Journal of Petroleum & Environmental Biotechnology

Ball et al., J Pet Environ Biotechnol 2012, 3:4
DOI: 10.4172/2157-7463.1000e107

Editorial Open Access

The "Some Sense" of Biofuels

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Over the past years, the production of biofuels worldwide has increased significantly due to concerns over the limited quantity and high environmental impact of crude oil. 2011 saw a 2.5% increase in global primary energy consumption, yet renewables still only account for 2.1% of total energy consumption [1]. Current biofuel production, primarily ethanol, has grown by the equivalent of more than 20 million tonnes of oil in the past decade [1], yet it makes up a very small fraction of the world energy sources. There is disagreement on whether biofuels are a worthy investment of research and production time and resources. Dr. Harmut Michel argues that it is nonsense to convert the solar energy into biofuel because of the poor energy capture by photosynthesis in plants, which gives as low as 0.2% energy efficiency [2]. In contrast, current solar cells have efficiencies as high as 15%, which can effectively absorb solar energy and then be stored in battery systems [2]. Furthermore, current biofuels depend mainly on crops, which may compete with food plants for agricultural land or result in removal of natural forests through conversion into oil palm plantations.

These arguments against biofuels are valid; however there are three other points to take into consideration (Figure 1).

First, the sun's light shines on the Earth whether or not we harvest it and convert it to a usable form. Thus, any conversion of the sun's energy into a usable energy from, given a net gain in energy, should be considered a positive output. Burning biomass for heating, biogas from anaerobic digestion, and pyrolysis (for biochar and syngas production) have been major renewable energy sources through human history. As long as the biofuel produced contains more energy than is used to generate it, and there is no significant increase in greenhouse gases, the biofuel is a large improvement over fossil fuels. In the production of ethanol, there are rather high energy and material costs for biomass production, in the forms of fertilizer, pesticides, transportation, and labor, biomass pretreatment, biofuel fermentation, and biofuel purification. A USDA publication lists the ratio of energy output to input at 1.34 for corn ethanol [3], while Pimentel reports that 29% more energy could be required to produce corn ethanol than the ethanol actually contains [4]. However, in Brazil, sugarcane ethanol has been shown to have an 8.3-9.3 output to input energy ratio [5,6]. This is in part because of co-utilization of bagasse for generating electricity in sugar cane mills, thus replacing fossil fuels to power sugarcane harvest, biofuel fermentation and separations. Moreover, countries like Brazil have rich fresh water resources which provide low irrigation costs, fertile land, and a majority of the electricity needs [7]. The agricultural processes are able to produce excessive and cheap crops for biofuel production without affecting national food supplies or seeking additional lands for biofuel crops.

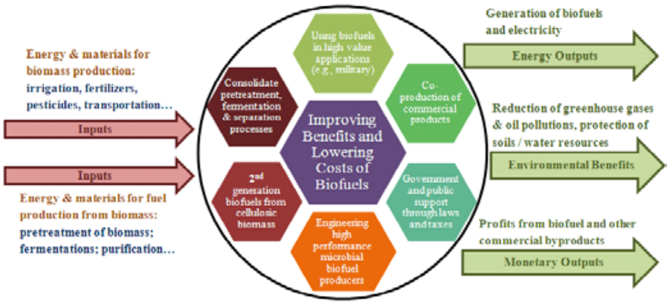

Figure 1: Cost and benefits of biofuels.

Second, there are a number of commercial benefits of biofuels that increase their monetary attractiveness. With rising oil prices, shrinking oil reserves, and the increasing cost of oil drilling, any fuel option that is not derived from petroleum becomes an emergent alternative. Furthermore, government support in the form of subsidies and taxes can help to make biofuels much more profitable. On the other hand, the biomass from crops can be used in simultaneous production with other value-added commercial products (e.g., cooking oil, sugars, animal feed stocks, etc.) and biomass-fired electricity, thus reducing the overall costs for biofuel production [8]. Aside from regular use of biofuels, there can be incredibly high value uses of biofuels by military. For example, during the military operation in Afghanistan, the United States army pays $ 400 per gallon for fuel to power trucks and tanks because of the high cost of transporting the fuel to military camps [9]. If biofuels could be produced closer to where they are needed, the military operation costs would decrease significantly.

Third, although technology limitations for improving photosynthesis, bio-hydrogen production, and micro-algae process hinder biofuel potentials, the second generation biofuels are being quickly developed to bypass these road blocks. For example, in United States, the Department of Energy has supported three bioenergy centers since 2007 (Great Lakes Bioenergy Research Center, Joint BioEnergy Institute, and BioEnergy Science Center). These research groups have focused on engineered plants (to reduce biomass recalcitrant), novel biomass pretreatment technology, and efficient microbial hosts for fermentation process. Genetically modified microorganisms and plants are continuously reported as successful in laboratories. It is possible that some new biological systems could move out of laboratories and be widely applied on a large industrial scale. With global efforts to

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Received June 21, 2012; **Accepted** June 22, 2012; **Published** June 24, 2012

Citation: Ball M, Chen R, Tang YJ (2012) The "Some Sense" of Biofuels. J Pet Environ Biotechnol 3:e107. doi:10.4172/2157-7463.1000e107

study second generation biofuels, the near future sees the utilization of cellulosic biomass (such as switch grass) for fuel production. Significant benefit outputs can be further achieved when biomass pretreatment, fermentation, and separation processes are integrated and consolidated in industry.

Finally, political decision plays important roles in successful biofuel industry. For example, during the oil crisis of the 1970s, Brazil could not afford to continue powering the country on imported oil, and thus began full support for sugarcane ethanol. Proalcool (Programa Nacional do Álcool) was implemented in 1975, which required the production of 3.5 billion liters of ethanol by 1980, implemented large subsidies for farmers and producers, and initiated an agreement between automobile manufacturers and the Brazilian government to produce cars to run on ethanol alone [10]. Large-scale sugarcane cultivation reduced production cost in Brazil. Sugarcane mills are designed to produce both sugar and ethanol from the same batch of sugarcane. The first purifications of the sugarcane go to produce a high quality sugar, while the remaining juice is fermented to produce ethanol. Depending on the market, either more sugar or more ethanol can be made to maximize the manufacturers' profits. Currently, most cars in Brazil are flex fuel, and can use any mix of ethanol and gasoline. In September of 2007, 86.3% of total automobile sales in Brazil were of flexible fuel vehicles [11]. The example of Brazil sugarcane ethanol industry is one that indicates the importance of an energy solution based on the needs and natural resources of a particular country as well as the long-term government support.

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