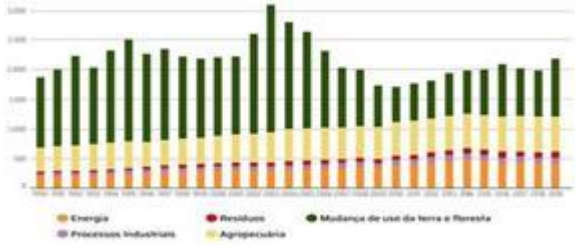


Graphic 1: Global GHG emissions - 2007 to 2021.

Source: NASA, (2021).

At the national level, it is opportune to highlight that the largest GHG generating sources in Brazil - according to the SEEG report issued between 2010 and 2018 - are: energy; transport; industry; agriculture; waste treatment; and changes in land use and forests. In this same context, SEEG points out that the state of Amazonas leads the ranking of the largest emitters of GHG in Brazil. According to SEEG, seven Amazonian municipalities emit about 29.7 million tons of CO2, because of deforestation, which is higher than the emissions of countries like Chile, Uruguay and others (Seeg, 2020).

However, given the analysis performed by SEEG, 2020, it is observed that Brazil increased its GHG emissions between the years 2010 to 2019, going in the opposite direction to the legal objectives, especially regarding the goal set by the NEP. The data can be verified by graph 2, cited below.



Graphic 2: Global GHG emissions - 2007 to 2021.

Source: SEEG, (2021).

III. MATERIALS AND METHODS

The focus of this study was to identify the sources to identify the sources generating GHG in a processing industry of photographic paper in the city of Manaus/AM, through the analysis of data of scope 1 and 2, of the period of two years (2019 and 2020), through the tool PBGHGP, a tool adapted to the Brazilian reality, as shown in Fig. 3, which will account for the emission of CO2e.

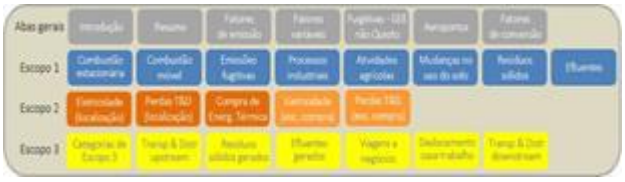


Fig. 3: Scope and activities generating GHGs

Source: FGV, (2021).

The industry has a physical size of approximately 6,661.54 m2 and according to the National Environment Policy (Law no. 6,938 of August 31st, 1981, Art. 17- D.), for the purposes of the Environmental Control and Inspection Rate, the company is framed as Large Size, for annual sales of over 12 million. In addition, the operational framework of the industry consists of about 26 (twenty-six) contract employees (Brazilian labor regulations - CLT) and 7 (seven) service providers (resident outsourced).

The division of the industry sectors focuses on: productive processes (encompasses the Receiving, Stock, Shipping sector, in addition to the QC), utilities/maintenance, administrative support and sewage treatment, located at its headquarters in the city of Manaus, which has 100% of the operational control for scopes 1 (direct) and 2 (indirect) of the PBGHGP tool for GHG inventories. Scope 3 (indirect) was not applicable as it is not considered mandatory.

The survey was conducted in the first half of 2021, specifically between January and June of the same year. With the aim of analyzing GHG emissions in the timeline, 2019 was defined as the base year for conducting the corporate inventory of the industry, given that the industry had not carried out any other GHG inventory previously. The following year, 2020, will be used for comparative analysis.

The universe and population carried out in the study focuses on the aspects that permeate how to supply sources of operational control in the production process, purchase of energy, treatment of effluents and others.

The research used statistical data that were indispensable for the foundation of the present study and the indication of the size of the impacts generated by the problematic that was addressed here. Therefore, the case study was applied in a determined industry of photographic paper processing in the region of Manaus/AM, using some materials and methods that could contribute to the capture, measurement, treatment, analysis and discussion of the data obtained.

In addition, in the practical phase, the analytical, quantitative and qualitative method was adopted, where the data were processed and pointed out within these three perspectives, in order to quantify and qualify the practical context of GHG emissions within the organization. We also analyzed the EMS scenario within the organization, verifying that this system is adopted and used, directing the researcher to make possible suggestions that can be used in this organization.

The study was also permeated by the analysis of legislation dealing with the problem worked here, to demonstrate how the issue is worked in the political-legal framework. As advantages we highlight the participation of industry, in the industrial context, which represents direct participation in global GHG emissions, as well as its strategic location, since the State of Amazonas has

achieved significant GHG emissions, negatively impacting the indexes promoted by Brazil and that make up world emissions, thus distancing itself from the objectives to which the country is co-signatory.

On the other hand, the disadvantages perceived by the study were all included in the measurement of the centralization of the analysis. However, the parameters achieved by the analysis were satisfactory for the extraction of the results that can be used to increase the effective participation of the industry.

IV. RESULTS AND DISCUSSION

Whereas the Amazon region has assumed a significant position in the ranking of national GHG emitters, it is of great importance for the present study to evaluate, separately and concomitantly, as such industry has positioned itself in the face of the control of its GHG emissions in Scopes 1 and 2.

Summarily, it is essential to highlight the delimitation of the macro-process. As the photographic paper processing industry has no participation in other organizations, regarding the definition of organizational boundaries, the approach used was operational control. This stage basically consisted of the identification of the organizational structure of the industry, over which it has direct control, and the characterization of its processes. These steps were described in image 4, highlighted below, to understand the processes involved in the study.

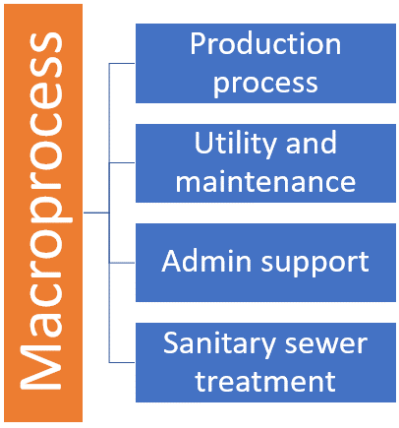


Fig. 4: Industry macro process (photographic paper finishing)

Source: Authors (2021).

The study in relation to PBGHGP, for scope 1, was marked only in the analysis of stationary and mobile fuels, fugitive emissions and effluents. Whereas Scope 2 was guided only by the analysis of localized electricity. The data for the year 2019 served as a base year for the factual analytical study. These results are shown in Table 2, below.

Table 2 - Sources of direct emission - Scope 1

Scope 1	**Data from activity (Source description)**	**Emission element (type)**	**Amount**	
			Year 2019	**Year 2020**
Combustion stationary	Power Generator Group	Diesel oil	200 liters	600 liters
Mobile Combustion	Lawnmower	Automotive gasoline	80 liters	120 liters
Fugitive emissions	Air conditioning system (equipment)	R410-A	22.7 kg	22.7 kg
Effluents	Treatment of liquid effluents (anaerobic process)	Biological effluent	861.2 m^3	653.8 m^3

Source: Authors, (2021).

For stationary combustion, there was a 200% increase in the volume of fuel consumed between 2020 and 2019. As for commercial automotive gasoline, in the mobile combustion category, an increase in consumption was identified by 50% when compared to the previous year. These fuels are used respectively in the power generating group and in the lawnmower.

It was identified during the study that the industry paralyzed its activities in the months of April to June 2020, a rainy period in the city, which may have contributed to the growth of undergrowth (grass). This period of downtime also resulted in a 24% reduction in the volume of effluents generated in 2020, when compared to the 2019 results.

Fugitive emissions remained stationary at 22.68 kg between 2019 and 2020, with no increase, much less reduction. Such emissions arise from leaks or any other

type of unintentional and irregular release of vapors and gases. In addition, fugitive emissions are difficult to control. GHG emissions by refrigeration and air-conditioning equipment, from the perspective of the mass balance (Kyoto) remained stationary at 47.34 t CO2e, according to the quantity transferred, between 2019 and 2020, as can be seen in Table 3, below.

Table 3 - GHG emissions by refrigeration and air-conditioning equipment - Mass balance (Kyoto).

Source record	**Gas or compound**	**GWP**	**VE –**	**Source record**	**Gas or compound**	**GWP**
2019	R-410A	2.088	-	22.68	-	47.34
2020	R-410A	2.088	-	22.68	-	47.34

Source: Authors, (2021).

Therefore, knowing that the study applies to Scopes 1 and 2, the indirect emissions defined in Scope 2 were also catalogued, in addition to identifying the non-applicable activities, within the same comparative used in the Scope 1 analysis, focusing on the income statement between 2019 and 2020. These results can be measured in Table 4, highlighted below:

Table 4 - Sources of direct emission - Scope 2

Emission element (type)	**Amount**		**Unit of Measurement**
	Year 2019	**Year 2020**	
Electricity	595,8	484,736	MWh

Source: Authors, (2021).

It is of great importance for the study to demonstrate the comparison of GHG emissions in tons, recorded between 2019 and 2020, to understand quantitatively the parameters measured between both years, thus enabling the expansion of the perception of the ecological-legal responsibility of the company. These results can be verified in Table 5 below.

Table 5 -GHG emissions in ton – 2019/2020

GHG	**Emissions in metric ton of CO2 equivalent (tCO2e) for the year 2019**		**Emissions in metric ton of CO2 equivalent (tCO2e) for the year 2020**	
	Scope 1	**Scope 2 (addresses gem by "location")**	**Scope 1**	**Scope 2 (addresses gem by "location")**
CO_2	0.60	43.61	1.6	30.89
CH_4	0.87	-	0.5	-
HFCs	47.34		47.3	
Total tCO2e	**48.82**	**43.614**	**49.47**	**30.89**

Source: Authors, (2021).

Emissions in tons of CO2e for Scope 1 in 2020 were 1.32% higher than in 2019. However, in Scope 2, there was a reduction of 29.19%, which is equivalent to more than 12.5 tons of CO2e. The Scope 2 emissions are unique and exclusively derived from the purchase and consumption of electric energy. Thus, it can be said that while the electric energy consumption of Scope 2 decreased by 19% in 2020, the reduction of its emissions was 10.19% higher than the energy consumption. Given the results perceived in the face of the reduction of localized electricity, it is explicit that the highest reduction rates occurred precisely in the period in which the industry had its activities paralyzed by COVID-19. When the activities were resumed the reductions continued to exist, but in a timid way, perhaps due to the low productive demands in the face of the instabilities presented by the market. In this context, there is clearly a need for industry to continue to proactively engage in activities that seek to reduce this type of consumption, since it focuses on global GHG emissions.

It was also possible to identify that more than 95% of the tons of CO2e of Scope 1, in both years, were due to fugitive emissions from the climate system used by the industry. These fugitive emissions were stationed at 22.68 Kg in both years (2019/2020) and are equivalent to 47.4 tCO2e.

V. CONCLUSION

Based on the results presented by the case study, which evaluated the GHG emissions of this industry based on PBGHGP, scopes 1 and 2, it has been found that for Scope 1 data GHG emissions have changed, which means that industry needs to be more attentive to the emissions captured by this target, since the reduction of these GHG levels is mandatory and not optional and can thus bring legal harm to this company.

Therefore, considering that during 2020 the industry targeted by the case study was closed for a period due to the social isolation caused by Covid-19, it should be noted that a reduction in GHG emissions of scope 1 would be favorable, although the increase does not have a highly problematic amplitude. But, considering that the Amazon region needs to present an improvement in the GHG emission framework, it is understood that the state industries need to be more careful in controlling such emissions.

Regarding the emissions measured in scope 2, there was a relevant reduction in the indexes, clearly noting that the period of closure of the industry may have corroborated for such a reduction, which did not occur in scope 1. As the reduction of Scope 2 emissions is optional, consideration should be given to the importance of assessing and better controlling Scope 1 emissions to reduce them and to contribute to increasing local, state and national GHG emissions.

Finally, it should be noted here that this research is not exhausted, since it was limited to the analysis of a given company, in each region. Thus, it is suggested that new studies be surveyed to investigate whether other sectors or branches of industry in the city of Manaus had a similar profile, what are the main sources of GHG emissions and whether the critical period of the Covid-19 pandemic established a similar emission profile in the Amazon, thus producing material that denotes the importance of a greater commitment of those involved in this context.

REFERENCES

[1] Associação Brasileira de Normas Técnicas (2015). NBR ISO 14001:2015. Rio de Janeiro: ABNT

[2] Associação Brasileira de Normas Técnicas (2007). NBR ISO 14.064-1:2007. 1. Rio de Janeiro: ABNT,

[3] Aguiar, L.V., Fortes, J.D.N., & Martins, E. (2016) Neutralização compensatória de carbono – estudo de caso: indústria do setor metal mecânic. Eng Sanit Ambient, Retrieved from: https://www.scielo.br/pdf/esa/v21n1/1413-4152-esa-21-01-00197.pdf

[4] Lei n. 6938, de 31 de agosto de 1981. Versa sobre a Política Nacional do Meio Ambiente (PNMA). Retrieved from: http://www.planalto.gov.br/ccivil_03/leis/l6938.htm

[5] Constituição da República Federativa do Brasil de 1988. Versa sobre as normas constitucionais do país. Retrieved from: http://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm

[6] Lei n. 12187, de 29 de dezembro de 2009. Versa sobre a inclusão da Política Nacional sobre Mudança do Clima - PNMC e dá outras providências. Retrieved from: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm

[7] Decreto n. 9073, de 5 de junho de 2017. Versa sobre a promulgação brasileira do Acordo de Paris sob a Convenção-Quadro das Nações Unidas sobre Mudança do Clima. Retrieved from: http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/decreto/d9073.htm

[8] Brasil, G. H., De Souza, P. A., & De Carvalho, J. A. (2009). Inventários corporativos de gases de efeito estufa: métodos e usos. Sistemas & Gestão, v. 3, n. 1, p. 15-26. Retrieved from: https://www.revistasg.uff.br/sg/article/view/SGV3N1A2

[9] Dal Forno, M.A.R. (2017). Fundamentos em Gestão Ambiental. 1 ed. Rio Grande do Sul: UFRGS.

[10] Dutra *et al*. (2019). Análise de Deslocamento dos Poluentes de Emissões na Cidade de Manaus, Brasil. Revista Brasileira de Geografia Física v.12, n.01, 039-056. Retrieved from: https://www.researchgate.net/profile/Helder-Relvas/publication/332817600_Revista_Brasileira_de_Geografia_Fisica_Analise_de_Deslocamento_dos_Poluentes_de_Emissoes_na_Cidade_de_Manaus_Brasil/links/5ccb0b1e92851c3c2f8167d9/Revista-Brasileira-de-Geografia-Fisica-Analise-de-Deslocamento-dos-Poluentes-de-Emissoes-na-Cidade-de-Manaus-Brasil.pdf.

[11] Fernandes, R. P.R., Nogueira, M.A., & Jimenez, I.J.T. (2020). Estudo de caso no aterro de resíduos sólidos urbanos de Manaus/AM. BIUS - Boletim Informativo Unimotrisaúde em Sociogerontologia, v. 23 n. 17: EDITORIAL DO BIUS DE DEZEMBRO/2020. Retrieved from: https://periodicos.ufam.edu.br/index.php/BIUS/article/view/8344

[12] Fundação Getúlio Vargas (2011). Especificações de Verificação do Programa Brasileiro GHG Protocol. Programa Brasileiro GHG Protocol. Retrieved from: http://bibliotecadigital.fgv.br/dspace/bitstream/handle/10438/30258/especificacoes-ghg2011.pdf?sequence=1&isAllowed=y

[13] Fiorillo, C.A.P. (2018). Curso de Direito Ambiental Brasileiro. 18 ed. São Paulo: Saraiva.

[14] IPCC. (2006). Incertezas. Retrieved from: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_3_Ch3_Uncertainties.pdf

[15] Krzysczak, F.R. (2016) As diferentes concepções de meio ambiente e suas visões. REI – REVISTA DE EDUCAÇÃO

DO IDEAU, Vol. 11 – Nº 23 – Janeiro - Junho, ISSN: 1809-6220. Retrieved from: https://www.passofundo.ideau.com.br/wp-content/files_mf/037781a20b7271d160dc922d7d1b9c44355_1.pdf

[16] Monzoni, M. (2008) Contabilização, quantificação e publicação de inventários corporativos de emissões de gases de efeito estufa. Programa Brasileiro GHG Protocol, 2 ed. São Paulo: FGV. Retrieved from: http://bibliotecadigital.fgv.br/dspace/themes/Mirage2/pages/pdfjs/web/viewer.html?file=http://bibliotecadigital.fgv.br/dspace/bitstream/handle/10438/15413/Especifica%c3%a7%c3%b5es%20do%20Programa%20Brasileiro%20GHG%20Protocol.pdf?sequence=1&isAllowed=y

[17] National Aeronautics and Space Administration (2021). Carbon Dioxide, Latest Measurement: February 2021, 416 ppm. Climate NASA, 2021. Retrieved from: https://climate.nasa.gov/vital-signs/carbon-dioxide/

[18] Peixer, J. F. B. (2019). A contribuição nacionalmente determinada do Brasil para cumprimento do acordo de paris: metas e perspectivas futuras. Tese (Doutorado em Direito) – Florianópolis: Universidade Federal de Santa Catarina – UFSC, 346f. Retrieved from: https://repositorio.ufsc.br/bitstream/handle/123456789/199009/PDPC1446-T.pdf?sequence=-1&isAllowed=y.

[19] Rolim, A. M. (2020). A reciclagem de resíduos plásticos pós-consumo em oito empresas do Rio Grande do Sul - 2000. Dissertação (Mestrado em Administração) - Porto Alegre: Universidade Federal do Rio Grande do Sul, 142f. Retrieved from: https://www.lume.ufrgs.br/bitstream/handle/10183/2397/000273408.pdf?sequence=1

[20] SEEG (2020). SEEH 8: Análise das emissões brasileiras de gases de efeito estufa e suas implicações para as metas de clima do Brasil 1970-2019. Retrieved from: https://seeg-br.s3.amazonaws.com/Documentos%20Analiticos/SEEG_8/SEEG8_DOC_ANALITICO_SINTESE_1990-2019.pdf

[21] Torres, C., Fermam, R.K.S., & Sbragia, I. (2016). Projetos de MDL no Brasil: Oportunidade de mercado para empresas e para novas entidades operacionais designadas. Ambiente & Sociedade, São Paulo v. XIX, n. 3 n p. 199-214. Retrieved from: https://www.scielo.br/pdf/asoc/v19n3/pt_1809-4422-asoc-19-03-00199.pdf