BIOETHANOL CARBON FOOTPRINT INTEGRATED 2019 REPORT

Report on bioethanol carbon footprint BIO4 BG1 BG2(2019).

This document summarizes the preliminary analysis of the productive chain of bioethanol and by-products from corn by Bio4 and its integrated biogas plants Rio Cuarto Córdoba

Bioethanol carbon footprint

This document summarizes the preliminary integrated analysis of the productive chain of bioethanol and by-products from corn from the integrated plants Bio4 and BG1 BG2 Rio IV Cordoba

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INTRODUCTION

We are facing a marked interest on the part of different actors of society in alternative energy vectors as well as other products derived from the transformation of biomass into bio refineries.

The demand for "sustainable" products continues to increase which implies a commitment of the entire supply chain. This evolution, combined with the need to diversify energy sources to reduce dependence on oil and its derivatives, and to find transitional fuels towards a new generation of energy sources, has led the central countries, mainly the European Union (EU) and the United States. United, to develop policies to encourage the use of biofuels. These policies have been multiplied in many countries with increasing incorporations of biofuels in their energy matrix and Argentina has become a leading country in this matter for its legal architecture as well as its levels of participation in the liquid fuel markets.

The transformation of renewable biomass has been established as one of the priority issues for its economic, social and energy environmental impacts. Thus, countries with strong agricultural systems are investing considerable amounts of resources to find new ways of using the carbon molecule contained in crops and organic waste of all kinds. This affects the very structure of the research centers where institutes are born that complement several disciplines and integrate young professionals from different institutions. The investigations are not left at the laboratory level but the centers themselves have the means to scale up the discoveries at the pilot and pre-commercial levels for their transfer to the productive sector. Its productivity is permanently measured not only in its scientific production of quality but in its successful patents and transfers to the productive sector.

Corn is the second most important crop in Argentina after soybeans, with a share of 24% of the country's total grain production. But since the production cost of corn is higher than that of soybean, since 1997 there has been a great growth in the area planted with soybeans, reaching a ratio of almost 4 hectares of soybean to one of corn. The change of administration caused a substantial modification of the conditions by reducing the levels of taxes on the export of corn, which caused an increase in the production of this crop.

This crop is key to strengthen a sustainable agriculture through its participation in the rotation. The fall in the price of oil added to the increase in the world consumption stock ratio in the last two four seasons has determined a fall in prices, determining a challenge for its development. It deserves to be highlighted given the recent successful campaigns in the northern hemisphere that the bioethanol industry has played a fundamental role in sustaining demand, avoiding a sharp drop and millions in losses to producers around the world.

The main destination of Argentine corn is export; therefore, maize production is concentrated mainly in the provinces that are closest to the ports, a situation that significantly affects the cost of freight, with maize cultivation reaching its maximum development in the Pampean region, an area of great extension of fertile lands and temperate climate. Concentrating therefore the production of corn in the provinces of Buenos Aires, Córdoba and Santa Fe, which together make up the core zone, which concentrates a little more than 70% of the total area planted with corn. In this zone, the majority of corn producers are exclusively agricultural that integrate production systems by contracts or networks. In this area the highest yields of the country are obtained since they have at their disposal the best technology for the production of corn (ie better seeds, fertilizers, phytosanitary products and agricultural machinery) which is applied by most of the producers regardless of how small is its scale of production. In contrast, in marginal areas the situation is completely different. There is a big difference between the big producers, who can access the best technology, and the medium and small producers, who in many cases produce with much more primitive technologies from sowing to harvesting. One of the advantages of Bio4 plants is that is owned by large farmers of the area. They apply good technology for the crop and obtain higher values than the mean of the area.

At present, direct sowing is maintained with some ups and downs as the most appropriate for the production of corn in Argentina, with about 80% being planted in recent years of the total area devoted to this crop. However, this technology brings with it some challenges, among which are the avoidance of soil compaction, increasing soil moisture retention efficiency, increasing the efficiency of the nutrient cycle; and also to prevent the possible appearance of diseases due to the accumulation of organic matter in the soil, as well as the appearance of resistant weeds and of different pests that demand new solutions. On the other hand, the technological advance on corn genetics allowed this crop to achieve the highest yield increases in the last 30 years, going from 3 t / ha in the decade of the '80 to values that exceed 12 t / ha in cash crops . Also, it is worth noting that in recent years, Argentina has become one of the benchmarks in Latin America in Precision Agriculture.

At present, the movement of grains in Argentina is eminently road, since 91% is carried out by truck, 8% by rail and 1% by barge. These percentages differ substantially with respect to other producing countries, such as the USA, where 60% of the movement is fluvial, or in Brazil where the participation of the railroad is approximately 30%. It is important to note that the movement of grains in Argentina historically takes place in two stages: the path between the production and storage area (cooperative), which includes a so-called "short" freight due to the proximity between origin and destination; and transport from storage area to port or industry known as "long" freight. The integration observed in the commercialization of grains in the last two decades promoted the direct movement from production to industry or port area, reducing it to a single stage. This is particularly applied to the case of Bio4 were the grans are produced within a small range of distance from the plant.

Argentina presents a very low degree of industrialization of its corn production. The imbalance in the rotations has been compensated in the last campaigns. The transformation of raw materials into products of more value is essential for the development of the country, and therefore some sectors of consumption find an opportunity for growth based on the high availability of domestic corn at low cost.

SUSTAINABILITY STUDIES

Since the beginning of the diffusion and start-up of the production of biofuels worldwide, three topics have always been at the table of discussion and controversy, these are the energy balances, the competition with food and the preservation of the environment. Nowadays, these questions are being expanded to other products in response to growing demands from large supermarket chains.

The action of different research centers, nongovernmental environmental organizations and stakeholders have strongly installed the issue of threats that arise in the face of an unrestricted expansion of biofuel production in the world as well as the impact of agricultural production.

The growing concern about the sustainability of biofuels has led scientific institutions, academics as well as certain governments and institutions to work intensively on these issues. Given the significant participation of Argentina as the world's leading exporter of biofuels, its evolution is analyzed with great attention as well as other possible sources of biomass, which implies a new demand for INTA areas and programs as well as its units.

DIRECTIVE 2009/28 / EC OF THE EUROPEAN PARLIAMENT concerning the promotion of the use of energy from renewable sources establishes criteria for the use of biofuels within the EU and the potential application to financial assistance programs. This Directive opened an opportunity for the Argentine Republic to supply this market. But on the other hand, also the same Directive, in Article 17, raises the sustainability criteria for biofuels and bioliquids, "regardless of whether the raw materials have been grown inside or outside the territory of the Community." This poses a great challenge to analyze and demonstrate the sustainability of the production systems of biofuels for export to the EU.

Within the criteria of sustainability, one of the analyzed is the reduction of greenhouse gas emissions (GHGs) derived from the use of biofuels. In particular, the Directive proposes that a reduction of at least 35% must be ensured in order to be able to access the corresponding tax benefits, subsequently raising a level of reductions as of 2017 (50%) and as of 2018 (60%).

The literature referred to the evaluation of bioethanol from corn starch is wide varied and presents strong contradictions and inconsistencies. Between 2005 and 2012, the CO2 emissions of the US corn bioethanol (the most produced in the world) have been reduced by 26.2% with respect to naphtha according to a Life Cycle Associates study commissioned by the Renewable Fuels Association including the emissions derived from the indirect land use change (ILUC, in its acronym in English). The conclusions warn that this difference will go further, since hydrocarbon sources (non-conventional gas through fracking and tar sands) are used more and more intensively in carbon emissions.

The average emissions of fuels derived from hydrocarbons went from 96.46 grams of CO2 equivalent per mega joule (gCO2e / MJ) in 2005 to 96.87 gCO2e / MJ in 2012. On the other hand, ethanol from cultivated corn in the United States it has happened in the same period from 76.34 to 65.54 gCO2e / MJ (ILUC included). The corresponding emissions to the one that also uses the residues derived from the corn crop have also decreased, going from 76.23 to 65.18 gCO2e / MJ. In both cases, it represents an average reduction of 26% with respect to fossil fuel, a difference that in 2012 stands at 32.3% and for 2022 it is expected to reach 42.7%. In the directive on renewables, the European Union marks a 35% reduction for 2012, 50% for January 1, 2017 and 60% for January 1, 2018. Another important requirement is that the lands on which a crops destined for biofuels have not been occupied by native forest or another high carbon biome as of January 2008.

Although the report prepared by the Life Cycle Associates (LCA) for the ethanol employers in the United States, the Renewable Fuels Association, most likely the biofuel analyzed does not currently meet the European directive, since, pending its modification , this does not require to include the emissions from the ILUC.

There are great differences in the methodologies that measure the ILUC. The report presents the analysis of the life cycle of several types of bioethanol and fossil fuels in which it is confirmed that while the emissions of these continue to grow, those of biofuels maintain a progressive decline. Without leaving to consider the ILUC, the great difference that exists according to the evaluations that are taken as a model, which can range from 19 to 100 gCO2e / MJ, is confirmed.

In a European and Spanish reading of the study, Abel Esteban recalls that, "unlike in the United States, both in Spain and in the EU they consume mainly biodiesel (more than 81% in Spain in 2011) and dieselization goes further, so that will aggravate the main problems of indirect changes in land use (emissions, deforestation ...) that occur due to the expansion of palm plantations in Southeast Asia. " Bioethanol from sugarcane has always had (independently of the methodology) direct and indirect emission values that are much better than biodiesel. In the ACV or LCA life cycle analysis study, emissions are compared with ILUC of different biofuels from the data of the Air Resources Board of the California Environmental Protection Agency and the figures go from 30 gCO2e / MJ of corn ethanol to 62 gCO2e / MJ of soybean diesel grown in the Midwestern United States. Taking into account the differential yields of each crop and the different use of fertilizers and crops, these numbers are very different in Argentina.

Recent studies Liska 2009 on a series of bioethanol plants located in the agricultural center of the United States yields values without considering changes in land use ranging between 37 and 48 gCO2 / MJ of bioethanol.

PRESENT STUDY

BioIV is performing carbon footprint measurements since 2014, being this one the third one with INTA.

To carry out this analysis, the information of all the sectors of the company involved was researched in a stabilization period of two months. The information and management systems of the company were used, a calculation model consistent with the standard developed by the European Union, and finally a tool for estimating greenhouse gas emissions that reflects the integrated operation of Bio4 with BG1 and BG2 was developed

LOCATION OF THE PLANTS

The plants under study occupy a land located in Rio4 Córdoba, The land on which the plants are located has an area of 30 hectares covering an area of 1.5 hectares

BIO 4 PLANT DESCRIPTION

The process of dry grinding begins with the cleaning of the grain of corn, which once clean passes through the mills that grind it into a fine powder - corn flour. The corn flour is blown in large tanks where it is mixed with water and the enzymes - alpha amylase - and passes through the kitchens where the starch is liquefied. To the mixture chemical components are added to maintain it in a range around pH of 7. In this stage heat is applied. High temperatures reduce the levels of bacteria present in the mash or must

The introduction of digestate coming from BG1is done in this stage. The mash of the kitchens is then cooled and a secondary enzyme glucoamylase is added to convert the molecules of the liquefied starch into fermentable sugars - dextrose.

Bioethanol is the product of fermentation. To the mash yeast is added to ferment the sugars and thereby obtain the bioethanol and carbon dioxide. In this process the mash remains about 48 hours before the distillation process begins. In fermentation, bioethanol retains much of the energy that was originally in the sugar. The fermented mash, now called beer, will contain alcohol - about 1% - and water, as well as all the non-fermentable solids of corn and yeast. The mash will then be pumped to a continuous flow, in the distillation column system, where the beer is boiled, separating ethyl alcohol from solids and water. The alcohol will leave the distillation column with a purity of 96%, and the waste mash, called stillage, will be transferred from the base of the column for introduction to the biogas plants. The alcohol passes through a system that removes the remaining water. Pure alcohol, without water, is called anhydrous alcohol.

There are two main byproducts of the process: carbon dioxide and distilled grains. Carbon dioxide is obtained in large quantities during fermentation, in the case of BIO4 it is released into the atmosphere. Distillate grains, wet and dry -DGS-, are obtained from stillage, which is centrifuged to separate the suspended and dissolved solids. An evaporator is used to concentrate the suspended and dissolved solids and then sent to a drying system to reduce the water content to approximately 10/12%. DGS contain the core of the corn minus the starch.

A syrup can be made that contains some of the solids that can be marketed together or independently of the distilled grains. This alternative is now minimize to reduce energy consumption and promote the use of this stillage on the biodigesters.

FINAL GENERATED PRODUCTS:

Bioethanol is produced by alcoholic fermentation by yeast. Yeasts ferment simple sugars, which comes from biomass, resulting in ethanol and carbon dioxide. In the case of corn, the starch that contains the grain is the only component that is transformed into alcohol. For this specific enzymes are used that hydrolyze the starch to simple sugars such as glucose. The alcohol produced in the alcoholic fermentation is distilled. The objective of the distillation is to produce alcohol of adequate quality and concentration (95% v / v). Later that alcohol is dehydrated, the absorption of water is produced by means of molecular sieves where the distillery alcohol remains with a concentration of 99.5% v / v. This is the degree of purity that is required for fuel use.

The syrup has been minimized during the last year of operation At the present stage it is obtained from the liquid fraction called corn distillate and pumped to BG1 and BG2 biogas plants. This fraction eventualy enters the evaporation zone where it is concentrated and that concentrated product is Syrup. When the syrup is eventually produced, one part is shipped and another part is mixed with the WDG (wet Burlanda)

The wet burlanda WDG is obtained as a byproduct of the process of dry grinding of corn for the production of ethanol. It is mainly composed of proteins, oils, fibers, minerals, vitamins and water, so it has a great nutritional value. During the production process, corn starch is converted to ethanol using enzymes and yeasts. After separating the ethanol in the distillation, the resulting must is centrifuged obtaining on one hand WDG (wet burlandand) and on the other hand, a liquid fraction called corn distillate.

The wet burlanda with WDGS syrup is the humid corn burlanda (WDG) if syrup is produced it is added. In general, after the centrifugation process, the content of fibers, proteins, ethereal extract and ashes are concentrated between 2.2 and 3 times, in relation to the original product. The protein content of the burlanda is high, around 26%.

The dry corn with or without syrup (DDGS) is obtained after the WDGS (wet Burlanda) enters drying ovens, and by means of indirect heat, the humidity percentage decreases from 68 to 10%. This drying system allows to maintain the nutritional conditions of the product and make it suitable for the international market.

BG1 & BG2 PLANT DESCRIPTION

Bioelectric 1 uses three types of biomass in its production process:

- Corn Silage: ENERGY CULTIVATION. Biomass with high energy content. (fading)
- Livestock manure: wet residual biomass. (fading)
- Bio4 corn light stylage increasing

Bioelectric 2 only uses Bio4 corn light stylage

The raw materials are fed to a primary biodigester where the process of anaerobic digestion is carried out at constant temperature and agitation. There microorganisms degrade the organic matter giving producing gases that make up the biogas (mainly CH4 and CO2) and a byproduct with high content of nutrients, such as nitrogen and phosphorus, called digestate or biofertilizer. It is a thermophilic process, since the operating temperature is higher than 50ºC. Subsequently, the mixture passes to the secondary biodigester where the degradation of the organic matter ends and the products of the digestion are stored: biogas and biofertilizer. The working temperature of this equipment is constant and lower than that of the primary biodigester.

The biogas generated requires purification operations to be fed to the motor generator. In the first instance traces of hydrogen sulfide (of the order of ppm) are eliminated by a chemical process thanks to the injection of air in minimum controlled quantities, the oxygen in the air reacts with the hydrogen sulfide generating solid sulfur and water, both compounds They are mixed with the liquid residues of the biodigester and form the mixture used as biofertilizer. Next, the water vapor present by its condensation is eliminated.

Finally, the purified biogas is conducted to the area of power generation, where it is burned in an internal combustion engine. The thermal energy released is transformed into mechanical energy. A generator coupled to the motor transforms mechanical energy into electrical energy. This process has efficiencies greater than 80%.

To market electric power, a transformer raises the voltage to the appropriate level of the local distribution network, it can be uploaded to the electricity distribution network.From the same network Bio4 consumes energy at the same time. We assume that all the electric energy consumption by Bio4 is provides by Bioelectric 1 & 2. The surplus energy is added to the national grid system.

Note: Although since selling and buying prices are different Bioelectric 1 & 2 delivers energy to the systema and Bio4 consumes from the same grid.

Part of the heat that is recovered in the motorgenerators cooling systems is used to heat the process through a heat exchanger. The surplus thermal energy is provided to Bio4 and this is reflected by a decrease in natural consumption of that plant already calculated..

At the end of the process the mixture no longer has the capacity to generate biogas, because all the digestible organic matter has been consumed, but it does have the nutrients that the corn took from the soil to grow and those that were present in the manure. These nutrients present in the liquid resulting from the process, called digestate or biofertilizar. This liquid is stored in a lagoon were some methanization occurs and then it is pumped into central pivot irrigation systems. A total of 1450 hectars are fertiirrigatied with the liquid fraction of the digestate. It is a process of circular agriculture, because the nutrients that the plant took from the soil to grow are intact in the digestate and are returned to the soil by means of fertiirrigation as a biofertilizer. This recirculation of nutrients decreases the dependence of exogenous nutrients.

For example, corn requires 4 Kg of phosphorus for each ton of grain produced, in the harvest 75% of the phosphorus leaves the agro-ecosystem (batch) and must be replaced, usually by synthetic fertilizer or by the soil in its default. The use of digestate as biofertilizer returns to the batch the nutrients that were extracted in the harvest.

Note: In the present study no credit was calculated for the crops being irrigated.

In order to preserve corn crop energy content silo technology is used. The corn silo generates leachate due to the humidity of the chopped corn at the moment of the silo making. This effluent is composed of water with dissolved soluble solids (mostly soluble sugars). The leachates that could be generated in the bunker silos are collected by a system of gutters, placed on the sides of it, and conducted to the tank where the mixture of raw materials (livestock waste and chopped corn) is made prior to entry into the primary biodigester tank.-

ESTIMATION MODEL OF GREENHOUSE GAS EMISSIONS

For the construction of the methodology for estimating GHG emissions, the European Directive was taken as a basis, which sets out in its Annexes the concepts to be included for estimating life cycle emissions and the calculation of the reductions achieved by biofuels. . In turn, some concepts were not included because they do not correspond to the production cycle of BIO IV. The basic equation according to the Directive is detailed below, and what concepts have been included or not in the present study.

$E = e_{ec} + e_l + e_p + e_{td} + e_u – e_{sca} – e_{ccs} – e_{ccr} – e_{ee},$

Table 1 Parameters included

	Concept	Desitio
E =	Fuel use	
e_{ec} =	Crop cultivation	Yes
e_l =	Change In coil carbon stocks	No No scientific evidence on carbón stocks change. Fields under cultivation before 2008
e_p =	Transformation process	Yes
e_{td} =	Transport and distribution	Yes
e_u =	Use of fuels	No Directiva Europea - Anexo V - Párrafo 13: “se considerará nula para los biocarburantes y biolíquidos”
e_{sca} =	Improvement in soil management	No Although a posible advantage due to no tillage use could be used.

e_{ccs} =	Crbon retención techniques	No No geologic practices.
e_{ccr} =	Credit for carbón sustitution	No
e_{ee} =	Surplus electricity	No for Bio4 Yes for BG2 Electricity is delivered to the national grid.

Finally the reduction of emissions is calculated, using the following equation:

REDUCTION = (EF - EB) / EF,

Being

- EB = the total emissions from the biofuel or bioliquid,

- EF = the total emissions from the reference fossil fuel.

According to the management systems and to facilitate the analysis of emissions, the cycle of production of Bioethanol has been divided into the following stages:

- Agricultural Production (eec): it includes all the operations associated with the fields, up to the gate of the farm.
- Raw Material Freight: includes all the operations from fields, including the transfer from producers to the stockpiles and between the stockpiles and the processing plant.
- Production of Bioethanol and co-products (ep): includes the industrial operation from grain conditioning, to the production of Bioethanol and the associated co-products (oils, DDGS, WDGS, carbon dioxide).
- Freight to destination (etd): an estimate of freight is included by truck to Rosario port and then ship to destination port (Rotterdam).

For the calculation of the values corresponding to each concept, the guidelines "Guidelines of the Intergovernmental Panel on Climate Change (IPCC) 2006 used for the national inventories of greenhouse gases" were used. Because these guidelines were not specifically designed to calculate the emissions of a product but of countries, it was necessary to use different bibliography and information sources such as biograce and ecoinvent

The sources of emission considered and the calculation schemes included in each stage are detailed below:

FARM PRODUCTION

Article 6 of the Directive states: "Emissions from the extraction or cultivation of raw materials, eec, shall include emissions from the extraction process or the crop itself, the collection of raw materials, waste and losses , and the production of chemical substances or products used in the extraction or cultivation. The estimates of the emissions from the crops can be elaborated from means calculated for smaller geographical areas than those used in the calculation of the values by defect, as an alternative to the use of real values. "

In the case of BIO4, the processed material comes from own and external fields with products generated in particular fields, therefore the company does not have a direct relationship with the agricultural production establishments.

In order to obtain all the information regarding inputs and field yields qualified referents that represent an area of 5213 hectares and an output of 44,416 tons to the plant, the values of the technological package used regarding the use of the main inputs and agricultural machinery were determined. These data was used in the estimation of the emissions at the field level on the basis of information represent 45 % of the corn used by the plant.

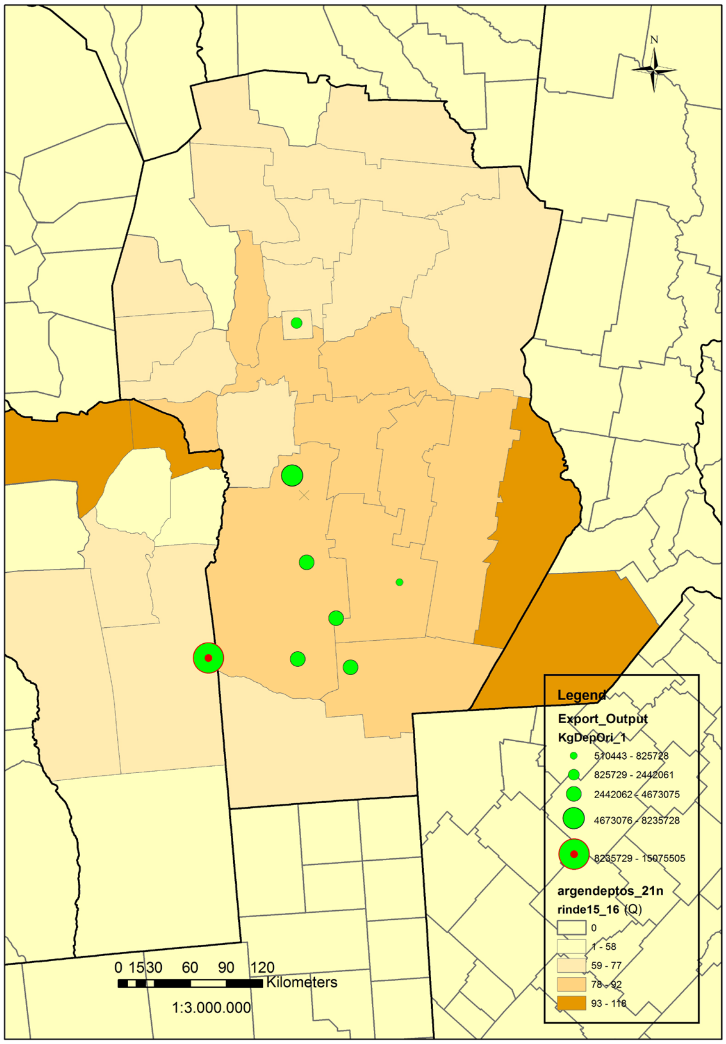


Figure 1 Field survey on provider farms

Se utilizó cada campo relevado para modelizar el paquete tecnológico empleado considerándolo representativo de un grupo de localidades (especificadas en las cartas de porte). A continuación, se detalla cada una de las fuentes consideradas y el esquema del calculador empleado:

CROP RESIDUE FOR BIO4 CORN AND BG1 CORN SILAGE

The methodology indicated in Chapter 11 - Volume 4 of the 2006 IPCC Guidelines - Level 1 was used. Sources of "Direct" and "Indirect by Leaching" emissions were included. For the estimation the following steps were carried out:

- - Step 1: Calculation of crop yield in Kg / Hectare.
- - Step 2: Calculation of N of agricultural residues, including N fixer crops and forage / pasture renewal, returned to soils (FCR) by Equation 11.7.
- - Step 3: Calculation of Direct emissions through the use of Equation 11.1 and Table 11.1.
- - Step 4: Calculation of Indirect Leaching emissions by means of Equation 11.10 and Table 11.3.

FERTILIZER USE FOR BIO4 CORN AND BG1 CORN SILAGE

"Direct" and "Indirect x Atmospheric Deposition and Leaching" sources associated with the application of synthetic fertilizers were included, and the CO2 emissions from the use of Urea and derivatives, for which the Level 1 methodology was used as indicated Chapter 11 - Volume 4 of the IPCC Guidelines 2006.

The steps followed in the calculation were:

- Step 1: Calculation of the amount of applied synthetic fertilizer (FSN) by applied fertilizer by type and composition.
- Step 2: Calculation of Direct emissions through the use of Equation 11.1 and Table 11.1.
- Step 3: Calculation of Indirect emissions by Atmospheric Deposition by means of Equation 11.09 and Table 11.3.
- Step 4: Calculation of Indirect Leaching emissions by means of Equation 11.10 and Table 11.3.
- Step 5: Calculation of the amount of Urea equivalent applied (FUREA).
- Step 6: Calculation of CO2 emissions by use of Urea using equation 11.3.

The data used for the calculation are the "Quantity", "Type of fertilizer" and "Composition" of synthetic fertilizers applied on average.

FUEL & LUBRICANTS FOR ALL OPERATIONS

This concept includes emissions of greenhouse gases (CO2-N2O-CH4) associated with the burning of Gas-Oil and Naphtha for the preparation, sowing, harvesting, application of fertilizers and agrochemicals. That is, the direct emissions produced at the level of the corn supplier fields.

Below are the steps to estimate the corresponding emissions Fuels and Lubricants:

- ✓ Step 1: Estimation of the consumption of fuels and lubricants, by converting the activities carried out to liters of fuel and lubricants. It is important to highlight that BIO4 as a company does not have its own fields (if it has partners with their own field that may or may not sell their production to the company and therefore the information is centered on third parties.) For this reason, the conversion is made through the average consumption for each activity
- ✓ Step 2: Calculation of Direct emissions multiplying the consumption of each fuel and lubricant by its corresponding emission factor.

FERTILIZER PRODUCTION FOR BIO4 CORN AND BG1 CORN SILAGE

This emission source refers to the GHG emissions associated with the production cycle of fertilizers applied during corn production. To make the estimation, the following methodology was used:

- Step 1: Estimation of the kilograms of fertilizers applied according to standardized corn production data, expressed as mass of N, P205, K20 and S.
- Step 2: Calculation of the emissions multiplying the quantity of each fertilizer element by the corresponding Emission Factor of the Biograce database

AGROCHEMICALS PRODUCTION FOR BIO4 AND BG1 CORN SILAGE

This source of emission refers to the GHG emissions associated with the production cycle of the agrochemicals applied during the production of corn. To make the estimation, the following methodology was used:

- Step 1: Estimation of the kilograms of agrochemicals applied according to standardized corn production data.
- Step 2: Calculation of the emissions multiplying the quantity of agrochemicals by the corresponding Emission Factor of the Biograce database.

SEED PRODUCTION FOR BIO4 AND BG1 CORN SILAGE

This source of emission refers to the GHG emissions associated with the production cycle of corn seeds planted in the fields for the production of corn. To make the estimation, the following methodology was used:

- Step 1: Estimation of the kilograms of maize seed applied.
- Step 2: Calculation of the emissions multiplying the amount of seed corn by the corresponding Emission Factor taken from the biograce database.

FUEL PRODUCTION AND LUBRICANTS FOR ALL OPERATIONS

In the case of emissions associated with the production of fuels and lubricants, the values used for the "Extraction" and "Refinery" stages were those indicated in the Methodology "Approved consolidated baseline and monitoring methodology ACM0017" Production of Bioethanol for use as fuel "- v.01.1 - UNFCCC - CDM Executive Board". In the case of naphtha and lubricants, since they do not have values, the same values were used in the first case as for Gas-Oil, and in the second, 10% of the combustion emissions. The estimation of emissions was made by multiplying the consumption of each of the fuels and lubricants by the corresponding value.

FUEL AND LUBRICANTS PRODUCTION FOR ALL OPERATIONS

En el caso de las emisiones asociadas a la producción de los combustibles y lubricantes, se utilizan los valores para las etapas de “Extracción” y “Refinería” indicados en la Metodología “*Approved consolidated baseline and monitoring methodology ACM0017 “Production of Bioetanol for use as fuel” - v.01.1 - UNFCCC - CDM Executive Board*”. En el caso de la nafta y los lubricantes al no contar con valores, se utilizan, en el primer caso, los mismos valores que para Gas-Oil, y en el segundo un 10% de las emisiones por combustión.

La estimación de emisiones se realiza multiplicando los consumos de cada uno de los combustibles y lubricantes por el valor correspondiente.

TRANSPORT OF RAW MATERIALS

In this concept all the movements of seeds from the fields to the silo were included. Another important consideration is that, in all freights, the round trip emissions were considered as indicated in the Methodology "Approved consolidated baseline and monitoring methodology ACM0017" Production of Bioethanol for use as fuel "- v.01.1 - UNFCCC - CDM Executive Board ".

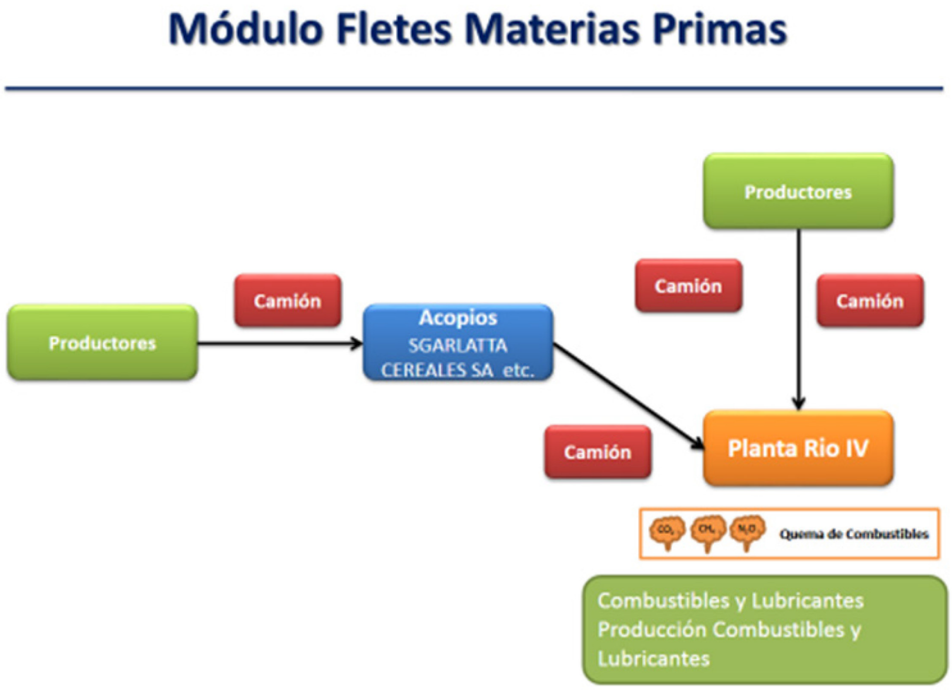


Figure 2 Bio4 corn supply transport description

TRANSPORT BY TRUCK

To estimate the kilometers traveled by truck per campaign, the data extracted from the supply management system of raw materials based on the waybills were used. In the specific case of this study given that the company contributed an estimated average weighted transport consumption of 38 liters per 100 kilometers. For the BIO4 case, the km declared by the waybill were taken and multiplied by two to consider round trip.

Table 2 Reference information

Emisiones por km recorrido Camion Cerealero		Unidades	Ecuacion	Valor
	Consumo específico de Gas-Oil	Lt/ 100 Km	Dato de Logistica BIOIV. Se toman maximos	38,00
FECO2 LTS	Factor de emision de CO2	KgsCO2/Lts	Ver Hoja Factores de emision Incluye LCA	2,67
CO2	Emisiones CO2 por Transporte por Km	KgsCO2/Km	Consumo x Km	1,02
FEN2O LTS	Factor de emision de N2O	mg N2O/Km	IPCC 2006 - Cuadro 3.2.5 - Pre-Euro Diesel - Autobus - Rural >16 t	30,00
N2O	Emisiones N2O por Gas-Oil Transporte	KgN20/Km	Cambio de unidades	0,00
FECH4 Lts	Factor de emision de CH4	mg CH4/ km	IPCC 2006 - Cuadro 3.2.5 - Pre-Euro Diesel - Autobus - Rural > 16 t	80,00
CH4	Emisiones CH4 por Gas-Oil Transporte	KgCH4/km	Cambio de unidades	0,00
$FE_{CO2eq\ Unidad}$	Factor de emision x KM recorrido	$KgsCO_{2eq}$ /Km	FE total x Km	1,03

BIOETHANOL AND COPRODUCT PRODUCTION

According to the European Directive in Annex V - Point 11: "The emissions from the transformation, ep, will include the emissions from the transformation itself, the waste and losses, and the production of chemical substances or products used in the transformation".

In this case with the objective of allocating the emissions among the co-products, the process was subdivided into:

- Reception
- Grinding and Fermentation
- Distillation
- Separation
- Drying
- Common Consumptions

The appropriation of the emissions between the co-products awasmade according to the following three criteria:

Energy Content: According to the European Directive "If a fuel production process produces, in combination, the fuel on which the emissions are calculated and one or more different products (called" co-products "), the emissions of greenhouse gases will be divided between the fuel or its intermediate product and co-products, proportional to their energy content (determined by the lower calorific value in the case of co-products other than electricity) ".

Additionally, a specific analysis was carried out, assigning the consumptions according to the consumption and yields of the process, which resulted in an improvement in the accuracy of the calculation.

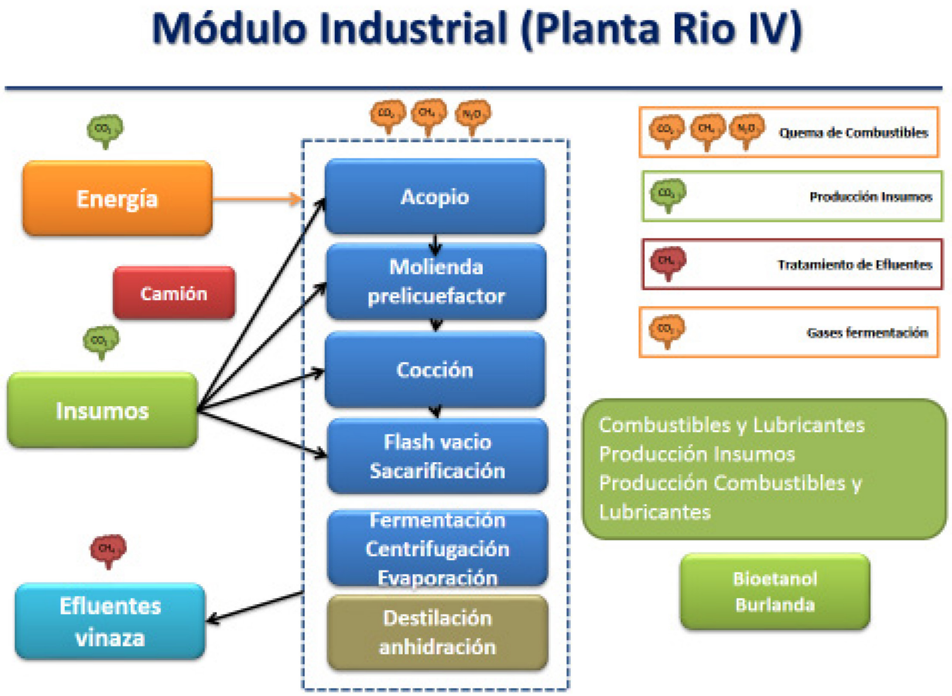


Figure 3 Industrial model

The appropriation of the emissions between the co-products are made according to the following three criteria:

- Mass balance: Emissions are appropriated according to the real performance (% by weight) of each stage.
- Energy Content: According to the European Directive "If a fuel production process produces, in combination, the fuel on which the emissions are calculated and one or more different products (called" co-products "), the emissions of greenhouse gases will be divided between the fuel or its intermediate product and co-products, proportional to their energy content (determined by the lower calorific value in the case of co-products other than electricity) ".
- Market Price: According to the EB 50 - of the Executive Board of the Clean Development Mechanism, for allocation of co-products. This methodology is used for projects that generate certified emission reductions.

Additionally, a specific analysis was carried out, assigning the consumptions according to the consumption and yields of the process, which resulted in an improvement in the accuracy of the calculation.

ENERGY

This concept includes all emission sources associated with the consumption of fuels and lubricants. For all cases, the total consumption of the plant was taken as a basis, being assigned between each of the stages based on the following criteria:

- Electric Power: Appropriation by installed electrical power

- Thermal Energy: Appropriation based on the estimated consumption of steam according to the contractual performance data of the technology provider.

For all fuels the calculation scheme is based on the global consumption of the plant multiplied by the corresponding emission factor, and then the appropriation for each stage.

The energy purchased from BIoelectrica (which has an emission factor 0,062 / kwh against 0.392 kgCO2 / kwh from the Network) was considered. The value was taken from the calculation of Biolectrica for 2016.

PRODUCTION INPUT MATERIALS:

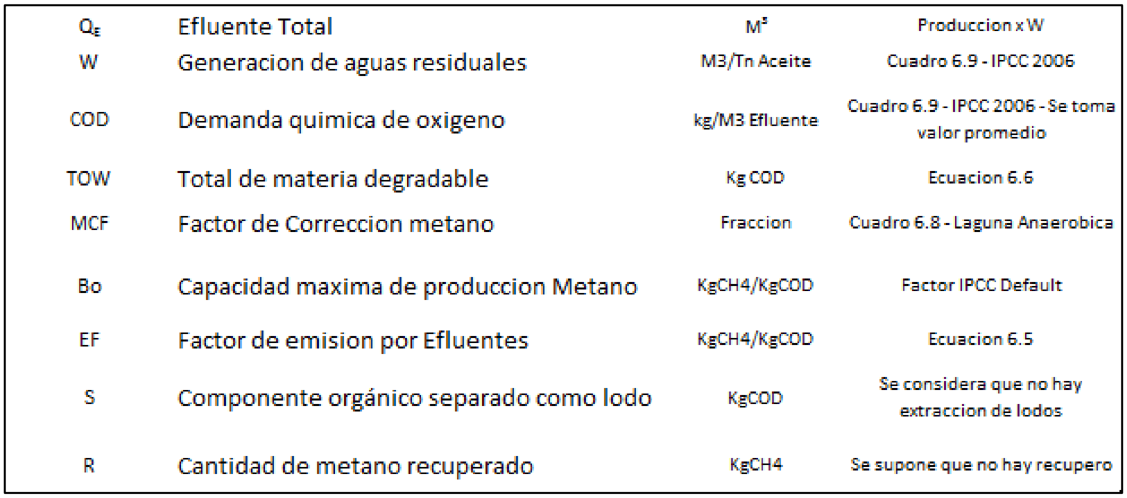
In the case of emissions due to the production of inputs, due to the lack of available information, only the emissions of alpha amylase, glucoamylase, sulfuric acid, urea and sodium hydroxide have been considered.

LIQUID EFFLUENTS:

The emissions due to the treatment of liquid effluents were estimated based on the methodology indicated in Chapter 6 - Volume 5 of the 2006 IPCC Guidelines. The steps followed are detailed below:

- Step 1: Calculation of residual water volume according to production.
- Step 2: Estimation of Total degradable matter (Equation 6.6)
- Step 3: Determination of the methane correction factor and emission factor by treatment system. (Table 6.8 and Equation 6.5)
- Step 3: Calculation of emissions by liquid effluents (Equation 6.4).

Table 3 Units and factors



Q_E	Efluente Total	M^3	Produccion x W
W	Generacion de aguas residuales	M3/Tn Aceite	Cuadro 6.9 - IPCC 2006
COD	Demanda quimica de oxigeno	kg/M3 Efluente	Cuadro 6.9 - IPCC 2006 - Se toma valor promedio
TOW	Total de materia degradable	Kg COD	Ecuacion 6.6
MCF	Factor de Correccion metano	Fraccion	Cuadro 6.8 - Laguna Anaerobica
Bo	Capacidad maxima de produccion Metano	KgCH4/KgCOD	Factor IPCC Default
EF	Factor de emision por Efluentes	KgCH4/KgCOD	Ecuacion 6.5
S	Componente orgánico separado como lodo	KgCOD	Se considera que no hay extraccion de lodos
R	Cantidad de metano recuperado	KgCH4	Se supone que no hay recupero

EMPLOYED EMISSION FACTORS FOR BIO4 AND BG1 & BG2

A continuación, se detallan los factores de emisión utilizados en los cálculos de emisiones de gases de efecto invernadero:

POTENTIALS OF GLOBAL WARMING

The values indicated in the European Biofuels Directive were used - EU 2009/28 / EC - Annex 5 - Point C. Methodology - Art. 5:

- CO_2: 1
- CH_4: 23
- N_2O: 296

ENERGY CONTENT

Next, the energy contents used for the changes of units as well as for the appropriation of emissions between co-products are detailed.

Table 4 Energy contents employed

Insumo	Humedad (%)	Contenido Energético (Kcal/Kg)	Contenido Energético (Mj/Kg)	Fuente
Alcohol etilico 95%	5%			
Alcohol etilico anhidro (Bioetanol)	0%	6.595,96	27,31	Analisis en Laboratorio Lantos. Muestra/identificacion: 2016-05-0207. Fecha de muestra: 13-05-2016 (Promedio valores maximos y minimos)
DDGS	11%	3.592,00	15,04	Fuente ACABIO: Calculo promedio calidad mensual periodo 01-01-2016 / 30-06-2016
WDGS	67%	1.293,00	5,41	Fuente ACABIO: Calculo promedio calidad mensual periodo 01-01-2016 / 30-06-2016
Aceite vegetal	0,30%	9.132,27	38,24	Analisis en Laboratorio Lantos. Muestra/identificacion: 2016-05-0208. Fecha de muestra: 13-05-2016

In the cases BG1 & BG2 they were only taken as outputs to biogas with their average energy content by adding the thermal energy actually delivered.

DEFAULT FACTORS FOR THE ESTIMATION OF THE N ADDED TO THE SOILS FROM AGRICULTURAL WASTE

For the estimation of N_2O emissions, the values for Level 1 included in Table 11.2 - Volume 4 - Chapter 11 - Page 19 - IPCC 2006 were used.

Note In this first calculation the fields surveyed did not receive contributions of macro nutrients from the application of digestate, therefore the calculated impact can be considered as maximum. If a system of re-fertilization and return of nutrients to the lots in production is established, this impact from the mineral fertilizers used could suffer important reductions.

N2O EMISSION FACTORS (DIRECT / INDIRECT SOURCES)

For the estimation of N20 emissions, the default coefficients indicated in tables 11.1 (Page 12) and 11.3 (Page 26) Volume 4 - Chapter 11 - IPCC 2006 were used. The coefficients used are extracted below:

Table 5 Employed factors

Factor	Descripción	Unidad	Valor por Defecto	Rango de incertidumbre
EF_1	Para aportes de N de fertilizantes minerales, abonos orgánicos y residuos agrícolas, y N mineralizado de suelos minerales a causa de pérdida de carbono del suelo	kg N_2O–N / kg N	0,01	0,003 - 0,03
$Frac_{GASF}$	**Volatilización de fertilizante sintético**	**(kg NH_3–N + NOx–N) / (kg N aplicado)**	**0,10**	**0,03 - 0,3**
EF_4	Factor de Volatilización y re-deposición de N	Kg. N_2O/ NH_3-N+Nox-N volatilizado)	0,01	0,002 - 0,05
$Frac_{Lixiviación-H}$	**Fracción pérdidas de N por lixiviación y escurrimiento**	**kg N Lixiviado / kg N aplicado**	**0,30**	**0,1 - 0,8**
EF_5	Factor de lixiviación y escurrimiento	kg. N_2O-N/Kg. N lixiviación/escurrimiento	0,0075	0,0005 - 0,025

Note: At this stage of the study, the possible impact on the emissions of the stubble due to the incorporation of biofertilizers was not taken into account. They respond in their magnitude to the doses, environmental and soil conditions, application technology and characteristics of the digestate.

ENERGY EMISSION FACTORS

The local emission factors were used, fundamentally included in the inventory of Greenhouse Gases included in the Third National Communication of the Argentine Republic to the United Nations Framework Convention on Climate Change 2012. Here are the factors used:

Table 6 Employed factores

Tipo de Combustible/Energético				Gas-Oil	Nafta	Nota 1 Lubricantes	G.L.P.	Gas Natural	Leña (dura)	Nota 2 Energía Electrica	Fuel-Oil
Variable	**Descripcion**	**Unidades**	**Fuente**	Lts	Lts	Lts	Kg	M^3	Kg	KwH	Kg
PCI	Poder Calorífico Inferior	Kcal/unidad	Balance Energético Nacional - Metodologia construccion BEN	8.619	7.607	8.503	10.950	8.300	2.300		9.800
D	Densidad	Kgs/unidad	Inventario 2012 - Factores Generales	0,8450	0,7350	0,8850	0,5370	0,7190			0,9450
Frac Ox	Fraccion de Carbono Oxidado	%	Inventario 2012 - Factores Generales.	1,000	1,000	1,000	1,000	1,000	1,000		1,000
C_C	Contenido de Carbono	TC/TJ	Inventario 2012 - Factores Generales	20,21	18,90	19,99	17,21	15,30	30,55		21,11
$FE_{CO2\ KCAL}$	Factor de emision de CO_2	KgsCO_2/Kcal	$FE_{CO2} = C_C$*Frac Ox * 44/12	0,0003102	0,0002901	0,0003069	0,0002642	0,0002349	0,0004689		0,0003241
$FE_{CO2\ Unidad}$	Factor de emision de CO_2	KgsCO_2/Unidad	FE x Unidad de consumo	2,67	2,21	2,61	2,89	1,95	1,08	0,392	3,18
FE_{N20}	Factor de emision de N_2O	KgsN_2O/TJ	Inventario 2012 - Factores Generales	0,6	0,6	0,6	0,1	0,1	4,0	-	0,6
$FE_{N2O\ KCAL}$	Factor de emision de N_2O	KgsN_2O/Kcal	Cambio de Unidades	0,000	0,000	0,000	0,000	0,000	0,000	-	0,000
$FE_{N2O\ Unidad}$	Factor de emision de N_2O	KgsCO_2/Unidad		0,000	0,000	0,000	0,000	0,000	0,000	-	0,000
FE_{CH4}	Factor de emision de CH_4	KgsCH_4/TJ	Inventario 2012 - Factores Generales	3,00	3,00	3,00	1,00	1,00	30,00	-	1,00
$FE_{CH4\ KCAL}$	Factor de emision de CH_4	KgsCH_4/Kcal	Cambio de Unidades	0,000	0,000	0,000	0,000	0,000	0,000	-	0,000
$FE_{CH4\ Unidad}$	Factor de emision de CH_4	KgsCO_2/Unidad		0,000	0,000	0,000	0,000	0,000	0,000	-	0,000
$FE_{CO2eq\ Unidad}$	Factor de emision de CO_{2eq}	KgsCO_{2eq} /Unidad	FE total x Unidad	2,68	2,21	2,62	2,90	1,95	1,10	0,392	3,18
$FE_{CO2eq\ Kcal}$	Factor de emision de CO_{2eq}	KgsCO_{2eq} /Kcal	FE total x Kcal	0,0003113	0,0002912	0,0003079	0,0002644	0,0002351	0,0004768		0,0003249

FACTORES USED FOR INPUT OF THE PLANT

Table F of the calculator groups together the main inputs used by the company in its stages of industrial processing. These factors are then taken into account to make the respective determinations.

Table 7 Factores for Bio4 plant inputs

Insumo	Factor de emision por KgsCO2eq/Kg	Energía fósil MJ/kg	Fuente
Alfa-amilasa	1,00	15,00	Nielsen, P.H., Oxenboll, K.M., Wenzel, H., 2007. Cradle-to-gate environmental assessment of enzyme products produced industrially in Denmark by Novozymes A/S. Int J LCA 12(6) 432-438.
Glucoamilasa	7,50	87,00	Nielsen, P.H., Oxenboll, K.M., Wenzel, H., 2007. Cradle-to-gate environmental assessment of enzyme products produced industrially in Denmark by Novozymes A/S. Int J LCA 12(6) 432-438.
Acido sulfurico 98%	0,21	3,90	JEC E3-database (version 31-7-2008) - BioGrace V4.d
Agua amoniacal 28%	2,66	44,39	JEC E3-database (version 31-7-2008) - BioGrace V4.d
Fermasure	-	-	No hay datos
Soda caustica 50%	0,47	10,22	JEC E3-database (version 31-7-2008) - BioGrace V4.d
Acido sulfamico	-	-	No hay datos
Levadura	-	-	No hay datos
Lactrol	-	-	No hay datos
Urea solida	0,61		Tabla 6 - Europe Average - Kongshaug (1998) - "A Review of Greenhouse Gas Emission Factors for Fertiliser Production" - Sam Wood and Annette Cowie - IEA Bioenergy Task 38 - Junio 2004.
Benzoato de denatonio	-	-	No hay datos
Soda caustica - Solvay	0,47	10,22	JEC E3-database (version 31-7-2008) - BioGrace V4.d
Carbonato de sodio	1,19	13,79	No hay datos
Monoetanolamina (MEA)			No hay datos
Amoníaco	2,66	44,39	JEC E3-database (version 31-7-2008) - BioGrace V4.d
Permanganato de potasio (KMnO4)			No hay datos
Silicagel			No hay datos
Carbon Activado			No hay datos

PRODUCTION OF FERTILIZERS, AGROCHEMICALS AND SEEDS

The emissions generated in the production of the three standard fertilizers used in the production of corn were estimated, based on the consumptions relieved in the witness fields used. The emission factors of Table 7 of the report "A Review of Greenhouse Gas EmissionFactorsforFertiliserProduction" and BioGrace (2011) were used.These can be found in the "Table I. Fertilizers" of the Corn Production Emissions chart.

Tabla 8 Factores of fertilizers

Nombre Fertilizante	U.M.	Categoria	Composicion (%)				UREA	Emisiones Ciclo de vida	
			N	P2O5	K2O	S	%	Kgs CO2eq/U.M.	Fuente
UREA	KG	Fertilizante	46,0%	0,0%	0,0%	0,0%	100%	0,61	Tabla 6 - Europe Average - Kongshaug (1998) - "A Review of Greenhouse Gas Emission Factors for Fertiliser Production" - Sam Wood and Annette Cowie - IEA Bioenergy Task 38 - Junio 2004.
DAP	KG	Fertilizante	18,0%	46,0%	0,0%	0,0%	0%	0,46	Tabla 7 - Europe Average - Kongshaug (1998) - "A Review of Greenhouse Gas Emission Factors for Fertiliser Production" - Sam Wood and Annette Cowie - IEA Bioenergy Task 38 - Junio 2004.
SOLMIX	KG	Fertilizante	30,0%	0,0%	0,0%	2,6%	0%	1,31	Tabla 6 - Europe Average - Kongshaug (1998) - "A Review of Greenhouse Gas Emission Factors for Fertiliser Production" - Sam Wood and Annette Cowie - IEA Bioenergy Task 38 - Junio 2004.
Cebador 14:34	KG	Fertilizante	14,0%	34,0%	0,0%	9,0%	0%	0,31	Tabla 7 - Europe Average - Kongshaug (1998) - "A Review of Greenhouse Gas Emission Factors for Fertiliser Production" - Sam Wood and Annette Cowie - IEA Bioenergy Task 38 - Junio 2004.
Microessential SZ	KG	Fertilizante	12,0%	40,0%	0,0%	10,0%	0%	0,31	Tabla 7 - Europe Average - Kongshaug (1998) - "A Review of Greenhouse Gas Emission Factors for Fertiliser Production" - Sam Wood and Annette Cowie - IEA Bioenergy Task 38 - Junio 2004.

Source: A Review of Greenhouse Gas Emission Factors for Fertilizer Production. Para IEA BioenergyTask 38, Junio 2004.

Regarding the emission factors for the production of agrochemicals, the literature is varied and it is considered appropriate to use the value proposed by BioGrace (2011) as emission factor for pesticides since it is conservative and has the approval of the ISCC (International Sustainability and Carbonization).) of the

European Union. Coadjutant (oil) or inoculant emissions are not considered. The emission factor for the corn seed production of Ecoinvent 2.2, 2010 was used, which is proposed by the ISCC.

Table 9 Factors of agrochemicals and seeds

Variable	Unidad	Valor por Defecto
Factor de Emisión para producción de agroquímicos	kg CO_2eq/ kg	10,97
Factor de Emisión para producción de semillas de maíz	**kg CO_2eq/ kg**	**1,93**

USE OF FUELS AND LUBRICANT IN THE CORN GRAIN PRODUCTION

To estimate the amount of fuel and lubricants used in the corn production, the consumptions surveyed in the control fields for each zone were taken into account. It was assumed that the spray is terrestrial for 80 l and that the fertilization is liquid. Each tillage activity was assigned an average fuel or lubricant consumption per surface as can be seen below. Unless otherwise indicated, it is assumed that the consumption of lubricants is 12% of fuel consumption.

Table 10 Fuel consumption for grain production

Labores	Combustible	Lts/Ha (Gas Oil)	Lts/Ha Nafta	Lts/Ha (Lubricantes*)	Observaciones	Fuente de Informacion
SIEMBRA	Gas-Oil	7,63		0,92	No es posible distinguir tipo de siembra por lo cual se promedian S.D. Grano Fino/Grueso	Tabla: El costo de los laboreos agricolas - 1/02/2011 - 42/43
PULVERIZACIÓN	Gas-Oil	1,65		0,20	Se toman valores de pulverizacion de arrastre	Tabla: El costo de los laboreos agricolas - 1/02/2011 - 43
COSECHA	Gas-Oil	15,58		1,87		Estudio Huella de Carbono en los Exportables de la Provincia de Buenos Aires - CFI - 2011

CORN FOR SILAGE AGRICULTURAL PRODUCTION

By means of personnel of the company, the five fields that provide corn for their silage were surveyed, from the information provided the values of the technological package used regarding the use of the main inputs and agricultural machinery were determined. These data was used in the estimation of emissions at the field level based on information representative of the fields of generation of maize for silage average of three campaigns. The totality of inputs and yield was calculated in order to obtain the carbon footprint of the corn silo as one of the inputs of BG1 although this type of material is fading up.

To estimate the amount of fuel and lubricants used in the corn production, the consumptions surveyed in the control fields for each zone were taken into account. It was assumed that the spray is terrestrial for 80 l and that the fertilization is liquid. Each tillage activity was assigned an average fuel or lubricant consumption per surface as can be seen below. Unless otherwise indicated, it is assumed that the consumption of lubricants is 12% of fuel consumption.

ACTIVITY DATA FOR BIO4 BG1 & BG2

FIELD EMISSIONS FOR GRAIN PRODUCTION

Based on the field information surveyed (nine fields) the activity data for each zone was estimated. The calculation of emissions per ton of grain was made for each of the surveyed regions and on average. In the case of regions with surveyed fields, the tons received were multiplied by the value corresponding to that area. For those fields that were in areas without surveyed fields, the average (simple) GHG emission of the surveyed fields was used.

TRANSPORTATION EMISSIONS FOR GRAINS

The movements from the corn suppliers to the industrial plant were based on the information contained in the "Letters of Carriage".

INDUSTRIAL PROCESS EMISSIONS

The information corresponding to the inputs used, the energy consumed and the products generated were contributed by the company.

LIGHT CORN STYLAGE

Since in the calculation of Bio4 there is not any specific allocation awarded for this product it is assumed that the environmental burdens were distributed among the other products of the distillery and therefore does not correspond to the processes of BG1 and BG2

RAW MATERIALS TRANSPORT FOR BG1 & BG2

This concept includes all movements of forage and manure from origination to the location of the digester. Another important consideration is that, in all freights, round trip emissions are considered as indicated in the Methodology "Approved consolidated baseline and monitoring methodology ACM0017" Production of Bioethanol for use as fuel "- v.01.1 - UNFCCC - CDM Executive Board".

The estimate of the kilometres travelled by truck per campaign were extracted from the company's declarations according to the distance of each establishment and the number of trips made in the campaign-

Note for the case of light vinasse was not considered the pumping energy expenditure since it was added in the processes of bio4 analyzed.

PRODUCTION OF BIOGAS AND DIGESTATE

According to the European Directive in Annex V - Point 11: "The emissions from the transformation, ep, will include the emissions from the transformation itself, the waste and losses, and the production of chemical substances or products used in the transformation".

In the case of the proposed model, within the concept and with the objective of allocating the emissions among the co-products, the process has been subdivided into:

- Reception
- Fermentation

- Digestate storage

The sources of emission considered for the transformation stage are detailed below:

ENERGY

This concept includes all emission sources associated with the consumption of fuels and lubricants. For all cases, the total consumption of the plant is taken as a basis, being assigned between each of the stages based on the following criteria:

BIOFERTILIZER OR DIGESTATE FROM BG1 & BG2 PLANTS:

The emissions due to intermediate storage and final application of the biofertilizer in the field were estimated based on the methodology indicated in Chapter 6 - Volume 5 of the IPCC 2006 Guidelines:

- Step 1: Calculation of the digestate volume.
- Step 2: Estimation of Total degradable matter (Equation 6.6)
- Step 3: Determination of the methane correction factor and emission factor by treatment system. (Table 6.8 and Equation 6.5)
- Step 3: Calculation of emissions by liquid effluents (Equation 6.4).

CALCULATORS FOR BIO IV & BG1 BG2

Specific calculators developed for the companies Bio4 and bioelectrica were used. They contain a number of spreadsheets in Excel version 2016, with dynamic tables. The complete system contains 34 related pages; it has all the reference information, income and sensitivity forms and evaluations for the external and national markets.

Inventario actividades BIOIV - Campaña 2016/2017

Resumen de contenidos planilla de calculo

Version 11 (LS) - 19/10/2017

Hoja de calculo	Contenido	Carga de datos	Pagina
Emisiones BIOIV	Resumen de emisiones de la campaña y calculo de emisiones por unidad de producto según criterio de Balance de masas (ajustado por contenido de humedad), Precio de Mercado, y Contenido Energético.	No	1
Grafico Inventario	Grafico de barras por fuente de emision para campaña 2015/16	No	2
Análisis Sensibilidad Rinde	Calculo de sensibilidad por rinde de acuerdo con dos modelos, uno con insumos por hectarea fijo y otro con fertilizacion proporcional a la extraccion por grano. Se toman las emisiones originales de la campaña 2014/15 y solo se recalculan las emsiones asociadas a la produccion de maiz. Contiene los gráficos de comparativa.	Si. Rinde a analizar	3
Análisis Exportacion UE	Estimación de emisiones BIOETANOL puesto en Europa, según directiva europea de Bioenergía.	No	4
Analisis Apropiación Linea	Cuadros y calculos de emisiones por cada sector de la planta de etanol. Se incluye una comparativa en funcion de los criterios de apropiacion por total de emisiones y discriminando las etapas productivas.	Si. Porcentajes de apropiación por sector de planta	5
Balance Energético	Calculo del balance de energia por producto (Tasa de retorno energético)	Si. Porcentajes de apropiación por sector de planta y contenido energético	6
Análisis Planta CO2	Estimación de las emisiones de los productos elaborados contemplando el "ahorro" de emisiones por no producir CO2 a partir de Gas Natural.	No	7
Auxiliar Grafico	Planilla auxiliar para realizar la representación gráfica	No	8
Diagrama de Flujo	Diagrama de proceso de la planta de Bioetanol	Sí	9

Figure 4 Calculator presentation

RESULTS 2009

The estimated emissions for 2019 based on the model prepared for BIO4 S.A & Bioelectrica, and the corresponding information. The income to the BIO4 plant reported in the summary form corresponds to the 18/19 campaign. Given that the field, energy consumption and production coincide with that period, it was decided to carry out the estimation with (fields 16/17 -figures). The models of fields surveyed correspond to the period 16/17.

CORN FIELD EMISSIONS

The information used is based on the 2016/17 survey: During that period, 195,998 tons of corn (net weight) were received at the plant from 166 suppliers from the provinces of Córdoba and San Luis. An estimate of the average yield of the province was made, using two methodologies in the calculator; the average yields per locality weighted by the income from the corresponding areas to the plant were taken.

Table 11 Yield estimation

Localidades	Kgs Recibidos	Kg Relevados	% Muestra	Ha Relevadas	Kgs/ha
Modelo 1	-	546.000	0%	80	6.825
Modelo 2	581.490	596.000	102%	56	10.643
Modelo 3	-	2.100.000	0%	302	6.954
Modelo 4	-	2.100.000	0%	311	6.752
Modelo 5	-	2.600.000	0%	268	9.701
Modelo 6	-	600.000	0%	88	6.818
Modelo 7	3.369.059	900.000	27%	121	7.438
Modelo 8	-	23.904.259	0%	2.880	8.300
Modelo 9	11.200.863	11.070.066	99%	1.107	10.000
Sin relevar	180.430.114				
Total Kg	**195.581.526**	**44.416.326**	**23%**	**5.213**	**8.520**

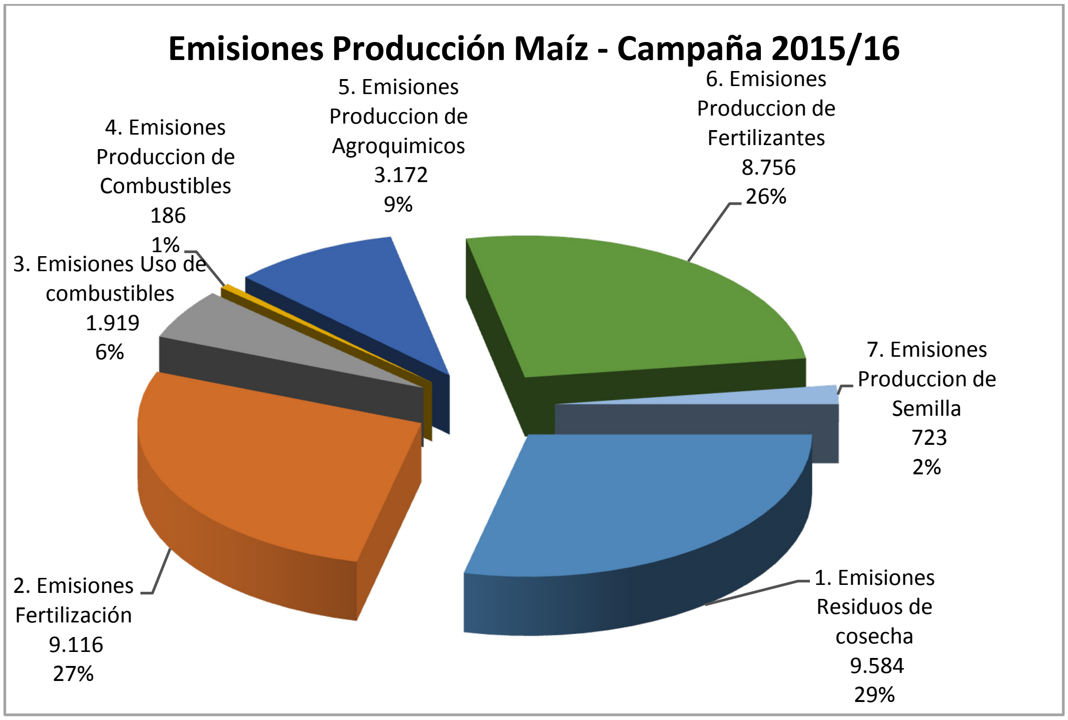


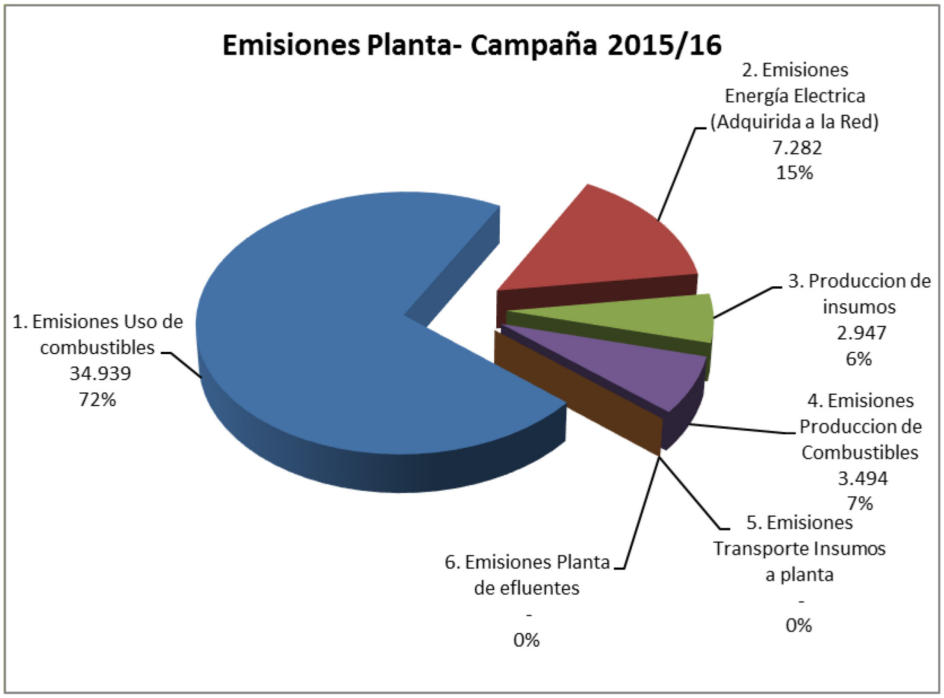
Figure 5 Field corn production GHG distribution

GRAIN TRANSPORT

In the case of maize freight, the originating information of 2016/17 study was used with the consignment notes associated to the corresponding period, from which a distance traveled from the fields to storage and from storage to plant was determined. This distance was doubled to consider the return trip reaching a total value of 981664 km. The emission was estimated at 1.03 according to the emission table x type of truck. With which the KgsCO2eq / Km was calculated which represents an average of 5.61 kg CO2eq per ton of corn received in Rio IV.

INDUSTRY (PLANT RIOIV)

Two main additional calculations were made in order to consider the effect of the reduction of syrup concentration, the contribution of heat from BG1 &BG2 and the electricity provided by those two plants. In order to calculate the carbon footprint of BG1 a full calculation was made. The electric energy from those plants was multiplied by this factor-



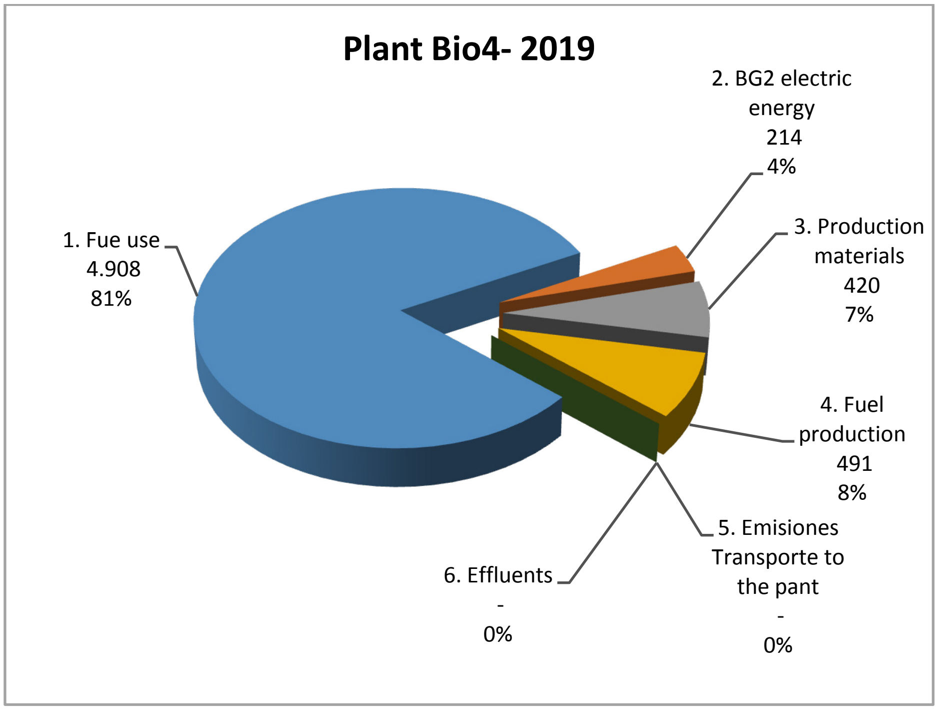


Figure 6 Plant Bio4 EMISSION distribution

The emissions associated with energy consumption reach 85% of the total from a previous 87 %, followed by emissions from the production of these fuels. To analyze the emissions per ton produced of ethanol we worked with the contributions by weight price of each product and energy content

The analysis of the emissions per ton produced of ethanol was adjusted by assigning the emissions of the common processes to the production of ethanol and burlanda based on the performance of each productive stage.

COMPLETE ANALYSIS

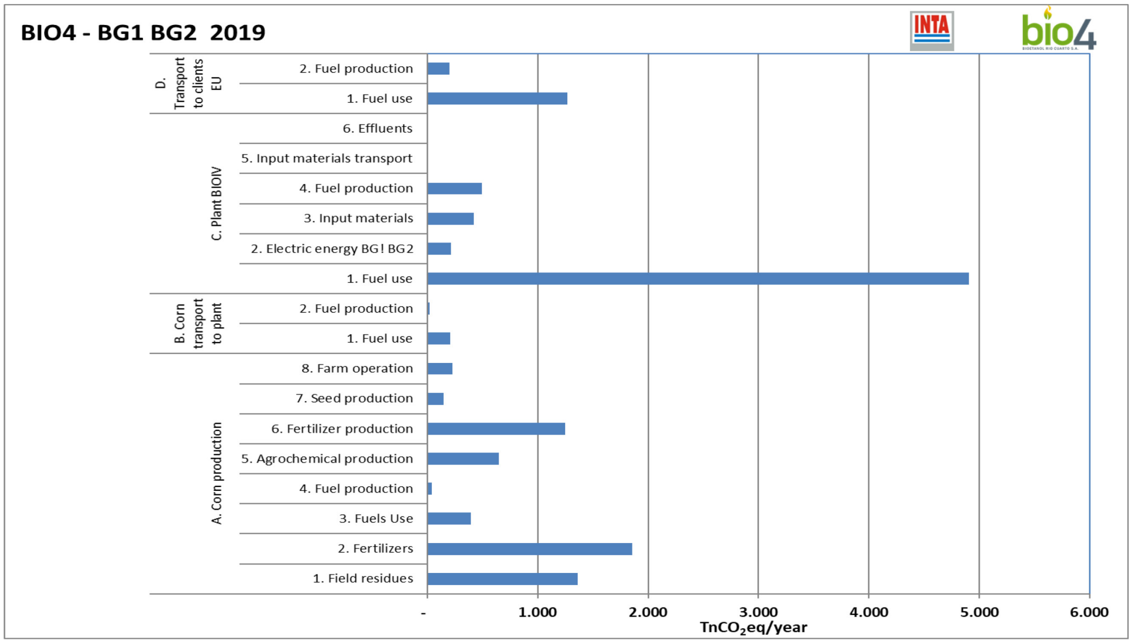


Figure 7 Activity distribution

In terms of carbon footprint per product line, the allocation of emissions per co-product was made. For this, the information we used the corresponding to the real yields of the productive process and the energy consumption.

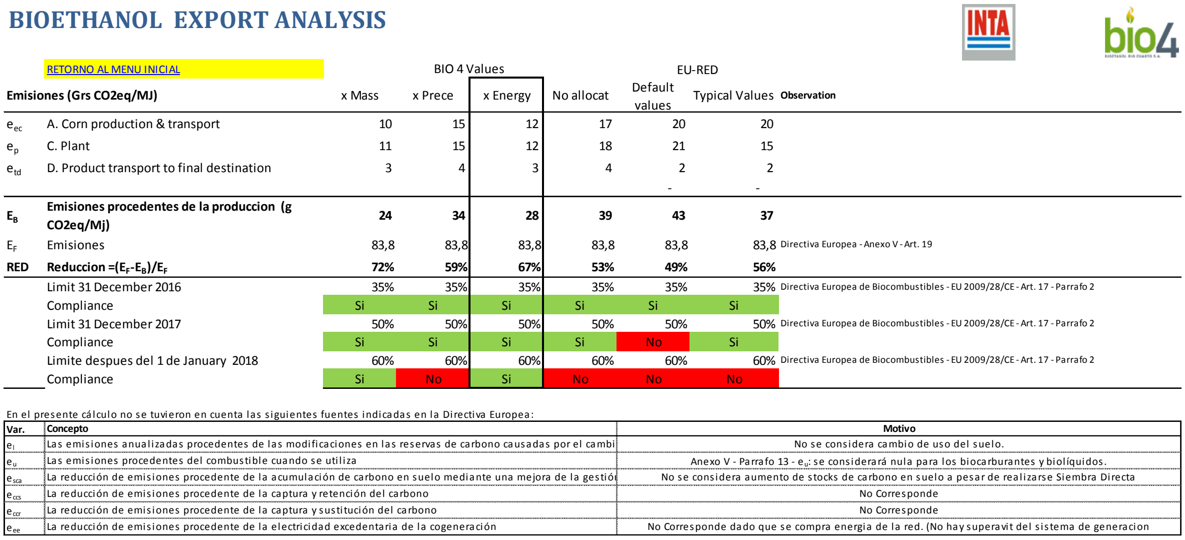
If all the emissions released during the maize chain were assigned, without considering the production of WDGS, DDGS, and syrups, an oversized value of 39 grsCO2 / Mj would be obtained. With a significant reduction from the previous calculations.

Table 12 Estimate of associated emissions per ton of each of the produced products expressed by energy unit in MJ according to three criteria: allocation by mass balance, market prices and energy content

ACHIEVED REDUCTIONS:

The reduction of emissions was calculated with reference to the value of the diesel considered in Annex V of the European Union directive in its article 19. This is established as a percentage for the case BIO4 considering allocation of all co products according to their energy content, the percentage of emission reduction would be 67 %. This value would be within the limits included in the European Biofuels Directive - EU 2009/28 / CE - Art. 17 - Paragraph 2 with effective date from January 1, 2018.

Table 13 Compliance with emission reduction



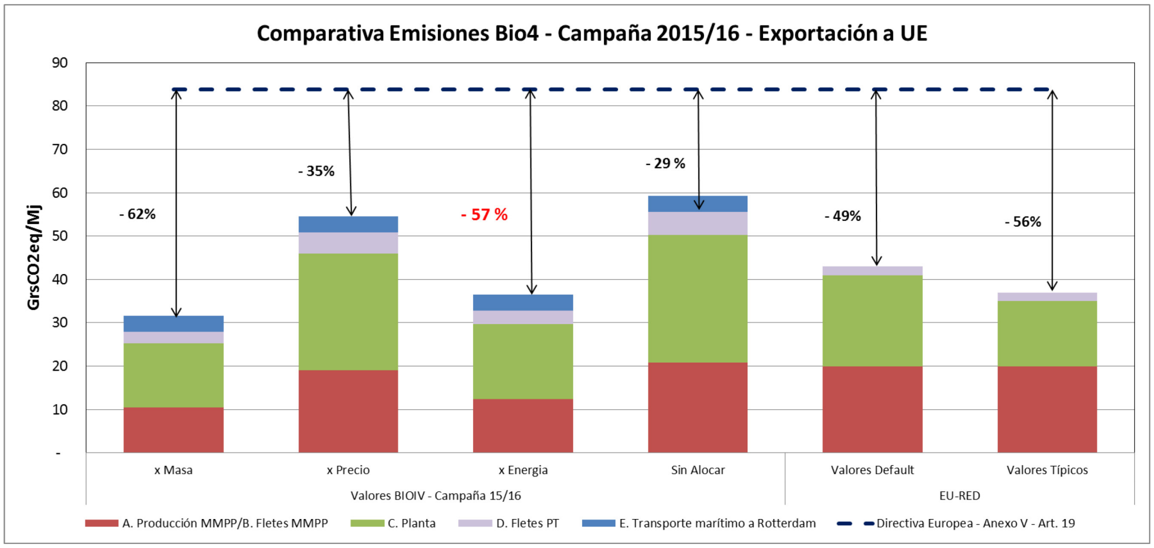
BIOETHANOL EXPORT ANALYSIS

RETORNO AL MENU INICIAL

		BIO 4 Values			EU-RED			
Emisiones (Grs CO2eq/MJ)		x Mass	x Prece	x Energy	No allocat	Default values	Typical Values	**Observation**
e_{ec}	A. Corn production & transport	10	15	12	17	20	20	
e_p	C. Plant	11	15	12	18	21	15	
e_{td}	D. Product transport to final destination	3	4	3	4	2	2	
						-	-	
E_B	**Emisiones procedentes de la produccion (g CO2eq/Mj)**	**24**	**34**	**28**	**39**	**43**	**37**	
E_F	Emisiones	83,8	83,8	83,8	83,8	83,8	83,8	Directiva Europea - Anexo V - Art. 19
RED	**Reduccion =(E_F-E_B)/E_F**	**72%**	**59%**	**67%**	**53%**	**49%**	**56%**	
	Limit 31 December 2016	35%	35%	35%	35%	35%	35%	Directiva Europea de Biocombustibles - EU 2009/28/CE - Art. 17 - Parrafo 2
	Compliance	Si	Si	Si	Si	Si	Si	
	Limit 31 December 2017	50%	50%	50%	50%	50%	50%	Directiva Europea de Biocombustibles - EU 2009/28/CE - Art. 17 - Parrafo 2
	Compliance	Si	Si	Si	Si	No	Si	
	Limite despues del 1 de January 2018	60%	60%	60%	60%	60%	60%	Directiva Europea de Biocombustibles - EU 2009/28/CE - Art. 17 - Parrafo 2
	Compliance	Si	No	Si	No	No	No	

En el presente cálculo no se tuvieron en cuenta las siguientes fuentes indicadas en la Directiva Europea:

Var.	Concepto	Motivo
e_l	Las emisiones anualizadas procedentes de las modificaciones en las reservas de carbono causadas por el cambi	No se considera cambio de uso del suelo.
e_u	Las emisiones procedentes del combustible cuando se utiliza	Anexo V - Parrafo 13 - e_u: se considerará nula para los biocarburantes y biolíquidos.
e_{sca}	La reducción de emisiones procedente de la acumulación de carbono en suelo mediante una mejora de la gestió	No se considera aumento de stocks de carbono en suelo a pesar de realizarse Siembra Directa
e_{ccs}	La reducción de emisiones procedente de la captura y retención del carbono	No Corresponde
e_{ccr}	La reducción de emisiones procedente de la captura y sustitución del carbono	No Corresponde
e_{ee}	La reducción de emisiones procedente de la electricidad excedentaria de la cogeneración	No Corresponde dado que se compra energia de la red. (No hay superavit del sistema de generacion



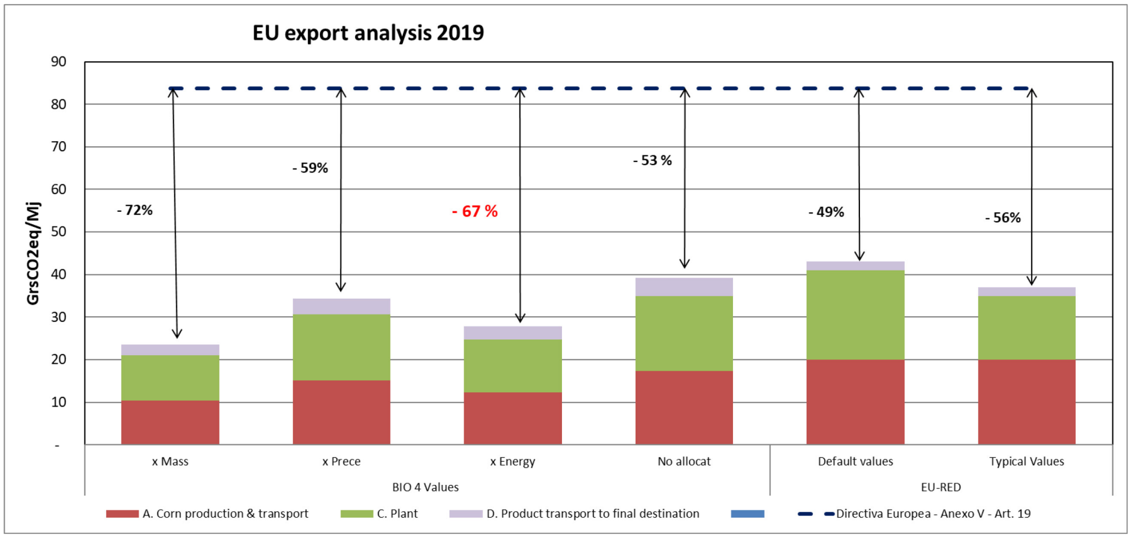


Figure 8 Comparative reduction

Although the reductions obtained are exposed according to the different allocation criteria, energy is the only one valid for the European Union. Annex V sets a typical value for corn bioethanol with cogeneration using 56% reductions as a natural fuel and 49% as a typical value.

In the case of taking as a reference the value of gasoline according to the National Energy Balance - Biennial Update 2014 MAyDS. Includes Extraction and Refining Emissions. (77 grsCO2eq / Mj) the reduction of emissions would reach 64 %. The following figure shows the reductions with the Argentine reference value according to the different allocation criteria used. In these cases only transport to the point of mixing by local oil companies is considered.

Table 14 Comparative values with national gasoline reference level

	BIOIV + BG1 BG2- 2019			
	x Mass	x Price	x Energy	No allocation
Steps	g CO2eq/MJ	g CO2eq/MJ	g CO2eq/MJ	g CO2eq/MJ
A. Corn Production & transport	10	15	12	17
C. Plant	11	15	12	18
D. Transport to clients EU	3	4	3	4
Total	**24**	**34**	**28**	**39**
Argentine gasoline(1)	**77**	**77**	**77**	**77**
Emition reductions	**69%**	**55%**	**64%**	**49%**

(1) Valores según Balance Energético Nacional - Informe Bienal de Actualización 2014 - MAyDS. Incluye Emisiones Extracción y Refinación

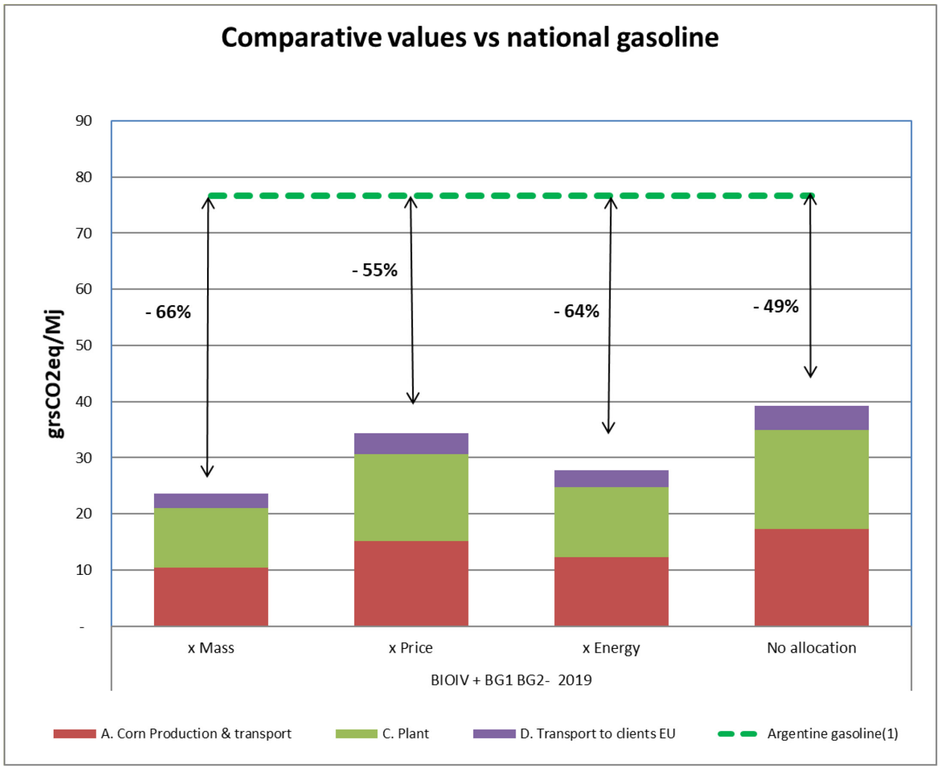


Figure 9 Allocation of emissions by different criteria and percentage of reduction with respect to naphtha in Argentina III communication..

THANKS

We appreciate the commitment and work done by all the management teams of the company without whose contribution it would have been impossible to arrive at a study of the depth and quality achieved. Especially a special mention to the coordinator by BIO4 Mercedes Vazquez and Marcelo Bordolini.

FINAL REMARKS

This preliminary study demonstrates the important improvement derived from the integration of Bio4 and BG1 & BG2. Although there are, limitations due to the reduced sample taken of only two months the differences are over 15 % in the carbon footprint achievement.

A compete study will be performed in the near future.

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