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Examining the potential for liquid biofuels production and usage in Ghana

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ABSTRACT

The perennial political and social upheavals in major oil-producing regions, the increasing energy demand from emerging economies, the global economic crisis and even environmental disasters, like the recent major oil spill in the Gulf of Mexico, all contribute to price fluctuations and escalations. Usually price instability affects the least-developed countries with the most fragile economies, like Ghana, the most. This paper gives a brief overview of the Ghanaian energy situation, describes the liquid biofuel production processes and examines the possibility of replacing some of the fossil fuels consumed annually, with locally produced renewable biofuels. Various scenarios for substituting different portions of petrol and diesel with biofuels derived from cassava and palm oil are examined. Based on 2009 crop production and fuel consumption data, replacement of 5% of both petrol and diesel with biofuels would require 1.96% and 17.3% of the cassava and palm oil produced in that year, respectively; while replacement of 10% of both fossil fuels would need 3.91% and 34.6% of the corresponding biofuels. Thus while petrol replacement could be initiated with little difficulty, regarding raw material availability, biodiesel would require enhanced palm oil production and/or oil supplement from other sources, including, potentially, jatropha. An implementation strategy is proposed.

1. Introduction

Although commercial quantities of crude oil have been found off the west coast of Ghana and the country started low-volume oil production at the end of 2010, the quest for alternative sources of fuel cannot be abandoned. Because of the multiplicity of factors that go into this exercise and its complexity, there is little agreement on the predicted peak production and subsequent permanent decline of world crude oil supplies. While some industry experts predicted world oil supply to have peaked by now, most studies expect this to occur between now and 2040. A few analysts even put the occurrence of this peak in the next century (Wells, 2007). However, everyone is in agreement on one thing—that oil is finite and that the difficulties associated with making it available are such that sovereign nations need to find alternatives. The low-hanging fruits have all been virtually plucked, and new oilfield discoveries are made at high costs under deep-sea beds. The price of oil is therefore not expected to go back down to the low levels experienced in the eighties (Campbell, 1997; Campbell and Laherrere, 1998; Drapcho et al., 2008; Ivanhoe, 1995; Youngquist, 1998; Wells, 2007).

Recent energy policy developments in industrialised countries, especially in the United States, point to a bright future for alternatives to fossil fuels. Although other energy technologies are in active development for running automobiles such as fuel cells, hydrogen gas and batteries, these alternatives have serious drawbacks, compared to biofuels, in terms of their raw material sources or adaptability of their technologies to local infrastructural conditions. Biofuels, especially, are unique for developing economies because they are tied to agriculture and therefore their raw material needs can be met locally. For a developing country like Ghana, the jobs that would be created in the agricultural sector and the increase in the income of farm owners and workers are perhaps the most significant gains. Brazil, Nigeria, South Africa, Indonesia and even the western neighbour, Ivory Coast, all expect to generate millions of direct jobs in connection with their biofuels projects (Biopact, 2006). The Greenpeace estimates that 8.5 million jobs could be created in the global economy by 2030, if governments were committed to switching from fossil fuels to renewable energy. By this same time, they also expect the world to meet 35% of its energy needs from renewable sources (Teske et al., 2007). In addition to their job-creating potential, biofuels have the ability to mitigate some undesirable effects of fossil fuels production and use, including conventional and greenhouse gas (GHG) pollutant emissions (US EPA, 2010).

Since the shock of the Arab oil embargo of the seventies, various countries have put in place policies to reduce their dependence on imported crude oil. Brazil has led the way, generating 46% of its total energy requirements from renewable sources, mainly biofuels, in 2007 (Biopact, 2008). From 2007, all

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diesel sold in Malaysia contained 5% biodiesel derived from palm oil. The Malaysian government is also expanding the production of palm oil in an attempt to target the European Union, which has decided to replace 10% of its transport fuel with biofuels by 2020 (EU Communication, 2007). The first biodiesel plant in Australia was opened in Darwin in November 2006 to produce 140 million liters of biodiesel annually, and more have since been added. The US government has also put forth numerous legislations in the last decade to promote the use of biofuels. These include the Energy Policy Act, the Volumetric Ethanol Excise Tax Credit and the Volumetric Tax Credit for Agri-diesel, all enacted in 2005. In December 2007, the American Congress also passed the Energy Independence and Security Act (EISA), a legislation that requires a step up in the production and use of ethanol and other liquid biofuels from 9 billion gallons in 2008 to 36 billion gallons in 2022 (Gaffigan et al., 2009).

The production and use of biofuels is not all good news, however; as with all energy sources there could be a dark side to them. They could produce adverse effects on the environment, including land and water resource depletion, air and ground water pollution, and also lead to increased food costs. On an energy-equivalent basis biofuels can emit even more GHGs than some fossil fuels, depending on the raw material used and the production process (US EPA, 2010). International NGOs have raised a lot of concern about the clearing of tropical rainforests in Indonesia for the cultivation of palm oil and there is the fear that it could do more harm than good, in terms of climate change (Friends of the Earth, 2006; Jessen, 2007). Therefore like any new technological innovation they would have to be properly managed to make them beneficial to society.

The focus of this work is on the substitution of portions of the automotive petroleum fuels used in Ghana with fuel alcohol and biodiesel produced from cassava and vegetable oils, respectively. Fuel alcohol basically refers to dehydrated ethanol, and it can be produced by the hydrolysis of cassava starch, followed by fermentation and distillation of the resulting broth. Biodiesel, on the other hand, is the product of a reaction between vegetable oils, animal fats and alcohol, usually methanol, which also produces glycerol as a by-product.

1.1. *The Ghana energy scene—a brief overview*

According to the Energy Commission of Ghana, the country's total energy consumption for 2008, the highest on record, was 10,715 kt of oil-equivalent. Of this amount, a hefty 76% was fuel from wood, mainly charcoal and firewood, while 17% and 7% respectively came from petroleum and electricity. As the rural population drifts inexorably toward the urban areas, each year the proportion of charcoal used in the energy mix also increases. Currently, charcoal constitutes 45% of the wood fuels used, but the percentage is expected to climb steadily, unless something is done to reverse the trend. The Energy Commission estimates that only 10% of urban dwellers use means other than charcoal for cooking (Ofosu-Ahenkorah et al., 2008).

Electricity is obtained from hydro and thermal sources. Ghana currently has two main dams, Akosombo and Kpone, with installed capacities of 1020 MW and 160 MW, respectively. A third dam, with a capacity of 400 MW, is under construction at Bui in the Brong Ahafo region on the Black Volta River. The new dam, being built as part of economic cooperation between the Chinese and Ghanaian governments on several fronts, have raised concerns about the destruction of the habitat of some endangered species and the advisability of putting up such a structure on a river with seasonal high and low water levels. While construction continues on the Bui dam, feasibility studies have been initiated on the development of hydroelectric power at various sites in the Volta River Basin and the Oti River (*Daily Graphic*, July 15, 2010).

Installed capacity for thermal power generation as at 2008 was 831 MW, giving a total capacity of 2011 MW. When it is in operation the aluminium smelter, VALCO, consumes over 30% of the electricity generated in the country. Plans to set up an integrated aluminium and steel industries mean that more power is going to be needed, and indeed an ambitious scheme to increase total power generation from current levels to 5000 MW in the next five years has been announced (*GTV News*, July 15, 2010). Ghana is part of the West African Gas Pipeline project, WAGP, along with Nigeria (the gas supplier), Togo and Benin. With an installed capacity of over 700 MW along the coastal areas, and the entry of private power generators like Asogli Power with a capacity of 200 MW into the mix, the country hopes to take advantage of the cheaper natural gas from Nigeria's delta oilfields to produce power at a lower cost than using crude oil. The WAGP project, which was delayed by several years, (Asante, 2004; Ofosu-Ahenkorah et al., 2008), finally starting delivering free-flowing gas at the end of 2010 for trials. This gas is currently in use at the Aboadze thermal plant, and it is expected to be used also by Asogli Power in Tema when it is eventually pressurised to the desired levels.

While the future looks bright for the country in terms of electricity generation major challenges still persists in this sector, especially in the area of power transmission. At a coverage of 66% nationwide, this means that about a third of the population still do not receive electricity and those who do, experience frequent power outages. Ninety percent of rural dwellers still get their lights from kerosene lamps. Also on the average, over 25% of the electricity generated is lost through technical and commercial lapses (Ofosu-Ahenkorah et al., 2008). Comprehensive plans exist at the energy ministry to solve these problems, but implementation has been sluggish.

Production of liquid biofuels would mainly affect the 17% of the total energy component, which comes from petroleum products. According to the Bank of Ghana, in 2008 the country imported US$2349 million worth of crude oil and refined petroleum products (Ghana Statistical Service, 2010). (The capacity of the country's only refinery can no longer meet the demands of the economy). To mitigate the continued depletion of the tropical forests, government has sought to promote the use of liquefied petroleum gas (LPG) using subsidies, but supply has been rather erratic and the benefits questionable. In 2006, the Energy Commission, the national agency responsible for energy policy formulation, published a detailed Strategic National Energy Plan in four volumes (SNEP I–IV), which charts a road map for energy provision for the country, including biofuels, from 2006–2020. There is no shortage of ideas, adequate funding has been the perennial problem.

2. Petrol replacement

Cassava can be grown on lands of marginal quality in the tropics (FAO, 1977), and considering its easy availability and affordability in Ghana, it is only logical that ethanol be produced from this crop. Commonly available local species of cassava such as *afisiafi* and *abasafitaa* have a starch content of between 19% and 25%. It has been reported that species containing as high as 40% starch have been developed by researchers at the International Institute of Tropical Agriculture, IITA, in Ibadan, Nigeria and elsewhere (Babaleye, 1996). Cassava production trends in Ghana from the year 2000–2009 and the land area on which the tuber is cultivated from year 2005 (the first year in