

# ANÁLISE DE VIABILIDADE TÉCNICA PARA INTRODUÇÃO DO ETANOL NA MATRIZ ENERGÉTICA PORTUGUESA

## *TECHNICAL FEASIBILITY ANALYSIS FOR INTRODUCTION OF ETHANOL FUEL IN THE ENERGY MATRIX OF PORTUGAL*

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### RESUMO

Tendo em atenção o problema do aquecimento global, cuja uma das grandes contribuições é o alto nível de emissões de gases do efeito estufa (especialmente o dióxido de carbono, emitido pela queima de combustíveis fósseis), e a fim de mitigar as emissões destes gases, recursos renováveis de energia como, por exemplo, os biocombustíveis, tem sido vistos como uma alternativa muito promissora, capaz de impactar positivamente no meio ambiente e ainda amenizar as questões críticas relativas ao consumo de combustíveis fósseis. Este trabalho tem como foco o etanol, que apesar das grandes vantagens e facilidades que apresenta, ainda não faz parte da matriz energética portuguesa. Pretende-se mostrar os principais aspectos do ciclo de vida desse combustível, bem como provar a sua viabilidade através de um caso de estudo onde a sua aplicação é bem sucedida, modelar um LCIA para etanol a base de trigo usando o GaBi® Software, e então cruzar todas as informações a fim de descobrir qual seria a melhor opção para introdução desse biocombustível na matriz energética de Portugal. Entende-se que apesar das limitações à utilização deste combustível, presentes nesse contexto em função de fatores agrários e tecnológicos, visto que não há veículos flex no país, recentes avanços neste campo de pesquisa tornam cada vez mais possível a utilização deste biocombustível.

**Palavras-chave:** Etanol, Avaliação do Impacto do Ciclo de Vida, Portugal, Perspectivas futuras para o etanol.

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## ABSTRACT

*Greenhouse gas emissions are among the major sources of global warming issue. Carbon dioxide emitted by burning of fossil fuels has a major contribution on this effect. Renewable energy resources such as biofuels have found to be a promising alternative, with positive impacts on environment, and a significant decrease of the critical issues related to the consumption of fossil fuels. Ethanol has been used as an alternative for fossil fuels in many regions such as Brazil and USA. Despite major advantages and facilities of Ethanol, this biofuel has not yet been considered in the Portuguese energy matrix. In this paper, we present the main aspects of the life cycle of this fuel, as well as a proof of its viability through a successful case study. A Life Cycle Impact Assessment (LCIA) of wheat-based ethanol was simulated with the Gabi® software, and then crossed all the information to find out what would be the best option to introduce this biofuel in the energy matrix of Portugal. Despite the limitations on the use of this fuel (agricultural and technological factors), knowing that there are no flex vehicles in the country, recent advances in this field of research could work as a great incentive to show that it is increasingly possible to use this biofuel.*

**Keywords:** Ethanol, Life Cycle Impact Assessment, Portugal, Future perspective of ethanol.

## MOTIVATION AND OBJECTIVES

According to the Biofuels Platform (2012?), Portugal had 'zero' ethanol production in 2009, and it is known that Portugal counts with crops of wheat, potato and sugar beet (STATISTICS PORTUGAL, 2011), that are all potential raw materials that could be used to produce this type of fuel. Therefore, a brief study for this purpose is presented in this work. In 2011, three main producers of ethanol were United States of America, Brazil and European Union respectively (US DEPARTMENT OF ENERGY, 2012?). The objective of this work is to show the general aspects of the life cycle of ethanol on three countries, introducing a successful study case that can prove the feasibility of the ethanol production. LCIA modeling of wheat-based ethanol has been developed using GaBi® Software. Using this information, as well as some assumptions that could show how the ethanol could be introduced in the energetic matrix of Portugal, it is aimed to suggest an alternative way to reach this goal. It is hoped that this work can be used as an encouragement to researchers start looking after this theme, especially in countries in which the development of this technology is not yet considered. Moreover, it could be a great opportunity to contribute with the environment and survive in case of some fossil fuel crisis.

## LITERATURE REVIEW

### Ethanol as a Fuel

It is not new that the Green House Gases (GHG) emissions are enormous problem when it comes to global warming, and the same though is applicable to the contribution of burning fossil fuels to this environmental problem. In front of that, scientists around the world are concentrating their efforts to discover alternatives to deal with it, since they know that beside this, the fossil fuel reserves are coming to end. Considering the Energy Policy Act of 1992, can be addressed as alternative fuels: biodiesel (B100), hydrogen, blends of 85% or more of methanol, denatured ethanol and other alcohols with gasoline or other fuels, fuels derived from biological materials, P-Series fuels, and others (US DEPARTMENT OF ENERGY, 2012?).

Bioethanol is ethanol derived from biomass sources such as wheat, sugar cane, corn etc. In the United States, it is currently primarily derived from corn feedstock, while in Brazil, the chief

biomass feedstock is sugarcane. Bioethanol can be used as a substitute to conventional gasoline, in passenger's vehicles. However, it is most commonly used as an additive with gasoline in mixture called gasohol, which can come as E10 (10% ethanol with gasoline) E20, (20% ethanol with gasoline), or E85 (85% ethanol with gasoline). In the US, E10 blends are used in modern vehicles without modification to the fuel system and engine while specially designed flex-fuel vehicles (FFVs) can run on E85 (RUSSEL and FRYMIER, 2012).

Economically speaking, we can compare E85 to gasoline prices. In terms of costs, it varies regionally, but generally E85 is cheaper than gasoline, what can be observed in the following figure (figure 1). Regarding to availability, in the United States there are more than two thousand filling stations that sell E85, and there is no noticeable difference in vehicle performance when E85 is used.

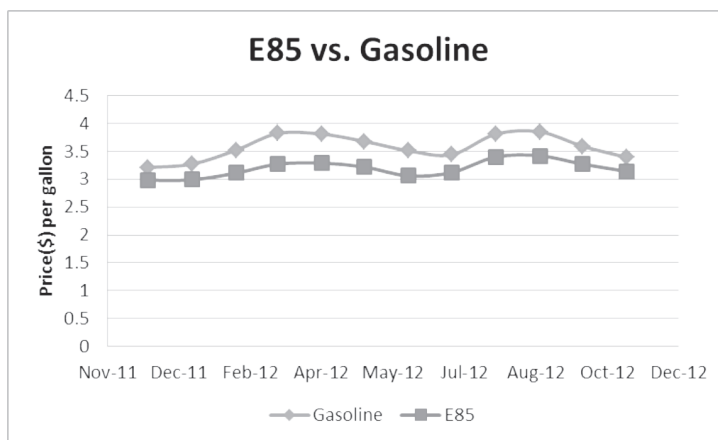


Figure 1: E85 vs. Gasoline price per gallon in US. (E85Prices, 2012?)

Flex-fuel vehicles operating on E85 usually experience a 25-30% drop in miles per gallon due to ethanol's lower energy content. Some of the advantages of this fuel could be domestically produced, reducing the use of imported petroleum, lowering the emission of air pollutants, giving more resistant to engine knock, and the flex vehicles cost is very small. In contrast to it, also has disadvantages such as the fact that can only be used in flex-fuel vehicles, lower energy content, resulting in fewer miles per gallon and limited availability and currently expensive to produce (US DEPARTMENT OF ENERGY, 201-).

## Life cycle

The feedstock crops availability, production process, distribution and end use of the ethanol in pioneer producers, (United States of America, Brazil and European Union), are presented (US DEPARTMENT OF ENERGY, 2012). The information will be collected from them and used as a base for considerations through all the life cycle of the ethanol.

### a) Feedstock

#### USA

According to the U.S. Department of Energy, corn is the leading U.S. crop and serve as the feedstock for most domestic ethanol production, but small amounts of wheat, corn, and sugarcane are also used, although the economics of these are not as favorable as corn. In 2012,

the U.S. Department of Agriculture reported that almost 80% of the produced corn was used for production of the alcohol as a fuel (US DEPARTMENT OF AGRICULTURE, 2012).

In addition to starch and sugar, there are other sources to produce ethanol, such as cellulosic feedstock. This kind of feedstock is non-food that includes crop residues, wood residues, dedicated energy crops, industrial and other wastes. It offers many advantages over starch and sugar-based feedstock, for instance they are more abundant and can be used to produce more substantial amounts of ethanol in order satisfy the U.S. fuel demand.

Harnessing cellulosic biomass to produce ethanol will require the development of economically viable technologies that can break the cellulose into the sugars that are distilled to produce ethanol. A probable duration of 3 to 10 years is required for commercializing cellulosic biomass, until then, corn will almost certainly remain the primary feedstock for U.S. ethanol production (MALCOM, AILLERY AND WEINBERG, 2009).

### **Brazil**

The main feedstock used in Brazil is sugarcane; this is due to several factors, including the superiority of sugarcane to corn as an ethanol feedstock; Brazil also has large unskilled labor force, and ideal climate for growing sugarcane (XAVIER, 2007).

The report “Statistics of agricultural production” published by the Brazilian Geographic and Statistics Institute, points that the sugarcane production in March 2012 was approximately 740 million tons (IBGE, 2012). Besides that, data about the balance of trade between 2011 and 2012 indicates in terms of value and quantity that the production of sugarcane increased up to 50% (MINISTÉRIO DA AGRICULTURA DO BRASIL, 2012). According to the Agriculture Ministry of Brazil, the ethanol produced by sugarcane has positive projections for the next years due to the growing of internal consumption. The target for 2019 is to rise production of ethanol to 150% of the current production, which means 64 billion liters of the fuel (BIODIESELBR, 2010).

### **EU**

EU has the third largest consumption in the world, with approximately 7.8 billion liters (2010), but the EU biofuels market is dominated by biodiesel (80 percent), although ethanol consumption has increased more rapidly than other biofuels in the last two years (SUGARCANE.ORG, 201-). EU biofuels annual report on 2012 showed that in 2010 the feedstock use of 20000 million tons, that has a share of 18% wheat, 12% corn, 6% rye, 3% rarely, and 51% sugar beet. It has been estimated that wheat and corn share will increase until the end of 2013, while the rye and rarely share will be stabilized and the sugar beet share will decrease (FLACH, BENDZ and LIEBERZ, 2012).

The three main ethanol producers are France, Germany and Spain (Figure 2). Specifically in those countries, the main ethanol feedstocks in 2006 were sugar beets, rye and wheat respectively (BIOENERGY WIKI, 2006?).

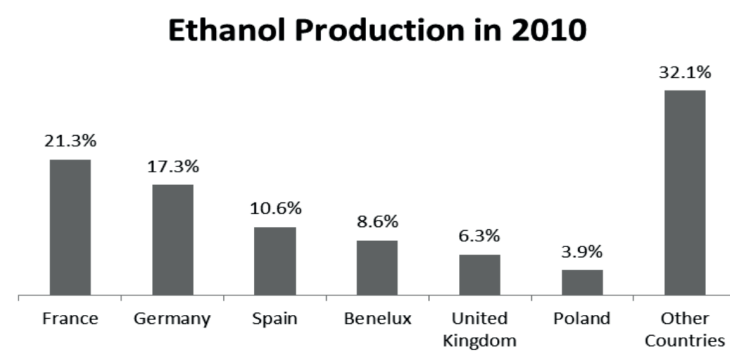


Figure 2: The main ethanol Producers. (BIOFUELS ANNUAL, 2012)

### Portugal

Due to conditions of plant, weather and soil, sugar beet is the most promising options for ethanol production, because Portugal is most prosperous in this scenario. Moreover, sweet sorghum could be an option to complement the sugar beet production, once that it is less selective in terms of conditions to grow up, and the production costs was estimated in half of the costs to ethanol from sugarcane (MONTEIRO, 2011).

Talking about ethanol from starch sources, corn and wheat are not good choices for ethanol production in Portugal. Nevertheless, in 2011 Monteiro et al. stated that potato could be considered a good option when compared to that other two, because even if the crop is not ideal for ethanol production, its utilization as a feedstock makes sense in terms of energetic and food production at the same time.

For the case of Portugal, potato and sugar beet are the best choices for ethanol production, data available in Food and Agriculture Organization Stat (FAOSTAT) website shows that the production of both crops has been decreasing since 2007. However, it is still relevant that the Portuguese government can consider these sources as a great option for the production of biofuels (MONTEIRO, 2011).

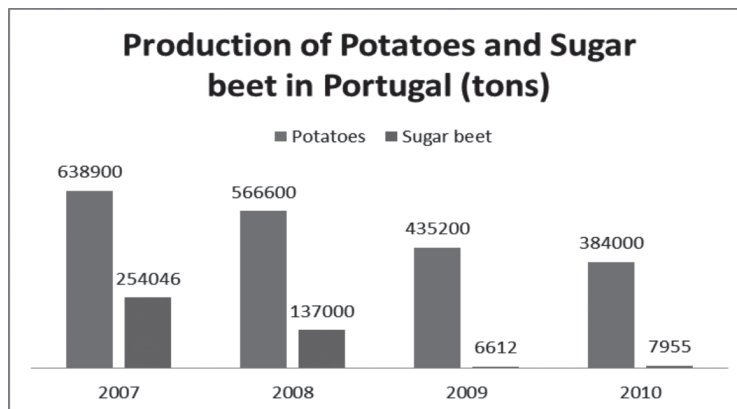


Figure 3: Production of potatoes and sugar beet. (FAOSTAT, 2011)

### b) Process

While the basic steps remain the same, the production process of ethanol from starch or sugar-based feedstocks has been considerably refined in recent years, leading to a very efficient process. There are two ways to produce ethanol: wet milling and dry milling. The main difference between these two routes is the initial treatment of the grain (RFA, 201-).

In wet milling, the initial treatment is done by soaking the grain in water and diluting sulfurous acid for 24 to 48 hours, easing the separation into its many components. After this step, the slurry made by the grain and the water, is processed through a series of grinders to separate the grain and its germ. The oil from the germ is extracted on-site or sold to crushers who can extract it. The remaining fiber (gluten and starch components) is segregated a little bit more using screen or hydrochloric centrifugal. The steeping liquor is concentrated in an evaporator, and co-dried with the fiber component to sell it as feed to livestock industry; the heavy steep water, is also sold as a feed ingredient to be used in Ice Ban process (process to remove ice from roads). The gluten component is filtered and dried to produce gluten meal, which is used as a feed ingredient in poultry broiler.

The starch and remaining water from the mash are processed by one of these three options: fermented into ethanol (which is quite similar to dry mill process); the dried waste is sold as a dried or modified starch; or, processed into syrup.

In dry milling process the entire starchy grains is first ground into flour, processed without separating out the various components of the grains. Then, the flour is slurries with water to form a mash. Enzymes and ammonia are added to this, the first to convert the starch to dextrose, the second to control the PH and as nutrient to the yeast of the fermentation. The next step, is process the mash in a high temperature cooker to reduce bacteria levels ahead of fermentation, and after this, it is cooled and transferred to fermenters where yeast is added to conversion of sugar to ethanol and carbon dioxide (RFA, 201-).

The fermentation process takes about 40 to 50 hours. Whilst, the mash is keeping agitated and cool to ease the yield activity. When this part is done, the mash is transferred to distillation columns, where ethanol and the remaining "stillage" are separated. Then, the ethanol, is dehydrated to approximately 200 proof in a molecular sieve system, blended with about 5% denaturant (such as natural gasoline) to render it undrinkable, and it is ready to be shipped to gasoline terminals or retailers.

The rests of this process, became into Condensed Distillers Soluble or syrup, dried distillers grains with soluble, and the CO<sub>2</sub> released during the fermentation is captured and sold for use in carbonating soft drinks and the manufacture of dry ice (RFA, 201-).

### **c) Distribution**

Bioethanol has mostly been used as biofuel for transport, especially in Brazil. The first large-scale bioethanol running vehicles was in Brazil. A blend of 5% ethanol and gasoline is common in EU, and the leading E85 consumer countries are Sweden, Germany, and France.

Figure 4 shows an overview of the bioethanol fuel market and the density of E85 stations in comparison with gasoline stations. The numbers of bioethanol stations are still very low in comparison with gasoline fuel stations. The first E85 filling station were built in 1995 however, steady expansion started only in 2002.

In the USA, depending on the state policy and natural resources, E85 is being used to a varying degree across most states. In 2012, U.S. Department of Energy reported 2'264 of E85 stations in USA.

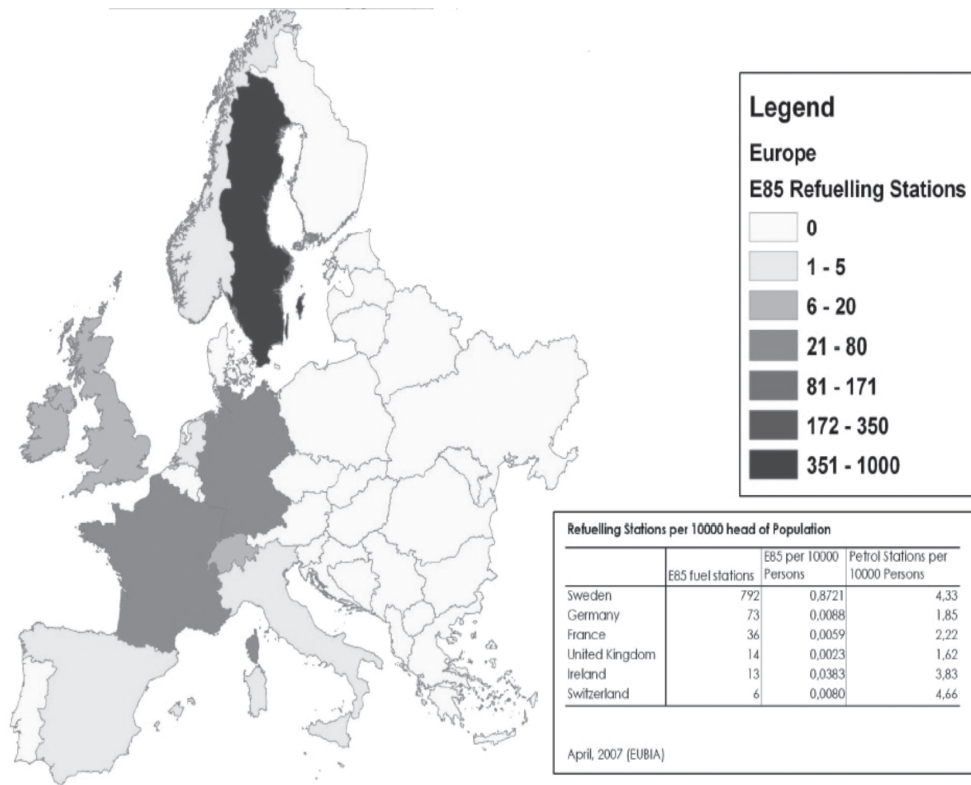


Figure 4 - E85 station density in Europe (2007). (EUBIA, 200-)

#### d) End use

The end use of ethanol is limited to consumption of this fuel in vehicles. Ethanol is particulate-free burning fuels source that combust with oxygen to form carbon dioxide, water and aldehydes. Ethanol produces 1.94 CO<sub>2</sub> equivalent kg/l while gasoline releases 2.44 CO<sub>2</sub> kg/l, which means it reduces CO<sub>2</sub> emissions by 21 percent (AUTOEVOLUTION, 2009).

Ethanol is most commonly used to power automobiles, although it may be used to power other vehicles, such as farm tractors, boats and airplanes. Ethanol (E100) consumption in an engine is approximately 51% higher than for gasoline since the energy per unit volume of ethanol is 34% lower than for gasoline.

Bioethanol can change the automotive industry in the next few years. Automobile manufacturers and governments must continue their efforts in this sector but, taking into account that the global recession changed almost everyone's view on fuel consumption and environment protection, it may be the 'ace up our sleeve' (AUTOEVOLUTION, 2009).

## SUCCESSFUL STUDY CASE

Usinas Sociais Inteligentes (USI) biorefineries, in Porto Alegre, Rio Grande do Sul, Brazil, has been using a supporting vision and sustainable knowledge to build integrated biorefineries modules to produce ethanol from feedstock such as sugarcane, sorghum, sweet potato, manioc and other cereals. Those modules are capable of production range of 500 to 5000L/day of ethanol in a process called by "cool enzymes", which makes hydrolyzation with cold enzymes and utilization of subjacent products (USI, 200-).



Biorefinery is a productive unit that is capable of producing biomass fuel, electricity and chemical products with high increasing value. Based on this concept, the main purpose of the business is offer to producers, cooperatives, associations and small companies an alternative to increase their profits by the production of ethanol (renewable fuel), animal food and bio fertilizers, making this activity self-sustainable. They have an agreement with the National Development Bank (BNDES) that offers financing to people or partnerships through Financial Institutions of the National Financial System. The fuel produced has all the certifications needed, proving that it can be used in cars, trucks, airplanes, electricity generators, etc. (USI, 200-).

Unfortunately, this project is not feasible just for sugarcane ethanol production, and so it is not using just sorghum feedstock. However, a combination of these two aspects may lead to business that is more profitable. Another commercial alternative is a combination of sorghum and sweet potato, but this choice depends of the weather and of the location of the bio refinery (CANOVA, 2011).

Regarding the economic perspective of the project, the operational costs are mostly influenced by the economical scorecards, and variations of productivity in the manioc and sweet potato crops presents the biggest negative effect in this economic measure index. Nevertheless, the sweet potato, manioc, and sorghum crops are now effective candidates to feedstock for the ethanol production, since it has a high production cost, and the amount of ethanol by ton compensate this fact, as long as the process can be improved (CANOVA, 2011).

## METODOLOGY

In terms of research approach, it can be said that this work is essentially qualitative, once there is no data collection that makes necessary a statistic treatment of them, it was only observation and description of the facts. In addition, about the procedures, this work can be classified as a descriptive exploratory research, because it is based on describing, observing, and correlation facts without manipulating them, developing hypothesis to create an ideal situation. When it comes to research techniques, it was only used the literature and document research, which is used to look for information in bibliographic and primary sources (MARCONI and LAKATOS, 2010).

Therefore, the methodology of this work consists of three parts. First, literature research, which includes the base for the discussion about the main technical, economical and social aspects of ethanol, second, modeling using GaBi® software, to check the environmental impacts of wheat-based ethanol life cycle and finally, the analysis of the results and complementary comments about the results obtained.

## RESULTS

### Life Cycle Impact Assessment (LCIA)

For the purpose of Life Cycle Impact Assessment (LCIA) calculations, GaBi® software was used. The LCIA identifies and evaluates the amount and significance of the potential environmental impacts arising from the LCI. The inputs and outputs are first assigned to impact categories, and their potential impacts quantifies according to characterization factors. Figure 5 shows the conversion from emission to impact potential via classification and characterization. The Life Cycle Impact Assessment involves several steps according to the ISO standard (more detail in the *ISO 14044* standard).



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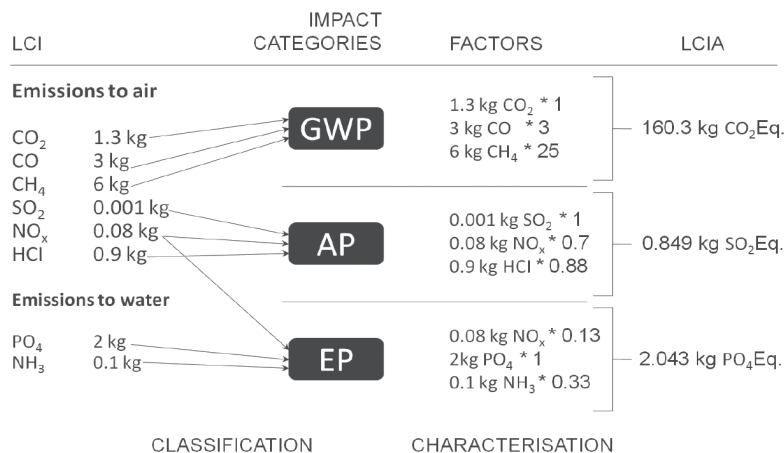


Figure 5: An example of classification and characterization: (GABI® SOFTWARE, 200-)

There are different methods that can be used to perform a Life Cycle Impact Assessment. These methods are continuously researched and developed by different scientific groups based on different methodologies. In the current work, the CML was used (Center for Environmental Studies) method for our LCIA results. The CML method includes classification, characterization, and normalization. The impact categories for the global warming potential and ozone layer depletion are based on IPCC factors.

Table 1: CML method classifications and units. (GABI® SOFTWARE, 200-)

Classification	Unit
<b>Global Warming Potential (GWP 100 years)</b>	[kg CO <sub>2</sub> – Equiv.]
<b>Ozone Layer Depletion Potential (ODP, steady state)</b>	[kg R11 – Equiv.]
<b>Acidification Potential (AP)</b>	[kg SO <sub>2</sub> – Equiv.]
<b>Eutrophication Potential (EP)</b>	[kg Phosphate – Equiv.]

The characterization factors are included in the selected impact category of CML method. Results of the LCI are converted into reference units using characterization factors. For example, the reference substance for the impact category “global warming potential” is CO<sub>2</sub> and the reference unit is defined as “kg CO<sub>2</sub>-equivalent”. All emissions that contribute to global warming are converted to kg CO<sub>2</sub>-equivalents according to the relevant characterization factor. Each emission has its own characterization factor. These characterization factors are according to the latest version of CML method from December 2007. According to the CML method, methane and carbon monoxide have characterization factors of 3 and 25 respectively. This means that CML has determined that methane contributes 25 times more than carbon dioxide to the global warming potential when a period of a hundred years is taken into account (figure 6).

**Modeling**

Life Cycle Impact Assessment of any biofuel could be divided in four steps: feedstock, process, distribution, and end use. Each step has its own impacts, in addition to these four steps, transport between each of these steps should be considered to make a model more realistic. Therefore, we have considered two transport stages between feedstock and process as well as process and distribu-

tion. The vehicle used for these transportations is truck and the fuel used is diesel from Europe Union.

Feedstock used in this study is wheat since the complete database of this feedstock was available in GaBi® software. Process is set to bioethanol plant with available database from Germany. Distribution stage is consisting of fuel station. End use step is the impacts of vehicle running on E85. Table 5 shows the assumptions and facts that were used when modeling the wheat-based bioethanol LCIA report.

Table 2: Inputs of the GaBi® software. (Made by the authors)

Assumption or Fact	Input of GaBi® software
Amount of bioethanol produced on plant	1'000 liters per day
Distance between feedstock and process	50 kilometers
Distance between process and distribution	30 kilometers
Cars per capita (Portugal)	537/1000 (NATION MASTER, 201-)
Portugal population (2011)	10'562'178 (THE WORLD BANK, 2012)
EU target for direct use of biofuel 2020	10% (EUROPEAN PARLIAMENT, 2009)
10% target of total vehicle	≈ 550'000 vehicle
Vehicle mileage	lometers

### Software Results<sup>3</sup>:

In the global warming potential analysis of the wheat-based bioethanol, a few amounts of impact for distribution step can be observed, but the software neglects the impact of this step. Generally, the GWP of the feedstock should be negative owing to farming effects on environment, but transport section changed it to positive value (figure 6). Regarding to process step, the amount of impact is fixed and it could not change. The largest impact is related to the end use segment; in order to increase this step, we should wait for improvement of technology. However, the GWP of the gasoline or diesel running vehicle is much larger than the E85 running vehicles.

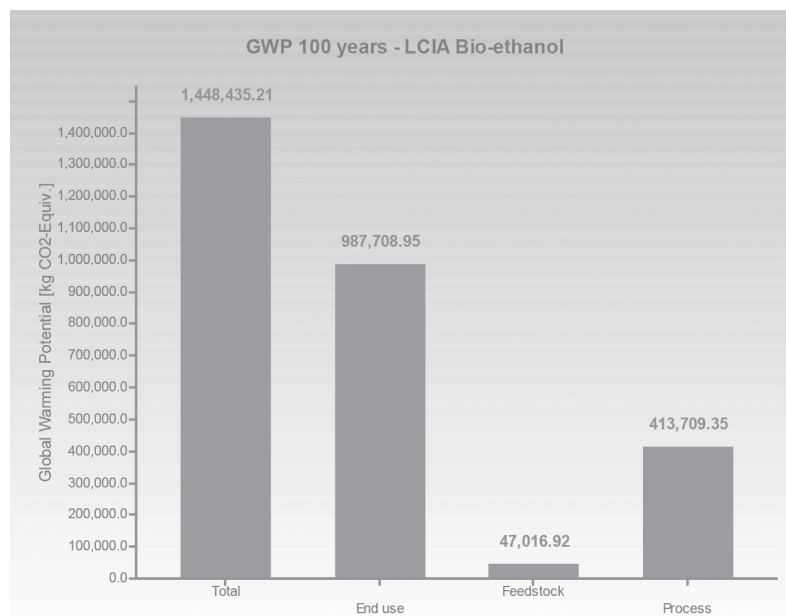


Figure 6: Global warming potential of wheat based bioethanol. (GaBi® software)

<sup>3</sup> Transportation between feedstock and process is calculated with feedstock step; also process step contains the transportation between process and distribution.

About the ozone depletion potential of our study, the impacts could be increased with the same consideration used for GWP. However, the total amount of impacts from wheat-based bioethanol is few as shown in figures 7, 8 and 9. In term of the emissions to environment (in kg), it was obtained that 120 million were to the resources of the production system, 105 million to fresh water and 18 million were to air, while the emissions to sea water, industrial and agricultural soil were ‘zero’. Table 3 shows the sources of each category.

Table 3: LCA balance report of wheat based bio ethanol. (GABI® SOFTWARE, 200-)

Category	Source
Resources	Energy resources, land use and material resources.
Emissions to air	Heavy metals, inorganic and organic emissions, radioactive, particles and etc.
Emissions to fresh water	Inorganic and organic , particles, heavy metals, radioactive, other emissions and etc.
Emissions to sea water	Analytical measures, inorganic and organic , particles, heavy metals, radioactive, other emissions and etc.
Emissions to agricultural soil	Heavy metals.
Emissions to industrial soil	Heavy metals, inorganic and organic.

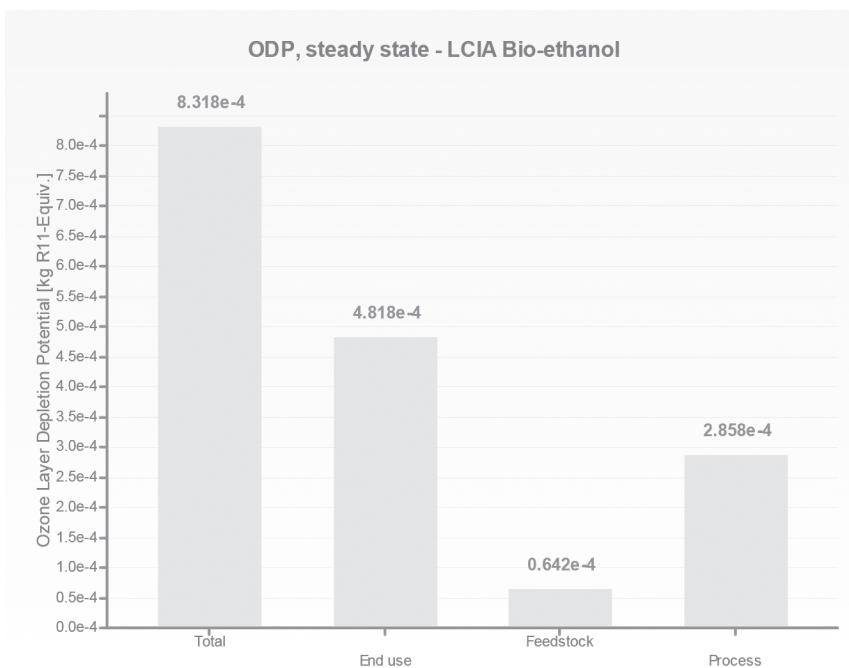


Figure 7: Ozone depletion of wheat based bioethanol. (GABI® software)

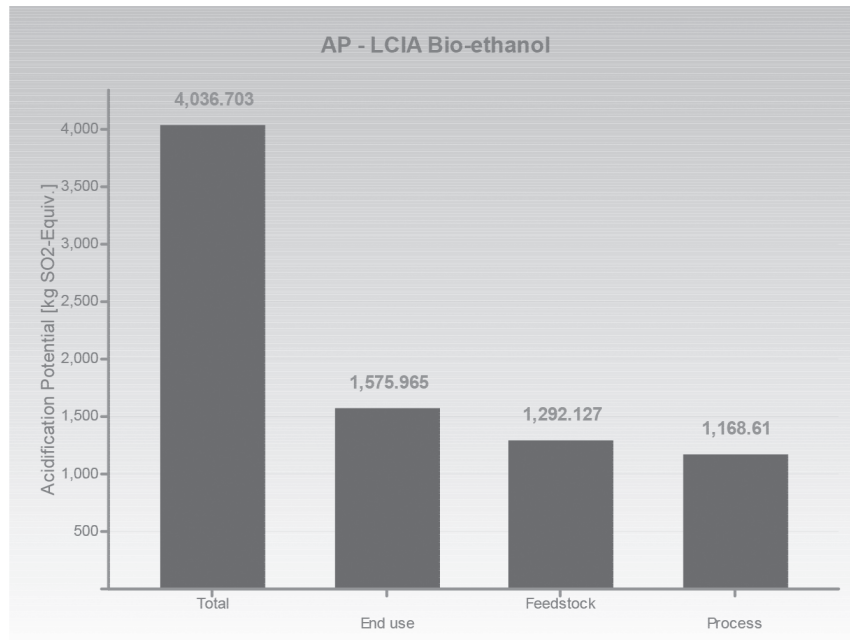


Figure 8: Acidification potential of the wheat based bioethanol. (GaBi® software)

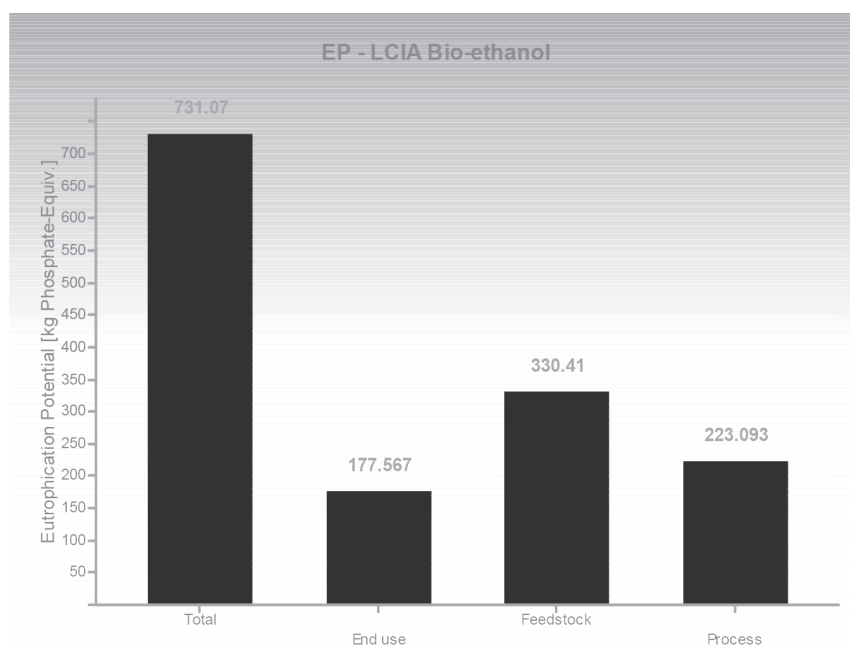


Figure 9: Eutrophication potential of the wheat based bioethanol. (GaBi® software)

## SOCIAL PERSPECTIVES

Social perspective can be categorized to three main concerns, the jobs that are available because of this activity, the local development with maintenance of family farming, and food insecurity (FIGUEIREDO, 2009). All these points have negatives but also positive impacts that should be observed by the governments or any organization that intend to invest on this type of energy.

The ethanol production can create many jobs in field and administrative sectors, because some necessary management will be needed to control the activities and the profitability of the business. However, in underdevelopment countries the trend is to create informal jobs, which mean that most of the people will probably have to work on the farm poor conditions.

Therefore, for certification of the biofuels, the regulatory agencies should make sure that: biofuel was not produced by workers in bad work conditions; do not yield any deforestation; the rights of workers must be respected; and, the work conditions should be appropriate to the activity.

Local development and maintenance of family farming is not commonly enough. A big concentration of productive field on hands of few people or companies, could happen because of the increase in the farms value that makes the small owners sell their property to the large companies. In contrast, when the family farming is correctly encouraged, this advantage could be used to increase the agriculture production, and this incentive could have a positive impact on the food insecurity issue, ensuring food supply.

Every time the ethanol theme is brought into discussion, the point fuel versus food is the most critical part to decide about it. In fact, an incorrect management of the crops to bioethanol production could result in risk to the food security of the people. What has to be done is to concentrate the efforts in producing enough crops to make ethanol and feed people because the ethanol process has a negative impact in food production, but this can be controlled finding a breakeven point that can be good for ethanol production, so as for food security.

## FUTURE PERSPECTIVES

### **Lignocellulosic feedstock – 2nd Generation of Bioethanol**

This kind of feedstock has been studied as a potential and competitive source of bioenergy as a whole since biomass is one of the few energy sources that can actually be utilized to produce several types of energy (motor fuel, electricity, heat) and beside of that, it is renewable and relatively found everywhere. Even this positives impacts are great, lignocellulosic feedstock has issues regarding biomass availability, supply chain, conversion process and economics that need a more comprehensive understanding in order to identify the near short term routes in biomass to bioenergy production (GONZALEZ, 2011).

The most complicated point of view about the production process of this fuel is the need of hydrolysis to break down the cellulosic feedstock into simple sugars for distillation; there are two ways to do it: using acid or enzyme hydrolysis, which makes the production process more expensive, and low down the economic feasibility of any project about this. Both this hydrolysis approaches have continuously being subject of research since the 1970s, and large investments are being made in the US and Europe to speed up development of this route to bioethanol (EUROPEAN BIOFUELS PLATAFORM, 200-; NREL, 2007).

Green liquor pretreatment could be used as a pretreatment pathway for the efficient conversion of lignocellulosic biomass into ethanol. An ideal solution is to activate closed operations in regions where the biorefinery can be an important source of employment and development for the economy (JOSHI, 2011).

## Advanced Ethanol

Dozens of companies are rapidly proving out new technologies that will turn America's waste products – garbage, wood chips, agricultural residue, corn stover and more – into renewable fuel and other bio-based products. In addition, many of these innovators have prototypes and demonstration level projects already producing fuel (RFA, 2012).

Many existing ethanol biorefineries are exploring technology upgrades that allow the production of ethanol from a broader range of feedstocks. These so-called bolt-on technologies permit ethanol producers to increase ethanol production by converting both grain starch and cellulosic material into fuel at the same facility. Using existing piping, storage, and loading infrastructure at current facilities may help to decrease the cost for the first commercial production of cellulosic and advanced ethanol.

## DISCUSSION AND CONCLUSION

The first consideration about the inclusion of ethanol on the energetic matrix of Portugal is about the feedstock, since it is known that Portugal does not have enough production of the crops, which can be used for this activity. This problem could be solved with two different approaches. First, the government could invest on agriculture, focused on sugar beet and potatoes, that way the production of fuel will not be in conflict with the food production. At second, to incentive research and development to discover a feasible way to produce 2<sup>nd</sup> generation bioethanol or advanced fuel, since this type does not have large impacts on agricultural production and food concern.

For countries like Portugal with no fossil fuel resources, using renewable energy sources like ethanol could help the country to become independent from importing fossil fuels. According to 2020 target of Europe Union, member states should substitute 10% of their energies to renewable energies. Ethanol could be a decent candidate for this matter, since CO<sub>2</sub> emissions can be reduced up to 21 percent in comparison with gasoline. Portugal needs to encourage its society to use ethanol fuel by opening some fuel stations that actually provide this fuel, and making contracts with car manufacturers to bring ethanol running vehicles to Portugal streets. Even if at the economic point of view, ethanol fuel is cheaper than gasoline, its production is still expensive, problem that can be solved with improvements of the related technology in the future.

The other aspect are about how to introduce the ethanol into the matrix. The USI case is a successful case that could be used for this purpose, and could do a lot for Portugal's agriculture, that now is weak and with almost any perspective to grow. The technical feasibility was proved, it is worthwhile to highlight that other works have shown that this option is also economic, social and legally feasible, once they are aspects required to support this project. However, it is known that all of these other dimension of analysis are critical aspects for any project, and the depth necessary to confirm any other feasibility beyond the technical was not reached on this work.

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