

## **Biodiesel @ Puerto Rico**

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### **Abstract**

The University of Puerto Rico, in collaboration with the Department of Energy-National Renewable Energy Laboratory, Panzardi-ERM, Caguas and Isabela Municipal Government, Puerto Rico Senate Energy Committee, and Puerto Rico Energy Affairs Administration, studied the transesterification process to convert waste greases, used cooking oil, and animal fats into fatty acid methyl esters (FAMES) also known as Biodiesel. In Phase I & II the long-term objective was the establishment of a Biodiesel Industry in Puerto Rico. The Phase I objectives included the development of laboratory expertise on Biodiesel process technologies using available raw materials, "Top Down" and "Bottom Up" studies regarding raw material availability and potential customers in Puerto Rico, and conduct engineering analysis for scale-up. In Phase II an aggressive demonstration program was established. In this presentation the most important results from Phase I and II will be discussed including an update on present biodiesel commercialization and research activities @ Puerto Rico.

### **Keywords**

Transesterification, Biodiesel, Fatty Acid Methyl Esters

### **1. Introduction**

In the last decade there has been a renewed interest in Puerto Rico regarding both energy dependence and environmental concerns. This is due to the isolated nature of the island and the high population density (>1000/ft<sup>2</sup>). In addition, the island's location on Hurricane alley provides additional risks regarding energy reliability. During the last decade several hurricanes have either hit the island (Hugo and Georges) or have been close enough to raise wind velocities affecting the distribution network. These experiences drove many consumers to become "independent" of the local utilities especially during emergency situations. The situation in Puerto Rico is very similar to other Caribbean Islands, Central and South America.

The establishment of a Biodiesel industry in Puerto Rico would offer unique energy and environmental benefits. This was recognized by the Department of Energy as evidenced by the approval of a project titled Grease Biodiesel for Puerto Rico in October 2000. The key objective was to develop a Center for Biodiesel Expertise in the Caribbean that could lead to and support a Biodiesel industry in Puerto Rico using domestic feedstocks such as recycled restaurant greases and other imported feedstocks. The main results of this initiative are discussed below.

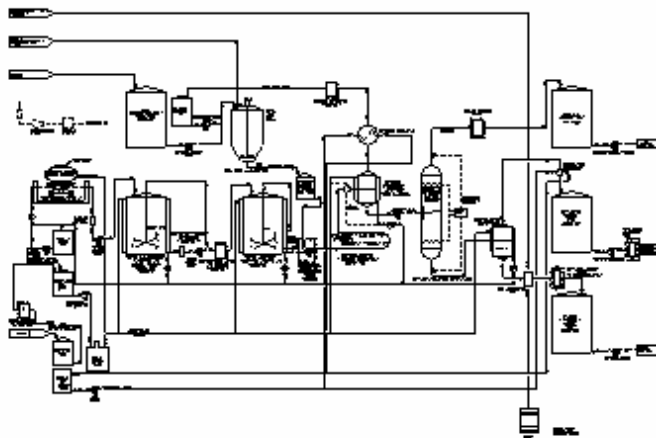
## 2. Results

The Biodiesel Initiative at Puerto Rico involved the following tasks:

*Tasks 1 and 2* – The main objectives of these tasks were to develop market data on the supply of biodiesel feedstock, quality, value, composition, current use and pretreatment. Another objective was to develop market data on the highest and best uses of biodiesel in the power and transportation industries. In addition, an evaluation of potential markets for biodiesel synthesis by-products such as glycerol and fertilizer was required. In performing the data collection process a “top down” and bottoms up” approach was used. The former refers to obtaining data from government agencies and/or regulating agencies and relevant organizations. The latter involved interviews at the source or “generators” and “collectors”. This approach was used for both raw material suppliers and consumers. The most important result in the resource assessment study was that in Puerto Rico there is a collection potential of used cooking oil and greases between 5.0 to 10.0 million gallons per year of which only 1.0 to 1.5 is presently collected. In the market assessment study, the most relevant result was that diesel consumption in Puerto Rico is distributed as follows (millions gallons per year); Agriculture (3), State Government (17), Services (18), Construction (32), Manufacture (33), Ground Transportation (37), Boats/Ships/Cruises (38), Electric Power Authority (414) and others (21).

*Task 3* – The objective here was the development of a Center of Expertise. It has two main components, Analytical and Conversion. The former emphasizes in developing expertise in critical analyses for both raw materials (oils and greases) and products (biodiesel and glycerol) in order to support a biodiesel industry. The ASTM PS121 (now ASTM 6751) required methods were used for the biodiesel quality analysis. The Conversion component is subdivided into Mass Balance Closure/Process Design Support, Reaction Engineering, Raw Materials/Catalysts, Patent Invention Disclosure and Dissemination efforts. In addition, the Reaction Engineering studies involved the effects of Agitation (Mechanical versus Ultrasound), Equilibrium (reactants ratii) and Temperature. The Raw Materials/Catalysts efforts included catalyst recovery studies. In the Mass Balance Closure/Process Design efforts the cases that were considered included virgin oils, tallow and yellow grease based biodiesel synthesis. The major component of the Conversion component was in Reaction Engineering, which included Mixing (two phase), Equilibrium and Temperature effects. An important finding in the reaction studies was that the estimated reaction rate constants using ultrasound were 3.0 to 4.5 times higher than those reported in the literature using mechanical agitation (1). Also, the estimated activation energies were consistent with those reported. Regarding alcohols, methanol was preferred, since it is readily available pure and in waste streams in Puerto Rico. Other alcohols studied were ethanol, butanol and isopropanol.

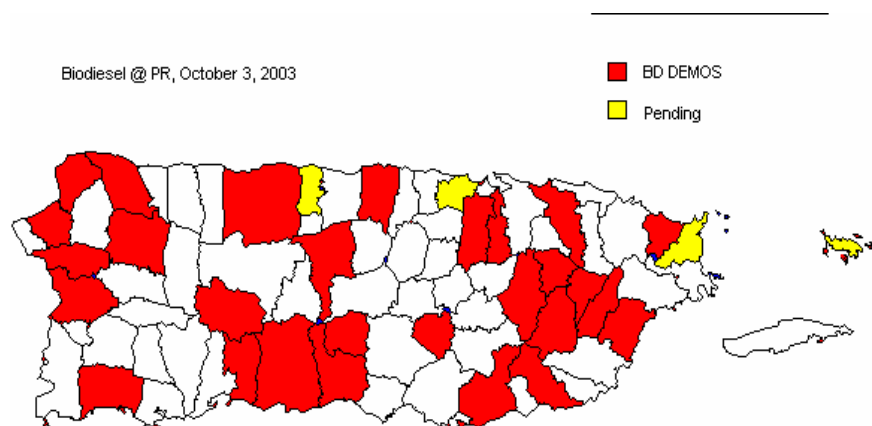
*Task 4* – This task was performed mainly by Panzardi-ERM in collaboration with UPRM personnel. The main objective was developing a conceptual design for a biodiesel manufacturing facility in Puerto Rico



(see figure). This facility should be able to process a wide variety of raw materials including tallow, used and virgin cooking oils. The study included turnkey units from Energea (Austria) and Química Nova (Argentina) and a “criollo” facility designed utilizing experimental data from the University of Puerto Rico. The main result from the study was that the investment for a facility that could produce between 10 to 15 million gallons per year of biodiesel would be approximately 6.0 to 10 million dollars. In addition to the design, a financial sensitivity analysis was performed to determine the economic

viability of the facility. In most cases net present values higher than 10.0 million dollars were obtained.

*Task 5* - Another key component of the Biodiesel for Puerto Rico Initiative are the Demonstrations. Over 20 demonstrations (see map below) were performed that included four municipalities, a state government



agency, eleven companies, six private citizens and two sites of the University of Puerto Rico. Four shipments of 2,200 gallons of B100 were delivered. In addition, there were several workshops and/or conferences that were attended by more than five hundred participants. There was also an aggressive public relations effort that included several press conferences, TV and radio interviews and

documentaries, news releases and articles in local technical publications. It is estimated that tens of thousands if not hundreds of thousands probably heard about the Biodiesel Initiative efforts at Puerto Rico. For example, *El Nuevo Día* has a circulation of over 250,000 reaching over 750,000 people.

### 3. Conclusions

A Biodiesel Industry in Puerto Rico will soon become a reality due to the product awareness efforts of the DOE sponsored Biodiesel Initiative and present diesel market conditions. At least three companies are pursuing biodiesel commercialization efforts that include the construction a biodiesel production facility and related activities. In addition, reaction engineering studies are underway in order to better understand biodiesel formation under ultrasound mixing conditions. This project sponsored by the Consortium of Plant Biotechnology Research and Kentucky Soybean Board is in collaboration with the University of Kentucky.

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