

BBFuels of Puerto Rico, LLC: A Sustainable Industrial Model for Bioethanol Production in Puerto Rico

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ABSTRACT

BBFuels de Puerto Rico, LLC is a green company that proposes a novel approach to biomass conversion to energy that reduces the overall process complexity required to produce ethanol by means of wet water hyacinth of Puerto Rico (*Eichhornia crassipes*). The problems that this project solves are the lack of E85 supply for FFV owners, and the overpopulation of hyacinths. Due to hyacinths high lignocelluloses content they can be considered a promising substrate for the production of bioethanol. For that reason, the development of ethanol from water hyacinth of Puerto Rico is the innovation offered by this proposal. Water Hyacinth has an extremely rapid growth rate that clogs rivers and prevents navigation due to a perfect environment: the tropics. It could be useful as a source of biomass because of its abundance and feasible cultivation. The impact that this innovation could have over society consists of improving the quality of life and the environment while providing an alternative fuel that is less pollutant at a lower cost than fossil fuels. This innovation would provide E85 ethanol for flex fuel vehicles being acquired despite the lack of E85 in the Puerto Rican market. In addition, production of ethanol 100 will satisfy other unattended markets such as Universities, Hospitals or local and federal emergency agencies. The bioethanol from water hyacinth and anaerobic bacteria has a significant reduction in the cost per gallon of ethanol, (estimated 64%) due to use of wet biomass instead of typical dry biomass from water hyacinths. The production of ethanol in Puerto Rico will provide a real option to FFV owners and has a potential commercial value since the amount of such vehicles being produced and acquired is increasing as a result of federal and local incentives.

Key words: water hyacinth, ethanol, E85, FFV.

1. INTRODUCTION

BBFuels of PR, LLC was born from the former Boriken Bio Fuels Corp. (BBF Corp.), when one of his founding fathers, won a business plan writing competition called: "La llave para tu negocio" held in 2005, by Metropolitan University of Puerto Rico (UMET). By means of a proposal submitted to NSF, UMET's Ecoenterprise competition enables a research of new entrepreneurs for green business in an incubator system, with a collaboration of the four Technology Innovation Regions in Puerto Rico. In 2010, Mr. Johnny Lugo Vega and Mr. Jorge L. Nina Espinosa, representing BBF Corp. were one of the winners of Ecoenterprise competition, receiving \$20,000.00 to start a green idea for research and development. At the beginning of 2011, BBFuels of Puerto Rico, LLC emerged to continue the lead path for waste biomass bioethanol research in Puerto Rico. BBFuels of PR, with Biotechnology Development and Training Complex (BDTC), in Mayaguez, Puerto Rico, has carried out experimental trials in a new fermentation process in order to submit this proposal. These are three of the critical problems of the Island of Puerto Rico: 1. waste problem, 2. water quality problem because of aggressive plant (water hyacinth), 3. fossil fuel dependency and greenhouse effect.

The research innovation proposed consists of the study of endemic tropical bacteria population from three different, non-food waste biomass, and their way to development of a third generation's fermentation process for the future conversion into ethanol.

This innovation is being proposed in order to 1. Reduce the solid waste problem by capturing biomass (over 30% of landfill waste that consists of biomass), 2. Improve the quality of water by removing an aggressive plant which is one of the sources of water quality problems in Puerto Rico (water hyacinth), 3. Offer an alternative product that is less pollutant than fossil fuels at a lower cost.

The waste problem is of large proportions. According to the Solid Waste Management Authority of Puerto Rico, water hyacinths, grass biomass, paper/waste fruits and sugar food waste mixed raw materials, represent 35% of Puerto Rico's total landfill waste (4M Tons/Y). Water hyacinths negatively affect the water quality, and fossil fuel is costly. Solid waste landfills are closing by regulations of USEPA, creating a solid waste disposal crisis starting in 2011. (ADS, 2011). According to ADS data, the average solid waste generation in Puerto Rico is 4MT/Year. Market integration with biomass ethanol production will create an open market in order to deal with solid waste reduction.

The impact that this innovation could have over society consists of improving the quality of life, and environment while providing an alternative product that is less pollutant and at a lower cost than fossil fuels. This innovation would provide E85 ethanol for flex fuel vehicles which are being acquired despite there not being availability of E85 in the Puerto Rican market. It would promote the acquisition of such vehicles in order to have a lower cost alternative. Employments throughout its different phases would be created in order to research, distribute, market, etc.

At the present time the direct solution to the problem presented by the Federal and Local government consists of legislation requiring and providing tax incentives for the creation and acquisition of hybrid and flex fuel vehicles. No ethanol is being provided at the present time for such, nor being developed in Puerto Rico.

2. OBJECTIVES

The objectives of BBF are to develop model of a sustainable industry in Puerto Rico by means of bioethanol production from of Water Hyacinths *Eichhornia crassipes*. The main objective is to discover how an anaerobic fermentation process will lead towards the best conversion of water hyacinth into bioethanol, biogas and bio-products. The development of ethanol from water hyacinth of Puerto Rico will allow us to work in the future with other types of biomass (grass, paper, etc.) and the correspondent bacteria population.

3.0 MATERIALS, METHOD AND PROCEDURE

3.1 PRETREATMENT OF WATER HYACINTH

The starting protocol consists of a pretreated two cycles path of steam explosion and hot water hydrolysis for cellulose/hemicellulose breakdown of Puerto Rico Water Hyacinth (*Eichhornia crassipes*). Then, an anaerobic fermentation with a special *bacteria X* will be performed in order to obtain the best glucose/ethanol content by g/L value, measured by YSI 2700 Select. Instead of using the regular hydrolysis protocol with sulfuric acid, a modified auto-hydrolysis pretreatment followed with two round steam explosion/hot water pre-treatment will be used. This method will avoid the use of strong acids and will reduce the amount of chemical waste. Water under high pressure can penetrate into the biomass, hydrate cellulose, and remove hemicelluloses and part lignin.

3.2 BACTERIA GROWTH PROCEDURE

Bacteria X was seeded in culture in a 500mL flask (Sartorius) containing 200 mL of maintenance media at 55°C for 48hrs. Following preparation, 200 ml of the media was added into 500 ml SCHOTT - Duran GL45 Premium Glass Bottle, and autoclaved for 30 minutes at 20 psi (121 °C). After cooling to 55°C, the bottles were flushed with instrument grade N2 until media is fully reduced (color will change from red to amber) and then with CO2 for 10 minutes to obtain a concentration of approximately 10% vol / vol.

The bottles were inoculated with 10% vol/vol of a 3 day culture. Maintenance cultures were grown unshaken at 55 °C by placing the bottles in an incubator (Certomat BS-1, Sartorius). Cultures were passed every 3 days. A series of 2L batch fermentations will be done using the same media as a nutrient source.

3.3 FERMENTATION

Biostat A plus bioreactor will be used for the fermentation of the bacteria. All media reagents will be prepared in a 5L vessel and autoclaved for 30 minutes at 20 psi. After calibration pH probe will be sterilized inside the vessel while dissolve oxygen probe will be sterilized separately to obtain the 100% Oxygen calibration prior its insertion onto the bioreactor vessel. Finally vessel was inoculated with 10% vol/vol of a 3 day culture and culture was maintained unshaken at 55 °C for 3 days. After determination of the optimal conditions for bacteria x optimal growth process will be adjusted for the use of water hyacinths as carbon source to obtain as primary fermentation byproduct ethanol. For this purpose the procedure will remain the same except for the use of the hyacinths in substitution of the glucose.

4.0 PRELIMINARY RESULTS

During summer of 2011, three (3) consecutive trials showed that a low cost procedure for the digestion of water hyacinth mother liquor (WHML) can be achieve in a short period a low temperature, *bacteria x* can growth in a very simple ambient. (Figure 1A, 1B). After 10 days of trials, WHML was reacted with *bacteria x* medium for glucose/mass behavior. Preliminary results showed that it can be possible to obtain glucose/acetic acid rate in a anaerobic climate, then, convert it to ethanol by a wet chemical procedure. Future outlooks over bacteria x and WHML combination in order to obtain glucose content from WHML is still on trials.



FIGURE 1A. WH PRETREATMENT AT BDTC FACILITIES AT GUANAJIBO INDUSTRIAL PARK IN MAYAGÜEZ, PR.

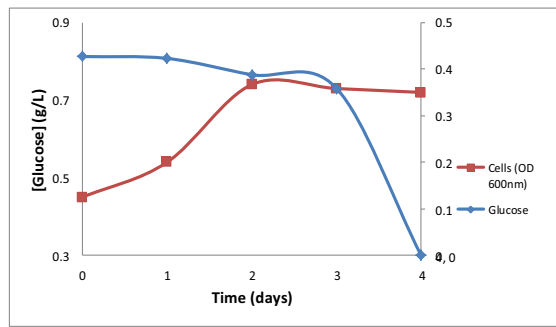


FIGURE 1B. GLUCOSE COMSUMTION, BACTERIA X GROWTH RATE

5.0 BBFUELS OF PUERTO RICO, LLC COMERCIALIZATION PLAN

BBFuels of Puerto Rico, LLC (BBF) consist in three main components. The immediately market: E100. Ethanol in Puerto Rico has a great potential market due to his geographical features. Even when we think in available space for the production of first generation biomass ethanol or different sources, (raw sugar cane, corn and Palm oil) Water hyacinths biomass has never been tested, neither in the Caribbean Basin. Our proposed project has a direct market with the production of pure 100 % ethanol (E100) and byproduct to satisfy the demand from institutions such as universities, hospitals and cleaning/sanitization industries. Secondly, E100 could be blended with gasoline in different percent rates: E10%:90% gasoline, E20%: 80% gasoline, E40%: 60% gasoline and finally E85%: 15% gasoline to achieve the Target Market: E85 & Flex Fuel Vehicles (FFV's). This last blend, E85 represents another direct market due to the flex fuel vehicles (FFV) market. There is no availability of E85 or other blends in Puerto Rico for FFV.

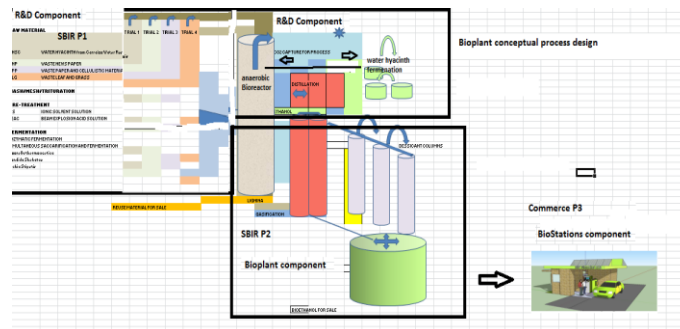


Figure 2. BBFuels of PR, LLC conceptual components and process architecture

The Diversification of the Market will be focus on Biogas, Organic Fertilizers and Furniture business. The BBF's process for bioethanol production from water hyacinths includes several materials, from raw material to final residues that will be recovered for his commercialization. Biogas from anaerobic fermentation process such as CO₂ and Methane have a special market which is non-attended at this moment in Puerto Rico while open a stimulus to the industrial sector to use biogas a low cost generated by a sustainable way. Calcium Phosphate in the form of Gypsum, could be reused to improve quality in fertilizers for damp places, whereas, all water hyacinth mother liquor and leaves stem residues will be used as a great nitrogen source for organic fertilizers and lignin and steam-roots residues used for furniture.

4.0 CITATIONS AND REFERENCE SECTION

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