Analysis of the supply chain of liquid biofuels

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Executive Summary

Due to political, economic, environmental and energy security reasons as well as climate change mitigation, the United States, Brazil and the European Union have promoted the substitution of fossil fuels for fuels derived from biomass, called biofuels.

Biofuels can be classified into three generations, depending on the origin of the biomass used for their production. First generation biofuels (1G) are those obtained from food crops such as sugarcane, corn, and vegetable oils. Second generation (2G) are obtained from waste not used for food, such as agricultural and forest residues, plant oil or animal fat among others; crops from marginal land are also considered second generation fuels because they do not compete with food production. Third generation biofuels (3G) are fast-growing non-food plants with high energy content (energy crops) in addition to having minimum supply of agricultural input, such as specialized algae, switchgrass or perennial grass.

However, in many cases the production of these biofuels has been carried out in a poorly sustainable manner, affecting food production. Environmental benefits are often little or null and economic benefits are dubious or nonexistent. The sustainability degree of biofuel production can only be assessed at a local level, since each case depends on the characteristics of the environment.

The policy for promoting biofuels in Mexico has been controversial; several studies indicate that the country has the potential for making use of residual biomass which can be raw material for the production of second-generation biofuels, but current public policy has been based on promoting first-generation biofuels.

To determine whether a project for the production of anhydrous ethanol is viable, it is necessary to identify its true sustainability degree, while considering all the stages involved. Reducing greenhouse gases, an energy efficient rate of more than one, which means that more energy is obtained from biofuels than that used to produce it, and that is economically viable, are the minimum requirements to be met by biofuel so it can be truly sustainable.

Therefore it's important to know which aspects would allow the production and marketing industry of liquid biofuels destined for the transportation sector in Mexico to finally take off, taking into account the current available technology, the potential availability of biomass and its environmental impacts and energy consumption. If the production of biofuels in Mexico does not comply with sustainable development principles there could be serious damages to the environment and energy balance. Any actions implemented must be technically, environmentally and energetically feasible in addition to being socially convenient.

This study is an analysis of possible scenarios to produce ethanol and biodiesel in Mexico and gives information on the impact of the carbon footprint and energy efficiency required for their implementation. In order to address the problem of climate change, the life cycle analysis methodology may be a tool for decision making in selecting the production of sustainable biofuels.

This study is the analysis of the supply chain of liquid biofuels from case studies. In the first part, a diagnosis of the international experience on the state of the art technological processes and raw materials for the production of biofuels was made, as well as an analysis of international and domestic prices and costs, and promoting policies.

In the second part, as baseline for the case studies we carried out an analysis of the potential use of the main lignocellulosic residue that can be used for the production of biofuels as well as the selection of case studies.

Finally the carbon footprint and energy return on investment (EROI) were estimated for selected case studies. The methodology used for the carbon footprint was the life cycle analysis and for energy return on investment estimation, we used the methodology included in the Mexican standard for sustainability certification of liquid biofuels.

From the analysis of the availability on the use of lignocellulosic residues, the top five selected residues are: corn crop residues, sugar production (bagasse and molasses), sugar cane, wheat and sorghum.

This analysis consists on three case studies for ethanol production with their respective scenarios for improvement, and a case study for the production of biodiesel. These studies were selected according to the current situation of the country and the diagnosis made in the first part.

Derived from PEMEX's last public bidding process, for the production and distribution of anhydrous ethanol, we analyzed various of the companies who obtained a bid, considering the availability, concentration and accessibility of biomass, selecting a company located in Veracruz, because the area has high sugar cane production and is developing production of first generation ethanol.

The selected case studies are:

1. Production of anhydrous ethanol from sugarcane molasses, located in the state of Veracruz
2. Production of anhydrous ethanol from sugar cane juice, located in Veracruz
3. Production of second generation anhydrous ethanol from sugar cane residues, located in the state of Veracruz
4. Production of biodiesel from used vegetable oils, located in the state of Quintana Roo

Carbon footprint

Carbon footprint is a measure that helps assess the environmental impact of global warming by estimating emissions of greenhouse gases in terms of carbon dioxide equivalent (CO_2eq). With the purpose of having a measure to assess the environmental impact of introducing biofuels in Mexico, the carbon footprint for four case studies was estimated from the perspective of life-cycle analysis.

The results indicate that, in the case study of anhydrous ethanol from sugar cane molasses, as currently ethanol is being proposed to be obtained in Mexico, would imply a 3 % increase in emissions of greenhouse gases regarding emissions from burning gas. Looking for options to reduce this impact, we propose using the cane stubble located nearby the facilities, under adequate transportation logistics and without affectations to the soil, for its use as an alternative fuel in biomass boilers, thus achieving a reduction of greenhouse gases emission of 52 %. The case study that has the greatest benefit in reducing emissions is the production of second-generation ethanol is the one using bagasse from sugar cane as raw material, resulting in a 90 % reduction in carbon footprint with respect to gas.

Energy balance

Energy return on investment is the numerical ratio between the energy contained in the biofuel and the energy consumed for its production throughout its life cycle. The result of this index must be greater than one, in order to be considered energetically acceptable. In the case studies analyzed in this document, ethanol from molasses is the only one that resulted in less than one; the case of second-generation ethanol from sugarcane bagasse is the most energy efficient, as long as it is accompanied by a cogeneration system and electricity surplus.

Figura 1: Summary Mitigation of GHG emissions vs fossil fuel

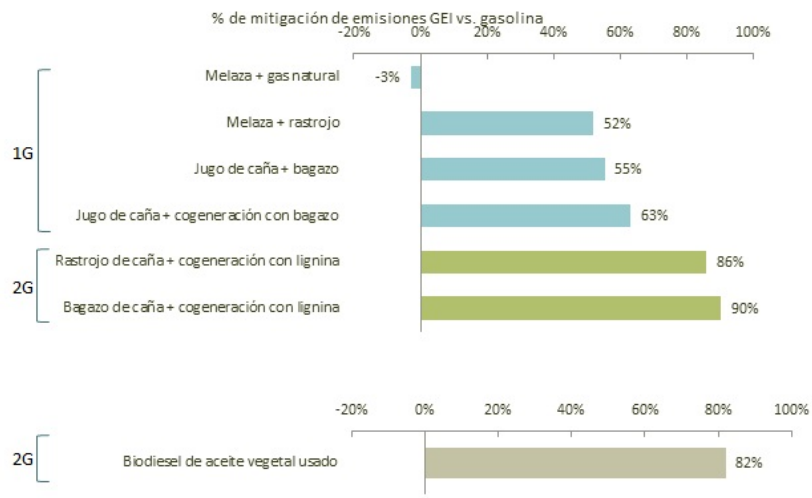
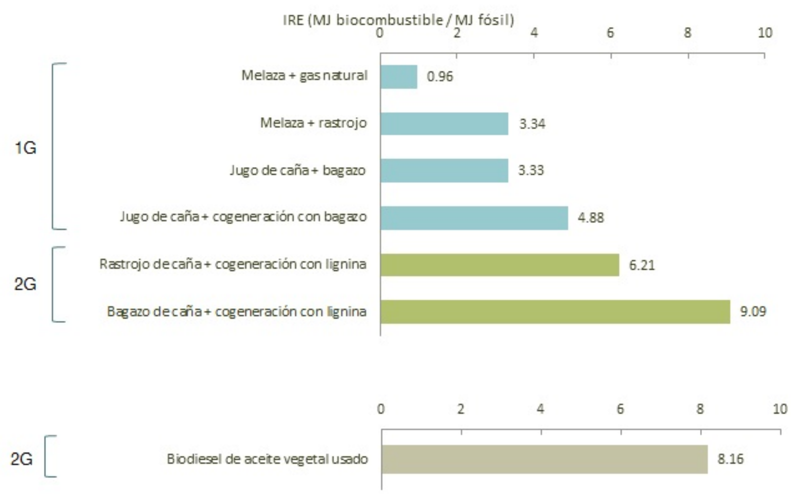


Figura 2: Summary Energy return on investment



In conclusion, out of the four case studies analyzed, the biofuel that does not contribute to reducing greenhouse gases and also is not energy efficient is ethanol obtained from sugar cane molasses. If we consider that instead of using natural gas for steam generation, as it will be implemented in PEMEX's plant which won the bidding offer, were the nearby agricultural wastes are used, we have energy gain and a reduction in emissions of greenhouse gases (GEI), being a better option for replacing gas.

The case study with the greatest reduction in emissions and a significant energy gain is second generation ethanol obtained from sugar cane bagasse, which in addition to obtaining thermal and electrical energy that self-supplies, its production and has surplus to upload to the electricity grid, making it the most sustainable option.

Generally, results indicate that while there is still consumption of fossil fuels and consumption of electricity from the power supply network for the production of biofuels, there won't be a significant reduction in GHG emissions and significant energy gain. However, there is a high potential for usage when using biomass to generate heat and electricity. It's important to implement cogeneration process to achieve significant reductions in the emission of greenhouse gases.

Although the current policy and government aid in Mexico continues to focus on the production of first generation biofuels, it is important to encourage and support production of second-generation biofuels. These biofuels are the ones that really contribute to reducing GHG emissions and have a positive energy return on investment as long as they're accompanied by cogeneration electricity.

The eventual success of biofuel projects depends a lot on local conditions, fluctuations in prices of raw materials, the limited supply of raw materials, modernization of productive activity in the field (mechanization, etc.), supply logistics, among others.

The policy for promoting biofuels in Mexico should establish mandatory sustainability criteria and not just a voluntary standard as is the case today. It should also encourage improvements to production process of biofuels by raising the threshold for reducing emissions in new facilities, promote greater penetration of advanced biofuels and not consider any kind of subsidy for biofuels that do not show a significant reduction in GHG emissions or are produced from food crops or livestock feed. Strategic alliances must be sought with companies producing enzymes and biotechnology developers, with large energy corporations and experienced global leaders like Brazil.

Analyzing and being aware of the problems that can generate unsustainable production of biofuels does not mean that Mexico is unable to carry out the production of such fuels, the knowledge, technology and the necessary raw material exist, and the key is to do it efficiently and without environmental repercussions.

The position of the Mario Molina Center remains the same, using biofuels correctly can certainly contribute to solving global and local issues in Mexico, and in addition the country can play a leadership role by demonstrating responsible and profitable use of its resources and energy.

In Mexico, for the use of biofuels to be beneficial for society and the environment, it is necessary to ensure that they:

- Contribute to regional and national economic welfare
- Don't unduly impact the quality of air, water, and soil
- Actually reduce net emissions of greenhouse gases
- Don't require large subsidies
- Don't compete with food production or adversely affect their markets

- Don't affect biodiversity nor contribute to deforestation
- Don't lead to the overuse of fertilizers and pesticides that harm ecosystems
- Don't degrade or exhaust essential natural resources such as water and fertile soils

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