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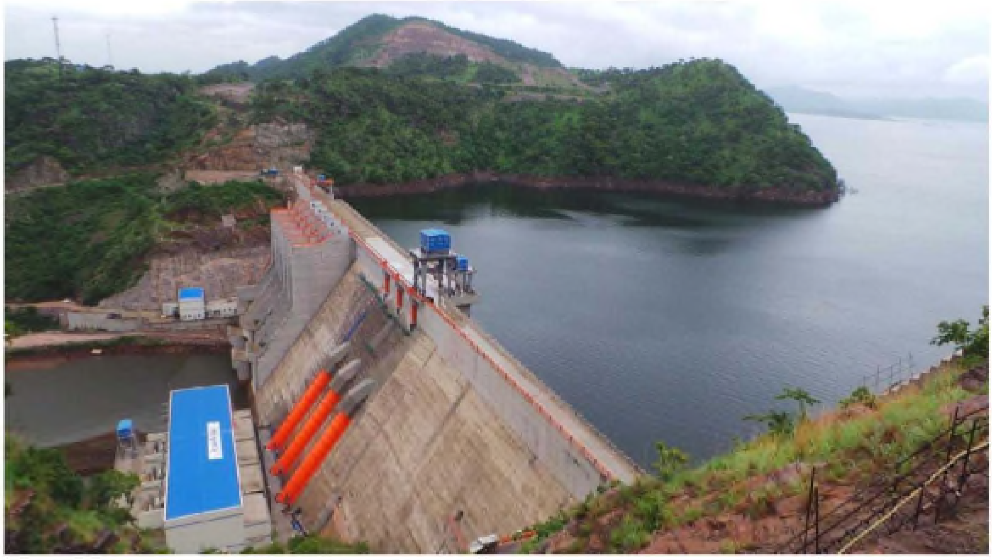

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PILOTING BIOFUELS USAGE IN THE TRANSPORTATION SECTOR OF GHANA

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ABSTRACT

The advantages and disadvantages of using liquid biofuels in automobiles are quite well-known, and a country that decides to benefit from these fuels also has to deal with their disadvantages. On the positive side of the balance sheet, they are renewable, they could create many jobs in an economy and they could reduce the global-warming contribution of fossil fuels used in transportation. On the negative side, they contain less fuel per unit volume, they usually cost more compared to the fossils, they require land which could otherwise be used for food cultivation and their production could also affect biodiversity, water quality and availability. For Ghana the strongest pull towards liquid biofuels usage may come from economics. The on-going power crisis has also undermined the reliability of traditional energy sources. This paper is a follow-up to an earlier publication in which a broad examination of the potential for the introduction of biofuels into the energy mix of Ghana was done. Here an implementation plan is presented, and a budget is also proposed for the pilot phase. An amount of US$1.56 million is estimated for the first year of pilot operations, with a total three-year requirement of US$2.66 million.

Keywords: *LIQUID BIOFUELS; PILOTING; BIODIESEL; BIO-ETHANOL; GHANA ENERGY SCENE*

1. 0 INTRODUCTION

A significant proportion of the annual budget of Ghana is spent on the importation of petroleum products. In 2008, for example, the total petroleum imports of US$2,349.2 million constituted 22.9% of the total national import bill, and as at 2011, the figure was around US$3,615 million, constituting 19.8% of the total national import cost (World Bank, 2015; IMF, 2015). The oil reserves found off the west coast of Ghana are therefore timely, considering the enormity of our development needs. Perhaps this is also the time, for reasons of affordability, to pursue in earnest the process of introducing renewable energies into the national energy mix. Although a 10% proportion for renewable is projected by 2020 (EC, 2010), at the current level of less than 1% of the total national consumption, a lot needs to be done if this target is to be achieved.

The replacement of fossil fuels with renewables could be beneficial for many reasons. For a developing country like Ghana, two reasons stand out: first foreign exchange could be conserved if indigenous, renewable sources are used, and secondly many jobs could be created in the economy in the process. The energy sector is unique in that it has a ready market. Whatever energy is produced, whether in the form of liquid fuels for use in vehicles or electrical power for connection to the national grid, the market, in principle, has the ability to absorb it. According to the Ghana Energy Commission (EC, 2014), grid electricity coverage, for example, currently stands at 76%, weighted from the individual percentage coverage of the ten regions, and the demand for electricity increases by 10% each year. Government, having difficulties with job creation, could therefore look at this sector seriously.

According to the CIA World Factbook (CIA, 2014), Ghana ranks forty-fifth on the list of proven oil reserves by countries, based on 1 January 2014 estimates, with 660 million barrels. When the oil reserves off the west coast of the country was first announced by the oil firm Kosmos in 2007, it was stated that the reserves were estimated at 600 million barrels. Since then new discoveries have been announced, and the estimates have been revised upwards, putting the country's oil reserves, as at 2014, at 876.7 million barrels and 2.3 tcf of gas, according to the Ministry of Finance (MoF, 2015). Tullow Oil Ghana Ltd, the British oil production company, initially announced that it hoped to level off production at a rate of 120 thousand barrels per day by the end of 2011. Beset with various technical and other problems the company has not yet achieved this target, and it is currently producing at a rate of 103,000 bpd from the Jubilee field.

Assuming, for the sake of analysis, that the proven oil reserves in Ghana are two billion barrels, and also that the production rate is not levelled off at 120 but at 200 thousand barrels per day. This means that the oil reserves would run out in less than thirty years. This further means that the country's membership of the club of oil-producing countries could be short-lived, although the future of gas production is brighter. Ghana is one of the oil-producing countries that still imports most of its petroleum needs and exports all the crude produced. (Although the country has one petroleum refinery, the capacity is below the national demand and it is often shut down.) The country is therefore vulnerable to external oil price fluctuations which can impact on the local pump price, and hence on the economy.

As we write, the country is currently going through a serious energy crisis, which has dealt a major blow to the economy. A load-shedding arrangement which sometimes alternate 12 hours of power with 24 hours of outage, has forced policy makers to take a hard look at energy mixing, and liquid biofuels are looking attractive as one of the components in this mix.

Table 1 gives the historical trends in the price of premium gasoline (*Super*) published by the National Petroleum Authority (NPA) for every other year-ending starting from 1992 (NPA, 2015). The ex-pump price - that is the price that motorists pay at the filling station - varied from a low of $1.43 per gallon in 1998 to a high of $5.99 in 2013, using the currency conversion rates provided by the NPA. Since year 2006, a gallon of petrol has always been higher than $3; this in a country with a per capita income of $1,858 for 2013 (World Bank, 2015). At the end of 2014, the figures for *Super*, gave a price tag of $6.67 per gallon of 4.5 litres, compared to a national 2014 US average of $3.367 (EIA, 2015), a country with a per capita income of $53,042 (World Bank, 2015). Thus, Ghanaian motorists are paying far more than their richer American counterparts, for the same amount of fuel.

It is significant to note, looking at the table, that the proportion of tax revenue derived from the sale of premium gasoline (*Super*) has declined considerably from a high of 56% in 1994 to 10.0% in 2013. This tax rate for *Super* is higher than the corresponding rate for diesel, which was determined to be 5.86% for the end of 2013. (In the 90s, taxes, as a percentage of ex-pump price was always higher than 40%). Up until November 2014 kerosene, premixed fuel for fishing and liquefied petroleum gas for cooking were subsidized outright by government.

The tight corner in which the government finds itself with regard to petroleum revenues is apparent. If Ghanaian motorists are paying more for fuel than motorists in America who have average individual incomes of about thirty times that of Ghanaians, then it becomes difficult for government to justify further increases in local prices, in spite of the subsidies. Although the decrease in world crude oil prices has brought some relief to the government in terms of the subsidies, the benefits have been mixed: the government of Ghana has also lost revenue from the oil the country produces and exports.

Table 1: Selected historical premium gasoline price variations (per gallon)

Year ending	Ex-pump (US$)	Ex-refinery as % of ex-pump price	Taxes, as % of ex-pump price
1992	2.50	34.6	53.7
1994	2.05	34.1	56.1
1996	1.83	45.9	42.4
1998	1.43	42.2	40.2
2000	1.56	62.6	27.2
2002	1.45	60.4	29.1
2004	2.31	50.7	36.4
2006	3.81	50.6	35.4
2008	3.09	48.3	33.8
2010	3.60	72.0	13.6
2011	5.11	74.8	12.5
2012	4.08	72.8	12.8
2013	5.99	75.1	10.0
2014	6.67	67.4	20.4

Source: NPA (2015), Accra, Ghana

According to the Ghana Energy Commission, 52.2% of what they describe as 'dependable' installed electricity generation capacity in the country is obtained from hydropower sources. The energy crisis that the country is currently going through, at a time when the price of crude oil on the world market is at its lowest in decades, shows that it takes more than price rise to create havoc in the energy sector of a country. The rainwater going into the dams may be less than expected, accidents could occur on the plant (and they have), fuel supplies may be disrupted, and so on. The need for energy diversification has always been part of the national plan, but investments in the production and use of renewable fuels has been lacking. Lately, renewables, especially solar, are finally receiving some long-overdue attention. Nuclear energy development, which was started in the 1960s but was abandoned later, is being seriously talked about again.

The fact that the ingredients for biofuels would be produced locally makes them amenable to local control, as opposed to imported fossil fuels. Biofuels for vehicular use, while they would not solve all the nation's energy needs, should be given serious attention not only to create jobs and stimulate the Ghanaian economy, but also to serve as an energy fallback for a day of national energy emergency.

2. 0 METHODS

The purpose of this paper is to bring up, discuss and quantify - where possible - the issues that a developing country should expect to confront if it decides to embark on a biofuels utilization programme, using Ghana as a case study. The production methods for the biofuels themselves are briefly touched on, but the financial requirements and issues which need to be considered carefully, as part of the implementation programme, are given expanded treatment.

2.1 LIQUID BIOFUELS PRODUCTION

Although new technologies are under development for biofuels production, commercial quantities are still obtained using low and old technologies which are within the reach of developing countries. Detailed description of the processes for the production of fuel ethanol and biodiesel for petrol and diesel replacements, respectively, have been given elsewhere (Afrane, 2011). An abbreviated version is given here.

2.1.1 Ethanol Production

In principle, the production of fuel alcohol can start from any material that contains sugars or can be converted into sugars. Crops like maize and cassava present the best option, in the initial stages of a local biofuels programme because of availability, and cassava is the selected candidate for Ghana because of its cheaper cost. Other potential feedstocks include sugarcane and palm wine, (a naturally occurring weak alcoholic drink derived from the palm tree), which are however not available in the desired quantities in Ghana for use as starting feedstock. The processes for the production of ethanol from cassava starch are well-understood (Grace, 1977). Starch slurry of pH 6.0-6.5 is heated to 95^oC to break the large molecules into simple sugars through the process of hydrolysis. The hydrolysis could proceed with acids or enzymes, and it occurs in two stages: the first stage is liquefaction during which α-amylase is typically used; and the second stage is saccarification, using glucose-producing enzymes. While liquefaction takes about two hours, the glucose-producing stage takes longer - about 40 hours - at a pH of 4-4.5 and a temperature of 60°C.

The sugars formed during the hydrolysis stage are converted into ethanol by fermentation, using yeasts at temperatures not exceeding 32ºC. A pH range of 4.8-5.0 is used to produce a broth of not less than 10% wt ethanol, with little impurities. This requires a careful control of all the parameters associated with the process such as feed concentration, temperature, pH and duration of fermentation. After initial distillation to reach the intermediate azeotropic concentration, the product undergoes further dehydration to obtain fuel alcohol. Molecular sieves are commonly used for dehydration (Basta and Basta, 1998).

2.1.2 Biodiesel Production

Biodiesel is an agricultural fuel which can be used in diesel-powered vehicles. The feedstocks for its production include palm oil, rapeseed oil, sunflower oil, soya bean oil, jatropha oil and animal fats. The oil palm has been of interest to biodiesel advocates for a number of reasons including its availability and affordability, but particularly its yield. Modern well-managed farms can produce 20 tonnes/ha of palm bunches per year. From the fresh fruit bunch (ffb) a yield of 21-23% oil can be obtained (Poku, 2002). Biodiesel can be produced by reacting heated vegetable oil or fats with hydrogen to produce a hydrotreated vegetable oil, HVO, also known as renewable diesel fuel. A more common process is to react the oil, triglycerides, with an alcohol, in a process known as transesterification. The HVO process removes hydrogen from the triglycerides and processing plants are normally integrated with existing oil refineries. Although the process produces a higher quality fuel, in terms of its emissions, deposit formation, storage stability and ageing of engine oil, the setup is more expensive than the alternatives (Aatola et al. 2008).

The transesterification process is generally accepted as the most appropriate way to produce the fuel because of its simplicity and cheaper cost, compared to hydrotreating. While any alcohol could be used, methanol is chosen as the favoured reactant because of its lower price. It has also been demonstrated that the alkali-catalyzed reaction is faster than those catalyzed with acids (Crabbe et al., 2001). Using five times the methanol required by stoichiometry to react with the oil, and a temperature of about 70^oC, a yield of up to 87% of oil to biodiesel can be obtained. A two-step process has been developed which can give a biodiesel yield of 98% or higher (Lu, et al. 2009).

2.2 ENERGY BALANCE AND USE OF BY-PRODUCTS

The energy balance of biofuels examines the ratio of energy obtainable from a given quantity of renewable fuel to the energy content of the fossil fuel used to produce the given quantity. Energy is input at the feedstock cultivation stage, during harvesting, transportation to processing plants, at the processing stage itself and finally at the sales point. The energy balance of the process tends to improve with time, as experience is gathered.

von Blottnitz and Curran (2007) have reviewed the literature on the production of bio-ethanol from biomass. Available data indicate that the bio-energy ratio is generally positive, and that between sugar-based and starch-based feedstock, the former performs better; which is not surprising considering the energy-demanding hydrolysis stage required by the latter. For the US corn-based programme a ratio of 1.3 is cited, one of the lowest reported. It must be noted however that the average US farmer uses a lot of machinery in the cultivation of crops. Ghana, with a labour-intensive cultivation stage, should be able to do better with the energy balance. Studies on palm oil and jatropha have reported favourable energy balances (Angarita et al, 2009; de Souza et al, 2010).

All the biomass used for fuel production leave behind a by-product that could be used for other useful purposes. For example, sugarcane produces bagasse and molasses, while the palm fruit produces shells, seeds and fibre as by-products which can be used for fuel production. Cassava and jatropha, as feedstocks, will give by-products which could be used as animal feed and fertilizer respectively. Also, the stillage from cassava-to-ethanol production has been used for the production of biogas for use as fuel (Nguyen and Gheewala, 2008). While some of these by-products do not contribute towards the total energy content, they can improve the economic viability of the biofuels programme.

3.0 DISCUSSION OF ISSUES RELEVANT TO IMPLEMENTATION

A national biofuels programme has to start with a pilot phase. Two options are open to policy-makers at the outset in setting up the programme: either land is acquired at a suitable location and all the structures and facilities needed for a permanent Biofuels Centre are built or the pilot project is attached to an existing institution which can provide some of the personnel and facilities required for the project. Each option has its positives and negatives. A national Biofuels Centre would provide a permanent location for research and development into renewable fuels, just like the various branches of the Council for Scientific and Industrial Research. This would be capital intensive, however. The other option would of course be cheaper, easier and faster to initiate, but additional funds would still be needed. Oil-marketing companies will be expected to build on the results generated from the pilot phase for commercialization. In this paper, the latter position is adopted as basis for analysis because of the lower initial financial requirement.

3.1 MANAGEMENT OF THE BIOFUELS PROGRAMME

Liquid biofuels are currently not in commercial use in Ghana, and therefore activities related to the industry will be new to most agencies of government when the implementation of the programme begins. The industry, as part of the all-important energy sector, is expected to grow into a major segment of the economy, if properly managed. It is proposed that a dedicated unit be set up under the Energy Commission to coordinate the activities of the agencies that will play a role in the implementation plan as outlined in the Draft Bioenergy Policy of the Energy Commission (EC, 2010).

3.2 PERSONNEL

A full-scale integration of biofuels into the automotive fuel mix will have to be preceded by a number of years of production and marketing trials. The key personnel that would be needed for this phase, going with the option of attaching the project to an existing institution, would be:

Project Administrator: The Project Administrator, based in Accra, would be an experienced administrator with scientific or engineering background and proven leadership abilities, who would be the face of the programme and who would lead all aspects of it, including legal, political, marketing, interaction with the media and the public, as well as with other relevant government departments and agencies.

Project Manager: The Project Manager will have technical knowledge of the field of renewable energies in general, and biofuels in particular. He will be responsible for the day-to-day running of the pilot project office.

Mechanical Engineer: The Mechanical Engineer will oversee the selection and operation of the various machines that will be used for the production of the fuels.

Automotive Engineer: The Automotive Engineer, who will be a key personnel on the project, will be responsible for monitoring the performance of the automotive engines that will be used for the project.

Process Engineer: The Process Engineer will design all the production equipment and oversee the processes that will lead to the production of both fuels – bioalcohol and biodiesel.

Agriculturalist: The Agriculturalist will work with farmers to optimize the cultivation and harvesting of the crops that will be used for the production of the biofuels during the pilot phase and beyond. Various national research institutions like the Crops Research Institute, the Forestry Research Institute of Ghana, both in Fumesua, the Soil Research Institute, Kwadaso, the Oil Palm Research Institute, Kade have all accumulated a wealth of knowledge which can be sourced for the development of the programme. The Agriculturalist will be in the best position to access and use this body of knowledge.

Business Development Manager: The BDM will handle interactions with the public, drivers, oil marketing companies and other relevant bodies, which will be needed in the course of the pilot programme. He/she should also have a scientific background.

Project Accountant: The Project Accountant will be responsible for managing the finances of the project.

3.3 EQUIPMENT AND FACILITIES

Because of the need to promote job creation, small-scale processing of feedstock should be encouraged nationwide. Palm oil - a potential feedstock for biodiesel - is already produced by many women-dominated cooperative groups in the rural areas, and it will be beneficial, from the socio-economic point of view, to promote the creation of more cooperative groups for the extraction of oil from jatropha seeds and production of cassava chips, across the country.

The cassava tuber has to be peeled, cut into pieces and dried before conveying to the ethanol production plant; the jatropha seed has to be dried, milled and the oil extracted by mechanical expression and, subsequently, liquid extraction; palm fruits have to be cooked, and the soft outer covering containing the oil, mechanically separated from the kernel, boiled in water and the oil skimmed from the surface of the mixture. The equipment needed for each production line generally depends on the level of sophistication of the production process. In a small-scale operation, the main equipment that would be used in processing are presented in Table 2.

Table 2: Equipment required for the processing of various kinds of feedstock

Feedstock	Required Equipment
Cassava	peeler, cutter, drier, miller, heated liquefaction tank, heated hydrolysis tank, fermentation unit, distillation unit, dehydration unit, storage tanks
Jatropha	miller, mechanical screw, strainer, heated reactor, storage tanks
Palm fruit	miller, cooker, strainer, storage tanks

As an indication of the low technological state of the country, there are no modern public machine shops that the authors know of where anything but the most basic industrial fabrication can be done. The Gratis Foundation workshops, the Suame Intermediate Technology Transfer Unit (ITTU) centre and the Rural Technology Facilities established under the Rural Enterprises Projects of International Fund for Agricultural Development (IFAD), have the capability to deliver most of the basic equipment needed; others, like the distillation and dehydration units, are best imported. As part of this preparation phase the team should ensure that the capability for making such units locally is developed. Process engineers will have to make a detailed design of all the equipment needed for the various production processes before fabrication or purchase.

3.4 JOB CREATION ESTIMATION

For a developing country like Ghana, job creation is perhaps the biggest incentive for the development of biofuels. It has been estimated that biofuels require 100 times more workers than fossil fuels to produce the same amount of energy (Meyer, 2010; DME, 2007). At a penetration of 2%, constituting 400 million litres of fuel alcohol based on sugar cane and sugar beet, South Africa hopes to create 25,000 direct jobs without affecting food security. At this level of penetration an investment of about $60 million is projected annually over a 5-year period. The Nigerian National Petroleum Corporation estimates that its public-private biofuels programme, which is to be based on the Brazilian model (which has been estimated to be responsible for 700,000 to 1,000,000 jobs and for the transformation of the rural economies of Brazil, will create 200,000 jobs in Nigeria (Meyer, 2010).

A 5% penetration of biofuels in Ghana would translate to 47.4 million and 77.4 million litres of fuel alcohol and biodiesel respectively, based on 2013 consumptions, giving a total of about 125 million litres of biofuels. Based on the South African projections, and assuming the same level of technology or lower, Ghana could create up to 10,000 direct jobs with 5% penetration. The Draft Bioenergy Policy for Ghana sets a target of 10% by 2020 and 20% by 2030, which would translate to 20,000 to 40,000 direct jobs respectively (EC, 2007). There is the potential for biofuels exportation throughout the sub-region, especially to the northern Sahelian countries, where water resources may not be able to support such a project. This would further enhance the job creation potential. The active support of government will be needed, as is done everywhere, for the success of this objective.

3.5 LOCATION OF THE PROJECT

Three institutions can be cited in the country with the capacity to host this project if existing facilities are to be used. These are the Koforidua Technical University in Koforidua, the Kwame Nkrumah University of Science and Technology, KNUST, in Kumasi and the Industrial Research Institute of the Council for Scientific and Industrial Research, Accra. Koforidua Technical University has a Department of Energy System Engineering and runs a programme in Renewable Energy. The Technical University also has an Automotive Engineering Department with modern equipment supplied by the Netherlands Government through NUFFIC, their overseas development agency. Some members of their staff have also been trained at home and abroad as part of the Dutch government support to the school. A five-storey structure under construction for the School of Engineering can provide some of the space needed for the project. Since the programme would be run under the auspices of the Ministry of Energy and all the relevant institutions are located in Accra-Tema area, Koforidua would have the advantage of proximity. A school farm near Okorase could supply some of the raw materials needed for the project. The full complement of skilled personnel may however be lacking.

KNUST, as the leading technology university in the country, has more academics and researchers experienced in running projects. They also have some facilities to contribute to the project in the College of Engineering, for example an automotive workshop. There is also an Energy Research Centre, which has pooled together expertise from various departments of the college, and also a new programme in Renewable Energy has been introduced. New structures going up in the college could provide some space for the project. It would however be the farthest removed from Accra, the centre of administration.

The Industrial Research Institute has a small unit which has been active in the area of biofuels research for some time. They have organized various workshops in this area over the years. Due to their proximity, they can pull expertise from various institutions in the capital. A modern automotive workshop and space for the project, which the others have, may not be available here.

At the commencement of implementation, the responsible agency should conduct a tour of the three facilities cited above, and any others they may have in mind, before making a decision on where to locate the project.

3.6 GOVERNMENT SPENDING AND PRICING

A comprehensive policy on pricing and production targets needs to be put in place for the proper development of the biofuels industry. Some levels of tax exemption will be needed by producers at the beginning. Crop producers should be given fixed prices regardless of the world price of crude oil. An important aspect of the biofuels programme will be the financial contract between farmers and biofuels producers and between producers and the oil marketing companies. The contract must come with an obligation to supply approved crops grown only on designated lands. Feedstock and biofuels should be bought at prices which would ensure the long-term viability of the programme. In particular, the prices at which biofuels producers buy crops must be the same as that paid by food merchants. Failure to do this contributed to the collapse of the Bawdjiase Ayensu Starch factory, a government-sponsored starch-producing factory in the Central Region of Ghana.

For the advanced biofuels programme of Brazil, ethanol production is profitable at an oil price of $45/bbl, while for the South African case, a price of $65/bbl is estimated for an economically viable production (DME, 2007). For a beginner nation like Ghana, and considering a starch-based feedstock like cassava for ethanol production, a crude oil price of between $70-80/ bbl would be a realistic range for profitability. In its five -year biofuels development programme, the government of South Africa hopes to spend R4 billion (over US$500 million) to achieve a penetration of 2% and create 25,000 jobs (DME, 2007). With a smaller economy and lower energy demand, Ghana should expect to spend less, and a commitment of US$100 million over five years or US$20 million per year should be in order.

4. 0 PROJECT BUDGET

A proposed budget, with four thematic areas, is presented for the project, taking into consideration some local practices and conventions. The four groupings considered are human resource requirements, travel costs and allowances, equipment and supplies, and other costs and services – a catch-all group. Estimates for the first year and for the three-year duration of the entire project, are provided.

4.1 HUMAN RESOURCE ALLOCATION

Salaries in Ghana are reported in three parts: a basic salary, the gross salary – which includes applicable allowances – and the net salary, which results after all applicable deductions, like taxes, pension contribution, etc, are made. The emolument figures are given in Table 3.1, and they represent the total burden on the budget, whatever it is called, due to that established position. The roles of the key personnel listed in the budget, are given under '3.2 *Personnel*' above. Provision has been made for 'Head of Institution' and some of his staff in the budget because the head of the host institution - if the project is attached to an existing institution as discussed above - and some of his staff, will play a facilitating role in the work of the project team. A little monetary inducement will be necessary to ensure their cooperation.

4.2 TRAVEL COSTS AND ALLOWANCES

The cost of travels and the personnel allowances associated with it are both given in Table 3.2. Project staff will travel to various towns and cities for procurement, meetings, seminars, workshops and others. The personnel will be paid allowances so that they would be able to cater for their living expenses while away from home. The use of project vehicles will also incur some costs, mainly fuel.

4.3 EQUIPMENT AND SUPPLIES

For an ethanol production unit capable of producing

Table 3.1: Human resource requirements					
Item	Unit	No. of units	Unit rate (US$)	Total cost (per month) (US$)	Total cost (3-year) (US$)
1.0Human Resources					
1.1 Technical					
1.1.1 Programme Administrator	Monthly	1	3,500	3,500	126,000
1.1.2 Programme Manager	Monthly	1	3,000	3,000	108,000
1.1.3 Head of Institution, staff	Monthly	1	1,000	1,000	36,000
1.1.4 Process Engineer	Monthly	1	2,500	2,500	90,000
1.1.5 Automotive Engineer	Monthly	1	2,500	2,500	90,000
1.1.6 Laboratory Technician	Monthly	2	1,000	2,000	72,000
1.1.7 Laboratory Assistant	Monthly	2	800	1,600	57,600
1.2 Administrative					
1.2.1 Project Accountant	Monthly	1	2,500	2,500	90,000
1.2.2 Business Development Mgr	Monthly	1	2,500	2,500	90,000
1.2.3 Administrative Assistants	Monthly	3	500	1,500	54,000
1.2.4 Clerk	Monthly	2	300	600	21,600
1.2.5 Driver	Monthly	2	250	500	18,000
1.2.6 Cleaner, messenger	Monthly	1	200	200	7,200
1.2.7 Labourer	Monthly	2	200	400	14,400
1.2.8 Security	Monthly	2	200	400	14,400
				24,700	**889,200**

Table 3.2: Travel costs and allowances					
2.1 Travel Allowance					
2.1.1Project Administrator (1personx2tripsx2days)	Per night	4	250	1,000	36,000
2.1.2 Project Manager (1personx2tripsx2nights)	Per night	4	200	800	28,800
2.1.3 Head of Institution (1person x1trip x 2nights)	Per night	2	200	400	14,400
2.1.4 Business Dev. Mgr. (1person x 4trips x 2nights)	Per night	8	150	1,200	43,200
2.1.5Project Accountant (1person x1trip x 2nights)	Per night	2	150	300	10,800
2.1.6 Driver (2personsx2tripsx2nights)	Per night	8	80	640	23,040
Subtotal Travel Allowance				4,340	156,240
2.2 Travel Costs (Fuel, tolls etc)					
2.2.1 Project Administrator (2trips)	Per trip	2	250	500	18,000
2.2.2 Project Manager (2trips)	Per trip	2	200	400	14,400
2.2.3 Head of Institution (1trip)	Per trip	1	200	200	7,200
2.2.4 Business Dev. Manager (4trips)	Per trip	4	200	800	28,800
2.2.4 Project Accountant(1trip)	Per trip	1	200	200	7,200
2.2.5 Driver (1trip)	Per trip	1	200	200	7,200
Subtotal Travel Costs				2,300	82,800

Table 3.3: Equipment and supplies					
3.1 Equipment and supplies					
3.1.1 Ethanol production unit	Unit	1	300,000	300,000	300,000
3.1.2 Biodiesel production unit	Unit	1	200,000	200,000	200,000
3.1.3 On-site building	Unit	1	250,000	250,000	250,000
3.1.4 4x4 Pickup truck	Unit	2	45,000	90,000	90,000
3.1.5 1.5-ton truck	Unit	1	55,000	55,000	55,000
3.1.6 Land	unit	4	10,000	40,000	40,000
3.1.7 Computers, office furniture	Set	4	3,000	12,000	12,000
3.1.8 Office equipment, supplies	Set	var	10,000	10,000	10,000
3.1.9 Tools	Set	3	1,500	4,500	4,500
Subtotal Equipment and Supplies				961,500	961,500

Table 3.4: Other costs and services, totals					
4. Other costs and services					
4.1 International travels	Per year			20,000	60,000
4.2 Publications	Per year			8,000	24,000
4.3 Workshops, seminars, conferences	Per year			20,000	60,000
4.4 Vehicle/equipment maintenance	Per year			10,000	30,000
4.5 Administrative costs	Per year			18,000	54,000
4.6 Rental of premises	per month	1	2,000	24,000	72,000
4.7 Utilities, telephone, etc	per month	var.	1,500	18,000	54,000
4.8 Raw materials/chemicals	Per month	var.	2,500	30,000	90,000
Subtotal Other costs and services				148,000	444,000
Total of Subtotals					2,533,740
5. Contingency (5% Total)					126,687
First Year				1,559,859	
GRAND TOTAL					2,660,427

three drums per hour, quotations of between $200,000 and $300,000 have been sighted. The distillation and dehydration processes will be continuous and hence will require automatic controls; these will make the units expensive. The quotations will also depend on the country of origin and the complexity of the units. The estimates given in Table 3.3 may however be taken as upper limits, thus giving room to the project team in the choice of capacity and level of sophistication. Apart from the distillation units, most of the other units required for both ethanol and biodiesel production are tanks for reaction or for storage, which could be made locally.

4.3.1 Land

The land required will be used for the installation of the equipment. A mid-size warehouse type building will be built on the land to provide space for production, storage, rest, and offices for some workers on the pilot plant.

4.3.2 Vehicles

The truck would be used to transport raw materials to the plant, while the pick-up would be used for personnel on the project. At least two vehicles, with petrol and diesel engines, will be required for testing.

4.3.3 Administrative costs

This will involve expenses associated with procurement, advertisements, financial services, sitting allowances, honorarium, and so on.

4.4 OTHER COSTS AND SERVICES

Publications, seminars and workshops are going to be important for such a project. It will also be important to make international travels as well, since a lot of countries have made significant progress in biofuels production and use, and it would not be worth reinventing the wheel, as it were. These funds should cater for tickets and per diems. Other costs, for example, rent and utilities are also normally associated with such projects.

4.5 CONTINGENCIES

A contingency allocation of 5% of the total first year and 3-year budgets has been added to cater for variations.

4.6 TOTALS

The first-year total of Table 3.4 was obtained by adding twelve times the subtotals for Tables 3.1 and 3.2 to the subtotals for Tables 3.3 and 3.4, which are one-off expenditures. The first- year contingency is obtained by multiplying this amount by the factor of 0.05. The 3-year grand total is obtained by simply summing up all the subtotals provided in the table and applying the contingency factor of 1.05.

5. CONCLUSIONS AND POLICY IMPLICATIONS

Hopefully the debilitating energy crisis Ghana has been going through for the past three years will motivate it to intensify its energy diversification efforts and take renewable sources more seriously. This paper is not meant to be the comprehensive document which a country needs to embark on a biofuels implementation programme. However, for a nation starting from scratch, it is meant as one of the contributions which could point policy-makers in the right direction. As discussed above, decision-makers have the choice of at least three institutions: KNUST, Koforidua Technical University and the Industrial Research Institute of CSIR in Accra. Expertise from science and engineering institutions around the country would be tapped as necessary. The trial project is expected to last for three years. The equipment and facility purchases are going to be one-time cost, and for this an amount of US$¢0.96 million is estimated. With an estimated expenditure of about US$1.56 million for the first year, the three-year period will require US$2.66 million.

A pilot stage is necessary because this period will be used for many useful preliminary activities. The trial period will be used to establish the raw material sources, their processing, quality and transportation to the point of fuel production. The impact of taking the raw materials from the various districts on the local economy, and on the project, will be examined. The fuel production processes, fuel testing, engine monitoring and maintenance, exhaust testing, the reaction and feedback of motorists and personnel training, will all form part of the activities of this period. A lot of learning will take place during this stage.

The piloting period would therefore be an important stage leading up to the public introduction of the biofuels. The involvement of the private sector in biofuels production is vital for the success of the project and must be actively promoted as part of the objectives, during this phase.

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