

Eixo Temático: Inovação e Sustentabilidade em Diferentes Setores

**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**

Anna Júlia Lorenzton Gelain e Seyedali Emami

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.

ABSTRACT

Taking into account the global warming problem, in which the high level of greenhouse gases emissions (particularly carbon dioxide, emitted by burning fossil fuels) has one of the major contributions on this effect, and in order to decrease greenhouse gas emissions, renewable energy resources such as biofuels, have been seen as a very promising alternative, with positive impacts on environment, and reduce the critical issues related to the consumption of fossil fuels. This work focuses on ethanol, which despite major advantages and facilities that was not yet part of the Portuguese energy matrix. Intended to show the main aspects of the life cycle of this fuel, as well as prove their viability through a case study where the application is successful, model an LCIA for ethanol from wheat using the Gabi software, and then cross all the information to find out what would be the best option for introducing this biofuel in the energy matrix of Portugal. It is understood that despite the limitations on the use of this fuel, present on this context due to agricultural and technological factors, since there is no flex vehicles in the country, recent advances in this field of research make it increasingly possible to use this biofuel.

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

MOTIVATION AND OBJECTIVES

This work will be focused on the ethanol theme because, second to the Biofuels Platform (2012?), Portugal had ethanol production equals to 'zero' 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, the three main producers of ethanol were United States of America (USA), Brazil and European Union respectively (US DEPARTMENT OF ENERGY, 2012?). The objective of these work is to show the general aspects of the life cycle of ethanol on these three countries, introducing a successful study case that can prove the feasibility of the ethanol production, LCIA modeling of wheat based ethanol using Gabi Software. Following by, using this information, as well as some assumptions that could show how the ethanol can be introduced in the energetic matrix of Portugal, and suggesting an alternative way to reach this goal. Furthermore, 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 considered yet., Furthermore, 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 a really big 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 concentrate their efforts to discover alternatives to deal with it, since they know that beside of this, the fossil fuel reserves are coming to end. Considering the Energy Policy Act of 1992, biodiesel (B100); natural gas and liquid fuels domestically produced from natural gas; propane (liquefied petroleum gas); electricity; hydrogen; blends of 85% or more of methanol, denatured ethanol, and other alcohols with gasoline or other fuels; methanol; denatured ethanol and other alcohols; coal-derived, domestically produced liquid fuels; fuels (other than alcohol) derived from biological materials; and P-Series fuels, can be addressed as alternative fuels (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 vs. gasoline prices. In terms of costs, varies regionally, but generally E85 is cheaper than gasoline and it can be observed in the follow 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.

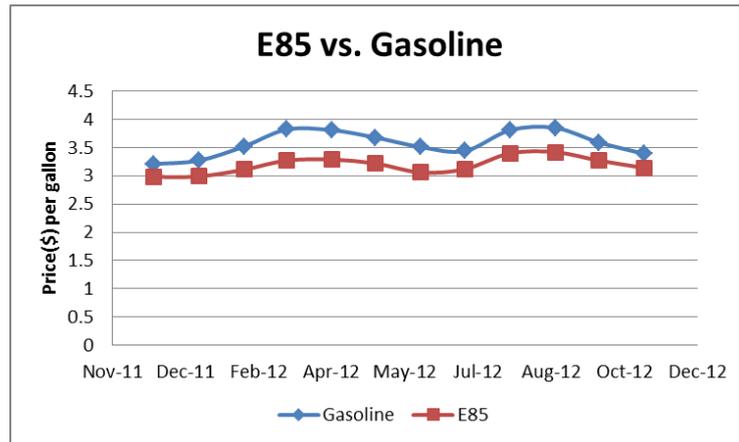


Figure 1: E85 vs. Gasoline price per gallon in US (E85Prices, 2012?)

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 use of imported petroleum, lower emission of air pollutants, more resistant to engine knock, add vehicle cost is very small. In contrast 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, 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 (USA), 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 U.S. Department of Energy, corn is the leading U.S. crop and serves as the feedstock for most domestic ethanol production, but small amounts of wheat, milo and sugarcane are also used, although the economics of these are not as favorable as corn. In 2012, 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 using the cellulosic feedstock. This kind of feedstock is non-food that includes crop residues, wood residues, dedicated energy crops, and 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 to meet 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. Probably 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 the sugarcane this is due to several factors, including the superiority of sugarcane to corn as an ethanol feedstock, Brazil 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 was increased up to 50%. (MINISTÉRIO DA AGRICULTURA DO BRASIL, 2012). According to the Agriculture Ministry of Brazil, the ethanol produced by the sugarcane has positive projections for the next years due to the growing of internal consumption. Target for 2019 is to rise production of ethanol in 150%, 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 from 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 the 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 be decreasing (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?).

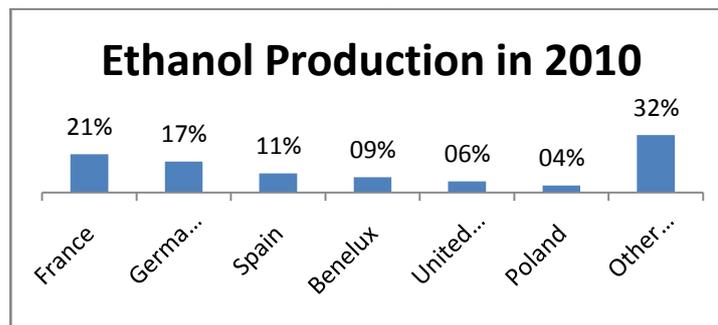


Figure 2: The main ethanol Producers (adapted from FLACH, BENDZ and LIEBERZ, 2012)

Portugal

Due to conditions of plant, weather, soil, and sugar beet are becoming the better options to ethanol production, because Portugal is most conducive in this scenario. Besides that, the sweet sorghum could be an option to complement the sugar beet production, once that it less selective in terms of conditions to grow up, and the productions costs was estimated in a 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. But, in 2011 Monteiro et al. stated that potato could be considered a good option when compared to this other two, because, even if the crop is not the ideal for ethanol production, its utilization as a feedstock make sense in terms of energetic and food production in the same time.

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

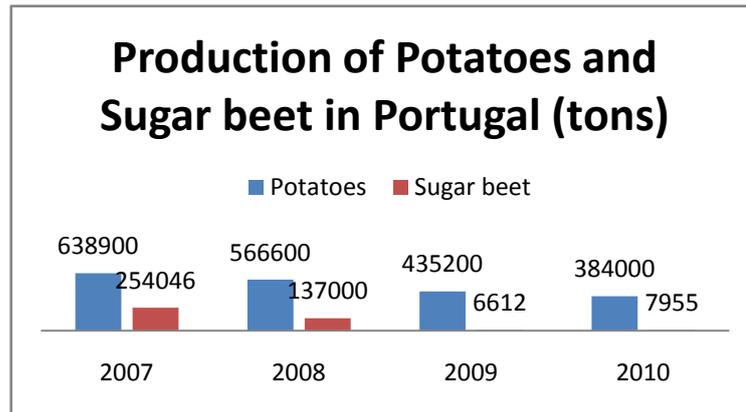


Figure 3: Production of potatoes and sugar beet (adapted from FAOSTAT, 2011)

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 it: 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 dilute sulfurous acid for 24 to 48 hours, facilitating 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. If the grain is available for, the oil from the germ is extracted on-site or sold to crushers who can extract it, and the remaining fiber (gluten and starch components) are 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 processes: fermented into ethanol (that it is very similar to dry mill process), dried 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, and enzymes and ammonia are added to this, the first to convert the starch to dextrose, the second to pH control and as nutrient to the yeast of the fermentation. The next step, is process the mash in 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 facilitate the yield activity. When this part is done, the “beer” 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 shipment to gasoline terminals or retailers.

The rests of this process, became into Condensed Distillers Soluble or syrup, dried distillers grains with soluble, and the CO₂ 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.

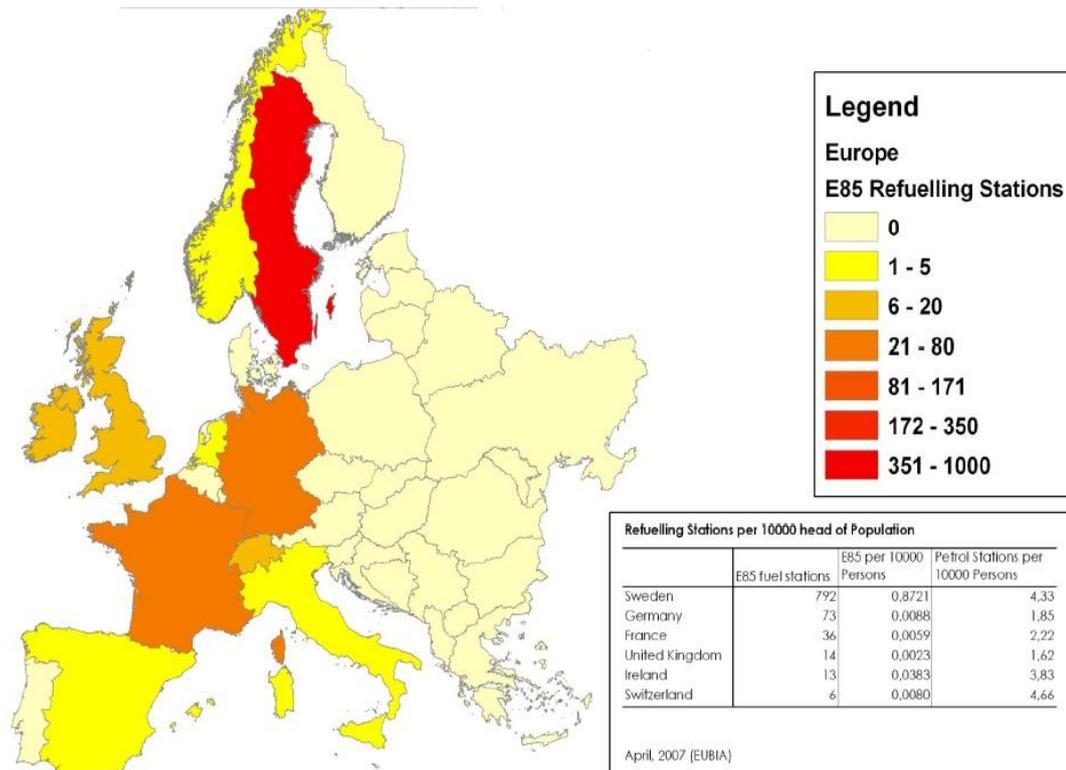


Figure 4- E85 station density in Europe (2007) (EUBIA, 200-)

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 CO₂ equivalent kg/l while gasoline releases 2.44 CO₂ kg/l, which means it reduces CO₂ 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 of their profits by 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 a financing to persons or partnerships through Financial Institutions of the National Financial System. And 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 to the economics 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 affect in this 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 costs, and the amount of ethanol by ton compensate this fact, once 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 observing 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).

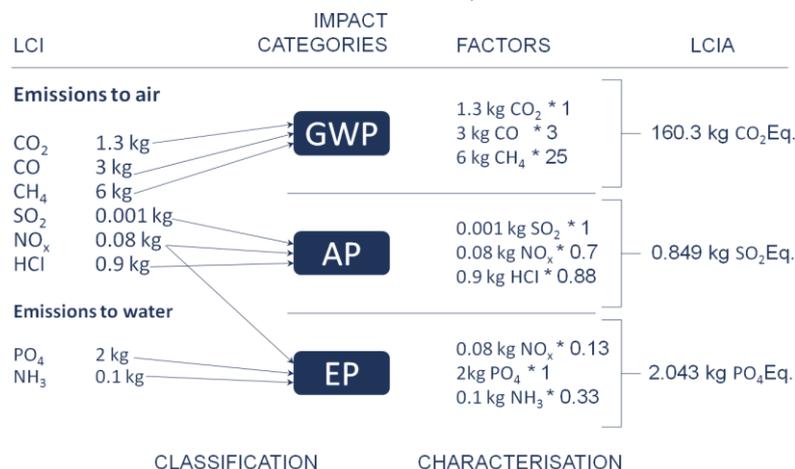


Figure 5: Classification and characterization (GABI SOFTWARE, 200-)

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 current work, we have used CML (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

Classification	Unit
Global Warming Potential (GWP 100 years)	[kg CO ₂ – Equiv.]
Ozone Layer Depletion Potential (ODP, steady state)	[kg R11 – Equiv.]
Acidification Potential (AP)	[kg SO ₂ – Equiv.]
Eutrophication Potential (EP)	[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 CO₂ and the reference unit is defined as “kg CO₂-equivalent”. All emissions that contribute to global warming are converted to kg CO₂-equivalents according to the relevant characterization factor. Each emission has its own characterization factor. These characterization factors are according to 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 to 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 distribution. 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 we used for the modeling of the wheat-based bioethanol Life Cycle Impact Assessment report.

Table 2: Inputs of the GaBi® software

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	100 lometers

Software Results¹:

In the global warming potential analysis of the wheat-based bioethanol, can be observed a few amounts of impact for distribution step, but the software neglects impact of this step. Generally, the GWP of the feedstock should be negative owing to farming effects on environment, but transport section made it positive (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

¹ 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.

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.

Table 3: LCA balance report of wheat based bioethanol

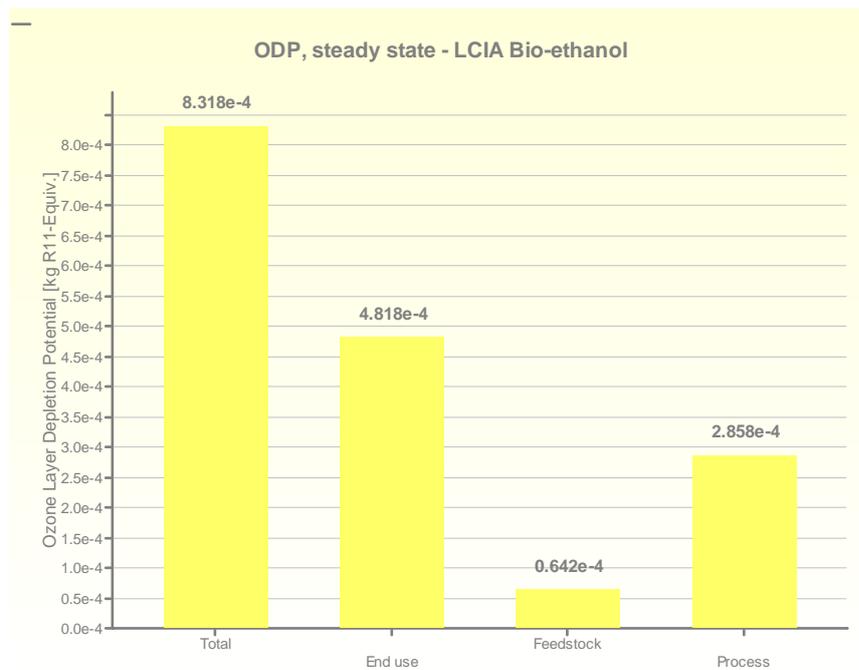


Figure 7: Ozone depletion of wheat based bioethanol

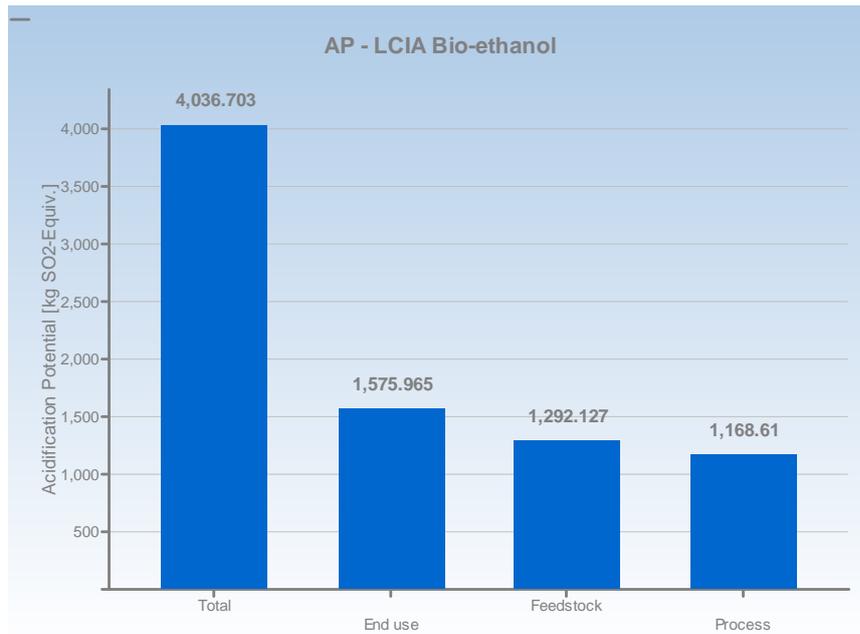


Figure 8: Acidification potential of the wheat based bioethanol

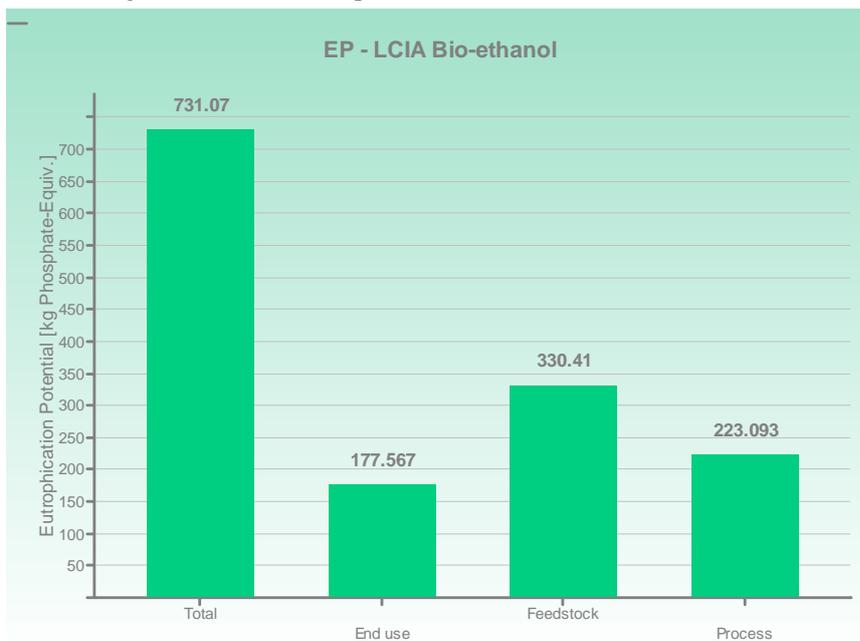


Figure 9: Eutrophication potential of the wheat based bioethanol

Social Perspectives

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

The ethanol production can create many jobs, both in the field and administrative sector, 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 under slave conditions.

Therefore, for certification of the biofuels the regulatory agencies should make sure that: biofuel was not produced using slavery; do not yield any deforestation; the rights of workers must be respected; and, the work conditions 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 on the farms value that makes the small owners sell their property to the large companies. In contract, 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.

Every time the ethanol theme is brought into discussion, the point fuel X food is the most critical part to decide about it. In fact, an incorrect management of the crops to bioethanol production could result in the risk to the food safety of the people. What have to be done is concentrate the efforts to produce enough 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 accord to ethanol and food parts.

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 in one 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 been the subject of continuing research interest 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 to 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 pilot 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. Utilizing of 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, so the production of fuel will not be in conflict with the food production. Second, incentive research and development to discover a feasible way to produce 2nd 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 of 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 decant candidate for this matter since, CO₂ emissions can be reduced up to 21 percent in comparison with gasoline. Portugal needs to encourage its society to using ethanol fuel by opening some fuel stations to provide this fuel, and making contracts with car manufacturers to bring ethanol running vehicles to Portugal streets. Even as the economic point of view, ethanol fuel is cheaper than gasoline, however currently its production is expensive, this problem can be solved with the improvements of technology in future.

The other aspect is about how to do this ethanol introduction in 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 any perspective to grow. But for anyway it will be needed a government incentive, because usually people that lives in the farms, or are available for this activity is poor and do not have enough money to invest.

The technical feasibility was proved, it is worthwhile to highlight that other works could be done to show 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 profundity necessary to confirm any other feasibility beyond the technical was not reached on this work.

REFERENCES

AUTOEVOLUTION. **Emissions: Gasoline vs. Diesel vs. Bioethanol**. 2009. Available in: <<http://www.autoevolution.com/news/emissions-gasoline-vs-diesel-vs-bioethanol-3657.html>>. Accessed in December 10, 2012.

BIOENERGY WIKI. **Ethanol producers by country**. 2006? Available in: <http://www.bioenergywiki.net/Ethanol_producers_by_country>. Accessed in November 21, 2012.

BIOFUELS PLATAFORM. **Production of bioethanol in the EU**. 2012? Available in <<http://www.biofuels-platform.ch/en/infos/eu-bioethanol.php>>. Accessed in November 14, 2012.

CANOVA, M. D. **Biocombustíveis: análise de viabilidade econômica da implantação de microdestilarias de etanol no Rio Grande do Sul**. Trabalho de diplomação em Engenharia Química, 2011. Available in: <<http://www.lume.ufrgs.br/bitstream/handle/10183/36917/000793112.pdf?sequence=1>>. Accessed in December 2, 2012.

E85PRICES. **Reported E85 Prices**. 2012? Available in: <<http://e85prices.com/>>. Accessed in November 14, 2012.

EUBIA - EUROPEAN BIOMASS INDUSTRY ASSOCIATION. **Creating Markets for Renewable Energy Technologies EU RES Technology Marketing Campaign**. 20---. Available in:

<http://www.erec.org/fileadmin/erec_docs/Projcet_Documents/RESTMAC/Brochure5_Bioethanol_low_res.pdf>. Accessed in November 21, 2012.

EUROPEAN BIOFUELS TECHNOLOGY PLATFORM. **Cellulosic Ethanol (CE)**. 200-. Available in: <http://www.biofuelstp.eu/cell_ethanol.html#ce1> Accessed in December 2, 2012.

EUROPEAN PARLIAMENT. **Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC**. 2009. Accessed in: <<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF>>. Available in December 2, 2012.

FAOSTAT. **Browse Data: By Country/Region**. 2011. Available in: <http://faostat3.fao.org/home/index.html#VISUALIZE_BY_DOMAIN>. Accessed in November 21, 2012.

FIGUEIREDO, C. B., FILHO, J. R. F. **Os Impactos Sociais dos Biocombustíveis**. V Congresso Nacional de Excelência em Gestão, Julho de 2009. ISSN 1984-9354. Available in: <http://www.excelenciaemgestao.org/Portals/2/documents/cneg5/anais/T8_0151_0798.pdf>. Accessed in December 2, 2012.

FLACH, B., BENDZ, K., LIEBERZ, S. **Biofuels Annual – EU Biofuels Annual 2012**. USDA Foreign Agricultural Service. Available in: <http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-27_6-25-2012.pdf>. Accessed in November 21, 2012.

GABI SOFTWARE. **Paper Clip Tutorial**. 200-. Available in: <<http://www.gabi-software.com/support/gabi-4-learning-center/paper-clip-tutorial/>>. Accessed in December 2, 2012.

GONZALEZ, R. W. **Biomass Supply Chain and Conversion Economics of Cellulosic Ethanol**. ProQuest Dissertations And Theses; Thesis (Ph.D.)--North Carolina State University, 2011. Publication Number: AAT 3463769; ISBN: 9781124753249. Source: Dissertation Abstracts International, Volume: 72-10, Section: B, 248 p. Available in: <<http://adsabs.harvard.edu/abs/2011PhDT.....43G>>. Accessed in December 2, 2012.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Estatísticas da Produção Agrícola**. March, 2012. Available in: <http://www.ibge.gov.br/home/estatistica/indicadores/agropecuaria/lspa/estProdAgr_201203.pdf>. Accessed in November 21, 2012.

JOSHI, B. ET AL. **Lignocellulosic ethanol production: Current practices and recent developments**. Biotechnology and Molecular Biology Review Vol. 6(8), pp. 172-182, November 2011. Available in: <<http://www.academicjournals.org/bmbr/PDF/Pdf2011/November/Joshi%20et%20al.pdf>>. Accessed in December 2, 2012.

MALCOM, S. A., AILLERY, M., WEINBERG, M. **Ethanol and a Changing Agricultural Landscape**. United States Department of Agriculture. November, 2009. Available in: <<http://www.ers.usda.gov/media/153816/err86.pdf>>. Accessed in November 21, 2012.

MARCONI, M. A; LAKATOS, E. M. **Fundamentos de Metodologia Científica**. 7ª Edição. São Paulo, SP. Editora Atlas, 2010.

MINISTÉRIO DA AGRICULTURA DO BRASIL. **Balança Comercial de Outubro de 2012**. Available in: <<http://www.agricultura.gov.br/internacional/indicadores-e-estatisticas/balanca-comercial>>. Accessed in November 21, 2012.

MONTEIRO, A. F. S. M. **Avaliação das Potencialidades de produção de bioetanol em Portugal**. Dissertação do Mestrado Integrado em Engenharia Mecânica, Faculdade de Engenharia da Universidade do Porto, 2011. Available in: <<http://repositorio-aberto.up.pt/bitstream/10216/61489/1/000148669.pdf>>. Accessed in November 21, 2012.

NATION MASTER. **Transportation Statistics, Motor vehicles (most recent) by country**. 201-. Available in: <http://www.nationmaster.com/graph/tra_mot_veh-transportation-motor-vehicles>. Accessed in December 10, 2012.

NREL - NATIONAL RENEWABLE ENERGY LABORATORY. **Research Advances – Cellulosic Ethanol**. 2007. Available in: <<http://www.nrel.gov/biomass/pdfs/40742.pdf>>. Accessed in December 2, 2012.

RFA - RENEWABLE FUELS ASSOCIATION. **Advanced Ethanol**. April, 2012. Available in: <<http://www.ethanolrfa.org/pages/advanced-ethanol>>. Accessed in December 2, 2012.

RFA - RENEWABLE FUELS ASSOCIATION. **How Ethanol is Made**. 201-. Available in: <<http://www.ethanolrfa.org/pages/how-ethanol-is-made>>. Accessed in November 21, 2012.

RUSSEL, T. H., FRYMIER, P. **Bioethanol Production in Thailand: A Teaching Case Study Comparing Cassava and Sugar Cane Molasses**. The Journal of Sustainability Education, march 19, 2012. Available in: http://www.jsedimensions.org/wordpress/content/bioethanol-production-in-thailand-a-teaching-case-study-comparing-cassava-and-sugar-cane-molasses_2012_03/. Accessed in November 14, 2012.

STATISTICS PORTUGAL. **Agricultural Statistics 2011**. Available in: <http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes&PUBLICACOESpub_boui=142185401&PUBLICACOESmodo=2>. Accessed in November 14, 2012.

SUGARCANE.ORG. **EU Ethanol Policy**. 201-. Available in: <<http://sugarcane.org/global-policies/policies-in-the-european-union/policy-overview-ethanol-in-europe>>. Accessed in November 21, 2012.

THE WORLD BANK. **Population “total by country”**. 2012. Available in: <http://data.worldbank.org/indicator/SP.POP.TOTL?cid=GPD_1>. Accessed in December 10, 2012.

US DEPARTMENT OF AGRICULTURE. ECONOMIC RESEARCH SERVICE. **Crops**. May, 2012. Available in: <<http://www.ers.usda.gov/topics/crops.aspx>>. November 14, 2012.

US DEPARTMENT OF ENERGY. ALTERNATIVE FUELS DATA CENTER. **Global Ethanol Production**. 2012?. Available in: <http://www.afdc.energy.gov/data/tab/fuels-infrastructure/data_set/10331>. Accessed in November 14, 2012.

US DEPARTMENT OF ENERGY. ALTERNATIVE FUELS DATA CENTER. **Glossary**. 2012? Available in: <<http://www.afdc.energy.gov/glossary.html#AlternativeFuels>>. Accessed in November 14, 2012.

US DEPARTMENT OF ENERGY. **Energy Efficiency & Renewable Energy. Ethanol**. 201-. Available in: < <http://www.fueleconomy.gov/feg/ethanol.shtml>>. Accessed in November 14, 2012.

USI - USINAS SOCIAIS INTELIGENTES. **Biorefinarias para o mundo**. 200- Available in: <<http://usibiorefinarias.com/default/>>. Accessed in December 2, 2012.

XAVIER, M. R. **The Brazilian sugarcane ethanol experience**. Issue analysis 3, 2007. Available in: <<http://www.cei.org/pdf/5774.pdf>>. Accessed in November 21, 2012.

