# *BIOFUEL POTENTIAL IN MEXICO: LAND USE, ECONOMIC AND ENVIRONMENTAL EFFECTS*

Hector M. Nuñez, Centro de Investigación y Docencia Económicas, (52) 449-9945150, hector.nunez@cide.edu
Anna D. Mata, Centro de Investigación y Docencia Económicas, (52) 449-9945150, ann.deyanira@gmail.com

## Overview

About 90% of Mexican energy consumption comes from fossil fuels, including that of the whole transportation sector (SENER, 2014). This helps make the country the 14th largest Greenhouse Gas (GHG) emitter in the world, contributing with about 1.5% of the global GHG emissions (World Resources Institute, 2015). The country's environmental goals, in accordance with the Intended Nationally Determined Contribution affirmed at the Paris climate summit, require that 35% of domestic energy comes from renewable sources by 2025. Meeting that goal is likely to require a domestic biofuel industry. The 2013 energy reform, however, was mostly designed to increase fossil fuels production.

There have been several attempts to introduce biofuels into the market (the current plan is to require gasoline be blended with 5.8% ethanol in most of the country) but so far no success. Anecdotal evidence suggests potential producers are unwilling to bear the fixed costs of setting up production systems because they doubt policies will endure. There has been a surplus of sugarcane as well as from other biomass (like agave residues) in several recent years, but no industrial-scale fermentation or distillation facilities to turn it into ethanol. It is thus paramount that whatever policies the country implements to promote biofuels be seen as sustainable. This paper is aimed directly at that goal, developing a framework to forecast economic and environmental impacts about a decade ahead from policies that promotes industrial-scale biofuel production.

## Methods

Technically, we develop an endogenous-price mathematical programming model emphasizing the Mexican agricultural and fuel sectors, which are embedded in a multi-region, multi-product, spatial partial equilibrium model of the world economy. There is a module for the United States (Mexico's main trade partner) and another for Rest of the World. Mexico is disaggregated into 193 agricultural districts. Production functions are specified for sugarcane, agave and twelve major crops including corn and sorghum as well as livestock (beef, chicken, dairy, hogs and eggs). Biofuel can be produced both from dedicated crops (sugarcane and sorghum) and from agroindustrial residues that result from the processing of spirits, sugar, corn and sorghum for human or animal consumption. (The agave and spirits industry residues have been the subject of significant research and are considered to have high potential as biofuel raw material (e.g. Munoz and Riley 2008; Cáceres-Farfán et al. 2008; Maldonado-Sanchez 2009; Nuñez, Rodriguez, and Khanna 2011; Davis, Dohleman, and Long 2010). Oil, diesel and gasoline production are also modeled in detail.

As usual, we assume all markets are competitive (an assumption which may be relaxed in various ways in future work) so that the economy maximizes the sum of producer and consumer surplus subject to resource limitations, material balance, technical constraints, foreign offer surfaces and policy restrictions. Consumers' surplus is derived from consumption of agricultural commodities and transportation fuels, the latter measured by vehicle-kilometers-traveled (VKT). The model is calibrated to 2008 market conditions. GHG emissions are calculated based on CO2 equivalent emissions factors for each crop, fuel or other products specified.
We consider three policy alternatives as well as a base case in which, as now, not liquid fuels receive either incentives or command and control policy. The first alternative consists of subsidies to biofuel producers, the second of blending mandates and the third of both combined. In all three cases, we consider several values for the policy variables -- i.e., several subsidy rates and several required percentages of biofuel in the blend. Biofuel imports are allowed in all cases.

## Results

Projecting market conditions to 2025, the model results show substantial losses for fuel and agricultural consumers, offset by producer gains. This suggests that some compensating redistribution may be needed if these policies are to be seen as politically sustainable. The reduction of GHG emissions results in a small social welfare gain for Mexico, although most of that benefit is enjoyed abroad.

## Conclusions

Although Mexico has a large potential for biofuel production, a well-designed policy is required to incentive a sustainable market. Different alternative policies than those assessed here (i.e. subsidies and mandates) must be considered, so that the country will be able to obtain most of the benefits from the introduction of biofuels into the domestic market.

## References

Adams, D., Alig, R., McCarl, B. A., & Murray, B. C. (2005). Fasomghg conceptual structure, and specification: Documentation.

Cáceres-Farfán, M., Lappe, P., Larqué-Saavedra, A., Magdub-Méndez, A., & Barahona-Pérez, L. (2008). Ethanol production from henequen (Agave fourcroydes Lem.) juice and molasses by a mixture of two yeasts. Bioresource Technology, 99(18), 9036–9039. doi:10.1016/j.biortech.2008.04.063

Chen, X., Huang, H., Khanna, M., & Onal, H. (2010). Meeting the Mandate for Biofuels: Implications for Land Use, Food and Fuel Prices. NBER Working Paper Series (Vol. 16697). Paper presented at the NBER Agricultural Economics Conference, Cambridge MA, March 4-5, 2010. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1657004.

Davis, S. C., Dohleman, F. G., & Long, S. P. (2010). Review of the global potential for Agave as a bioenergy feedstock. Global Change Biology Bioenergy, Submitted.

Fabiosa, J. F., Beghin, J. C., Dong, F., Elobeid, A., Tokgoz, S., & Yu, T.-H. T.-H. (2010). Land Allocation Effects of the Global Ethanol Surge: Predictions from the International FAPRI Model. Land Economics, 86(4), 687–706.

Maldonado-Sanchez, A.-E. (2009). Improved Agave Cultivars (Agave Angustifolia Haw) for Profitable and Sustainable Bioethanol Production in Mexico. Chapingo Autonomous University. From http://www.nodai.ac.jp/cip/iss/english/9th_iss/fullpaper/2-1-3uach-maldonado.pdf.

Munoz, L. E. A., & Riley, M. R. (2008). Utilization of cellulosic waste from tequila bagasse and production of polyhydroxyalkanoate (pha) bioplastics by Saccharophagus degradans. Biotechnology and Bioengineering, 100(5), 882–888. doi:10.1002/bit.21854

Nuñez, H. M., Önal, H., & Khanna, M. (2013). Land use and economic effects of alternative biofuel policies in Brazil and the United States. Agricultural Economics, 44(4-5), 487–499.

Nuñez, H. M., Rodriguez, L. F., & Khanna, M. (2011). Agave for tequila and biofuels: an economic assessment and potential opportunities. GCB Bioenergy, 3(1), 43–57. doi:10.1111/j.1757-1707.2010.01084.x

SENER. (2014). Balance Nacional de Energía. Secretaria Nacional de Energía.

World Resources Institute. (2015). CAIT Climate Data Explorer.