Bioethanol: Challenges For Implementation[1]

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Introduction

Biomass can be used to produce gaseous, solid, and liquid biofuels.[2] Of these, fuel ethanol and biodiesel have acquired special importance because of their direct applications, principally to transport.

The so-called *first generation technologies*, that is, technologies using biomass (corn starch and starch from other grains, sugarcane and grain oils, among others), which are the raw materials used for food, should not be encouraged in Mexico unless food self-sufficiency (food security) has been achieved.[3] *Second generation* technologies based on non-edible biomass, such as lignocellulose and oil obtained from inedible oleaginous plants and micro-algae, do not compete with the supply of food for arable land.[4] These should be the basis for Mexico's encouraging research and scientific and technological innovation through private companies and Pemex, to provide strong support for the rural farming sector, in order to achieve positive impacts on all sectors involved in the production of biofuels.

To endow this category with economic sustainability and technical feasibility, it is essential that biofuel generation embrace the production of other products that will replace materials currently obtained from petroleum such as plastics and biodegradable polymers, resins, and other specialized biofuels such as bio-butane and bio-jet fuel, solvents, resins and organic and fatty acids, among others.

The implementation of technologies to enable this step will require cutting-edge scientific research in agriculture, agronomy, sociology, economics, politics, environmental science, and biotechnology, to create methodologies that have not yet reached technological maturity anywhere. The interaction and integration of scientific and technological knowledge, in addition to the combined efforts of the various sectors involved, are key to enabling successful technological implementation in Mexico.

Oil and Biofuels in the Context Of Renewable Energy

If action is not taken to provide alternatives to oil and other fossil fuels for certain purposes, Mexico will probably suffer an energy, economic, and political crisis. In this context, alternative energies such as wind, hydro-electric, tidal, geothermal, nuclear, and solar power represent a wide variety of options to replace fossil fuels in the generation of electricity. However, present and future needs require the use of other energy sources whether in solid, liquid, or gaseous states. In this sense, bioenergy, energy derived from biological resources, is in practical terms the only current and medium-term fuel alternative available in all three states.

Transportation fuels, particularly in liquid form, are the second largest type of petroleum or gas consumption in Mexico. However, using biotechnological processes, biomass can be converted into a liquid biological energy source, known by the generic name of "biofuels."

This concept is currently used in several countries. Brazil and the United States are leaders in the production and consumption of so-called fuel ethanol, obtained from the starch in corn and the sucrose in sugarcane. The United States and some European countries like Germany also use biodiesel produced from vegetable oils. Both biofuels (ethanol and biodiesel) obtained from the sources described are known as

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first-generation because, as mentioned above, the raw materials are also used as food for humans.

The Biorefinery Concept

The variety of products that can be obtained through biomass processing is extensive, and more can be done with them than replacing the primary fuels today derived from oil. This process is known as biorefining. Depending on the writer or the context, the term includes a differing set of products. In the present case, the biorefinery concept brings together biomass conversion processes to produce biofuels of various kinds, heat for processing, electricity, and chemical products.

Biorefineries are the basis of a new industry built on biological materials that are biodegradable, renewable, sustainable, and generally more environmentally friendly, including a substantial reduction in emissions. It should be noted that to ensure financial sustainability, the production of biofuels must also lead to the creation of other useful by-products.

Factors Driving the Introduction and Use of Biofuels

Over six years ago a number of Mexican legislators and researchers took the initiative to create a law to promote the use of bioenergy. After years of analysis, the Law to Foster and Develop Bio-energy was published in the *Diario oficial de la federación* (Federal Official Gazette) on February 1, 2008. Its objective is to promote and develop "bioenergy to contribute to energy diversification and sustainable development as conditions to ensure support for the Mexican countryside."[5] Its first article sets out the foundations "to promote the production of bioenergy inputs from agricultural activities, forestry, algae, biotechnology, and enzymatic processes in Mexican farmland, without jeopardizing national food security and sovereignty; develop the production, marketing, and efficient use of bioenergy to contribute to the revival of the rural sector, job creation, and improved quality of life for the populace (particularly in areas of high and extreme poverty); promote regional development and of disadvantaged rural communities and seek to reduce atmospheric emissions and greenhouse gases."

The "Regulations of the Law to Promote and Develop Bio-energy" was published in the *Diario oficial de la federación* on June 18, 2009.[6] In its initial stage, the National Biofuels Program aimed to cultivate 300 000 hectares of sugarcane by 2012 and to produce about 200 million liters of ethanol per year. A national tender (18576112-022-09) was issued in October 2009 for Pemex to buy 658.4 million liters of anhydrous ethanol[7] from 2011 to 2015 at Mex$8.20 per liter, intended for use as an oxygenate in gasoline in the metropolitan area of Guadalajara and for the state oil company's storage

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and distribution terminals (El Castillo and Zapopan) in the municipality of El Salto, Jalisco.

It must be borne in mind that oxygenates are compounds containing oxygen among their molecules and which are added to fuels thereby increasing the oxygen content in the liquid phase (such as ethanol in gasoline) before mixing with the gaseous oxygen (contained in the air) in the engine's combustion chamber. An oxygenator improves the quality of combustion by 10 percent and reduces emissions of compounds, including carbon monoxide. If ethanol is obtained from biological material, for example from the sugars in sugarcane or from lignocellulosic biomass, and the use of fossil fuels is minimized in the process of ethanol production by using pure ethanol as fuel, CO_2 emissions are also reduced by up to 90 percent compared to the emissions of this compound resulting from the processing of oil into gasoline.

In addition to the above measures, an Agreement Issuing Guidelines for Granting Permits for the Production, Storage, Transport, and Commercialization of Bioenergy in the Form of Anhydrous Ethanol and Biodiesel was published on November 13, 2009.[8] As of December 2011, none of these goals had been met.

Despite the fact that the law, its regulations, and derivative documents may be improved on —and they have been subject to criticism— they are a starting point for the creation of a new industry in Mexico, based on rural biomass generation, without compromising the production of primary foodstuffs for human consumption. These documents have also allowed us to confirm the backing that the federal government, the Senate, and the Chamber of Deputies have decided to grant the production of biofuels.

In this context, several other government initiatives exist to promote the production of biofuels, such as ethanol fuel mainly from sugarcane and sweet sorghum; biodiesel from inedible oil oilseeds like jatropha and the castor oil plant, or from oleaginous microalgae; and methane or biogas from animal manure and organic waste.

Other factors drive the development and use of biofuels:

1) the environment: seeking to reduce polluting emissions from the use of fossil fuels and a substantial reduction in greenhouse gases generated by transportation;
2) energy: seeking to retain what is known as energy independence and sovereignty, as well as an acceptable level of control of fuel prices, conserving energy security;
3) agricultural and social development: to generate employment and improve the quality of life in these sectors;
4) the economy and the market: to create jobs and a market for new products and the commercialization of inputs.

The Status of First- and Second-Generation Ethanol Production

As mentioned, the raw materials used to produce over 40 billion liters of ethanol fuel, primarily in the U.S. and Brazil, come from starch found in corn and the sucrose in sugarcane. From the standpoint of food security, the idea of producing ethanol from starch from corn or other grains is contrary to all good sense. Mexico is not and will not be self-sufficient in food production in the short term, particularly in the area of grains, of which we import more than 15 million tons each year.

Corn is the staple food for most of the Mexican population and more than 8 million tons are imported per year, although it is not used directly to feed the population, but for livestock feed. In this context, it is imperative to solve the food security situation first, and only later to think about other uses for this type of grain.

On the other hand, sugarcane production costs in Mexico are unfortunately the highest in the world (about US$36 per ton versus US$12 in Brazil), and corn prices rose sharply in early 2007 as a result of the United States dedicating about 15 percent of its production to making ethanol. In early 2011, they rose further because of heavy frosts in the state of Sinaloa, Mexico's main corn producer. Consequently, the production of fuel ethanol from raw materials is currently neither viable nor sustainable in Mexico from the economic and food security perspective.

Recent research has focused on developing new technologies for producing fuel ethanol from lignocellulosic biomass instead of using starches, since it can substantially reduce competition for agricultural land. This material may come

from municipal waste, agricultural waste, forestry, and energy plantations of agave and fast-growing grasses, among others.

Considering that wood is the most abundant source of biomass and that agro-industrial waste is not utilized anywhere in the country, the sustainable use of forest waste products, of energy plantations on land unsuitable for food production, and agro-industrial waste from a wide variety of products are alternatives that offer the greatest productivity potential in biofuel production.[9]

It is pertinent to note that from the technological point of view, current trends indicate that demand for food and biofuels will lead to the technological optimization of land use, because there is still ample room to increase productivity per hectare, and to use semiarid and marginal land to grow biomass-producing crops, so that the demand for both food and bioenergy can be satisfied. However, we should recognize that even if there is more food per capita, social inequality remains an over-arching problem, since the population without food security is precisely the sector that lacks the income to buy the food it needs. Therefore, if biomass production begins to generate income for small-scale farmers, bioenergy can contribute positively to the improvement of food security.

Another important option for reducing competition for land use involves the recovery of contaminated land that is not important to food production or nature conservation. In that regard, the production of biomass from perennial species (which are also lignocellulosic) may contribute significantly to reducing erosion.

Ethanol as a Reducer of Pollutant Emissions

As noted above, ethanol is mainly used as an oxygenate in gasoline, which, besides diminishing the use of other synthetic oxygenates, can reduce the emission of a wide range of pollutants. Fortunately, there are other longer-chain alcohols that have better fuel properties, such as bio-butane, whose formula means it does not trap water, making it a better option than ethanol for blending with gasoline, since ethanol's properties allow it to capture water from the environment and to cause separation from the gasoline in the storage tank, which affects the combustion process. Furthermore, bio-butane's energy content, vapor pressure, and other properties similar to gasoline make it completely compatible with the Pemex infrastructure and today's internal combustion engines, whether gasoline or hybrid.

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Final Remarks

The potential for the production of *second generation* biofuels is enormous. Their lower environmental impact would substantially reduce the emission of greenhouse gases generated by transportation. One of the main limitations in our country lies in the implementation of a program for the sustainable production of non-food biomass to embrace rural, social, environmental, ecological, political, land-use, technological, market, and economic factors. Another limitation involves the development and use of frontier technologies,[10] whose fundamental requirement is the creation of scientific biotechnology knowledge and processes for culturing microorganisms and microalgae, the efficient conversion of carbon sources, sugars from biomass and carbon dioxide from industrial emissions, ethanol and oils and their extraction, purification and conditioning for anhydrous ethanol and biodiesel with a quality that meets the requirements of vehicles and Pemex, and also meets the requirements of energy efficiency and the reduction of emissions and greenhouse gases.

This will require long-term programs that promote frontier research and successfully bring together multi-disciplinary, multi-institutional, and cross-sectoral research groups.

The creation of an office in the National System for Research and Technology Transfer of the Ministry of Agriculture, Livestock, Rural Development, Fisheries, and Food (Sagarpa) and the Biofuels Department of the Energy Ministry (Sener) are initial efforts by the federal government to create links in the chain, but feedback, support, and advice from scientists and academics who are experts in these areas are also needed.

Another initiative is Conacyt's establishment of a network related to renewable energy sources that requires the necessary financial support and administrative efficiency to compete internationally in important multi-disciplinary projects in the biofuels field. These initiatives remain isolated, and a body, probably a council or national commission, should be

created to develop bioenergy and jointly coordinate the activities of these bodies, to define development policies, and above all to include scientists, academics, peasant organizations, entrepreneurs, Pemex, and other stakeholders.

Financial incentives should target not only biomass generation: comprehensive support should be given to rural development as a whole, and also to scientific and industrial development for the efficient transformation of biomass not only into biofuels but also into high-value-added products. The construction of biorefineries provides scientific, technological, and financial support for the production of biofuels, but the creation of a national biofuel research center would be desirable in the short term. Various national scientific institutions have the capability to develop part of these processes, reason enough not to wait for technologies conceived in developed countries to reach maturity and be marketed in Mexico. Domestic technology and its application on a commercial scale should be encouraged, not only to generate biofuels, but, as mentioned, to set up biorefineries. VM

NOTES

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[2] Biomass is the biological material derived from animals and plants, which is generally not used as food; for example, agricultural, domestic, and livestock waste, etc.

[3] According to the Food and Agriculture Organization (FAO), food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. About this definition, see World Food Summit 1996 document, June 6, ftp://ftp.fao.org/es/esa/policybriefs/pb_02.pdf.

[4] Lignocellulose biomass is a type derived from plants, made up of compounds that humans and many animals cannot digest. Some common lignocellulosic residues include the stalks and leaves of corn, wheat, and sorghum; forestry residues such as shavings, sawdust, and firewood; and sugarcane and agave bagasse.

[5] Secretaría de Energía, "Ley de promoción y desarrollo de los bioenergéticos," http://dof.gob.mx/nota_to_imagen_fs.php?codnota=5029330&fecha=01/02/2008&cod_diario=213102. [Editor's Note.]

[6] See this legislation at http://dof.gob.mx/nota_to_imagen_fs.php?codnota=5094933&fecha=18/06/2009&cod_diario=220873. [Editor's Note.]

[7] Anhydrous ethanol does not contain water and must be subjected to another process after distilling, while non-anhydrous ethanol is alcohol containing 96 percent ethanol and 4 percent water, the maximum concentration reached after the distillation process.

[8] Secretaría de Energía, http://www.sener.gob.mx/res/0/Acuerdos_SENER_131109.pdf. [Editor's Note.]

[9] Energy plantations are plantations of trees or fast-growing plants whose specific purpose is to produce energy by burning directly or through transformation to produce a biofuel.

[10] Frontier technologies are those that are not yet commercially available and still require basic research using knowledge recently developed by researchers in many disciplines, such as the case of the bio-technology under discussion.

Energy and GHG Policy Options For Mexico's Private Transport

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INTRODUCTION

According to reports by the U.S. Department of Energy published in 2011, world oil demand will grow about 53 percent by 2035, and production capacity is already being used. In the same time frame, oil prices are expected to rise to about US$125 per barrel and green house gas (GHG) emissions will grow about 53 percent. In addition, oil production is expected to decrease by 70 percent in 30 years, though this may be delayed by a few years due to new deep-water oil discoveries

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