INTERNATIONAL TROPICAL TIMBER ORGANIZATION

ITTO

PRE-PROJECT PROPOSAL

TITLE	DEVELOPMENT OF ENERGY ALTERNATIVES FOR THE EFFICIENT UTILIZATION OF WOOD PROCESSING RESIDUE: CO-GENERATION AND BRIQUETTE PRODUCTION
SERIAL NUMBER	PPD 53/02 REV.1 (I)
COMMITTEE	FOREST INDUSTRY
SUBMITTED BY	GOVERNMENT OF GHANA
ORIGINAL	ENGLISH

SUMMARY

In the normal operation of wood processing large quantities of wood residues are generated. These form environmental hazards and poor aesthetics. It is possible to use the residue to generate energy for domestic and industrial application through briquetting (with and without carbonization) and process heat and/or power generation (co-generation). Energy thus generated could be used to produce electrical power and process steam for (i) steaming peeler blocks for plywood manufacture; (ii) drying of lumber and (iii) reduce the mills dependency on the national grid. For the co-generation studies 3 mills will be used for sizing the plant and for creating awareness for the economic and financial benefits to stakeholders. The briquette studies will be partly laboratory research and partly community based activity (creating awareness and market potential in 3 selected communities). This project therefore addresses the need to introduce and transfer biomass energy technologies in the commercial and domestic sectors in Ghana to improve the livelihood of the rural and urban population.

EXECUTING AGENCY	Forestry Research Institute of Ghana (FORIG)	
DURATION	12 MONTHS	
APPROXIMATE STARTING DATE	UPON APPROVAL	
PROPOSED BUDGET AND OTHER FUNDING SOURCES	Source	Contribution in (US$)
	ITTO	**78,208**
	Gov't of Ghana	9,594
	TOTAL	**87,802**

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PART 1: CONTEXT

1. Origin

This pre-proposal is submitted by the Government of Ghana for a study of methods to address the growing but serious problem of wood processing residues. The existing wood industries generate large volumes of wood wastes, sawdust, slabs, edgings, offcuts, etc.

The ITTO Project PD 74/90 "Better utilisation of tropical timber resources in order to improve sustainability and reduce negative ecological inputs" was undertaken by FORIG (Forestry Research Institute of Ghana) and Federal Centre of Forestry and Forest Products in Hamburg, Germany. The results showed that overall the average recovery on sawmilling in one of the areas of study was 45% raw lumber, 8% by products, 8% sawdust and 39% solid residue. In a similar study in another area the following data was obtained - mean recovery rate of 44.1% lumber, 4.2% by-products 6.2% sawdust and 45.5% solid residue. It was estimated that wood residue in the forest floor amounted to 48%, 50% and 63% in the three areas which were studied. All these show that wood residues from the forest floor and forest industries wastes are very high and need to be put to good and profitable use.

Kumasi where most of the forest industries in Ghana are situated, the residues are constantly burnt in the open air in and around the factory sites causing air pollution in the immediate environment. Piles of these residues are seen in the neighbourhood and emanating from these are obnoxious smell due to intermittent soaking by rain and attack by fungi and bacteria. It can be assumed that similar situations exist in other developing countries with comparable forestry resources.

2. Sectoral Policies

Ghana Forest Policy objective is to manage, protect, conserve and develop her forest in order to ensure sustainable wood (as well as Non-Timber Forest Products) production and utilisation to optimize the economic, social and environmental benefits to the people and to provide sustainable support for the country's forest-based industries. Optimization of forest benefits is enhanced when timber products derived from the forests are processed as efficiently as possible using the most efficient technologies. The action program for the attainment of the national forestry policy has the following components:

(a) sustainable management of the forest estate;
(b) protection and conservation of the forest ecosystem;
(c) optimum utilisation of harvested wood; and
(d) forestry research and institutional development

3. Programmes and Operational Activities

The forestry sector of Ghana has as its objective generation of information for sustainable management of the forests, maximum utilisation of the forest products, avoid wastage and provide for the economic benefit of all Ghanaians. In this regard there have been many programmes to ensure this. Some of these programmes include Forest Resources Management Programme (FRMP) which was supported by the World Bank, DFID, DANIDA and the Natural Resources Management Programme (NRMP) which is ongoing and again supported by these organisations.

ITTO assisted projects include:-

(i) "Man made forests of indigenous species - A systematic preparation of industrial tree plantations";
(ii) "Better utilisation of tropical timber resources in order to improve sustainability and reduce ecological impacts";
(iii) "Industrial utilisation and improved marketing of some less-used species from a sustainable managed forest";
(iv) "Development of genetic resistance in the tropical hardwood Iroko to the damaging insect pest, *Phytolyma lata*";
(v) "Conservation and provenance planting and integrated pest management to sustain Iroko production in West Africa";
(vi) "Forest Fire management in Ghana";
(vii) Handbook on tree and wood identification of 100 lesser-used and lesser-known species from Tropical Africa with notes on ethnography, silviculture, and uses; and
(viii) "Silviculture and economics of improved and natural forest management in Ghana and rehabilitation of degraded forests through collaboration with local communities.

PART II: THE PRE-PROJECT

1. Pre-Project Objectives:

1.1 <u>Development objective</u>: The pre-project addresses the need to promote the domestic and industrial utilisation of wood processing residues to enhance sustainable timber production and reduce environmental pollution in Ghana.

1.2 <u>Specific Objective</u>: *Identification and documentation of domestic and commercial options with emphasis on co-generation for efficient utilization of wood residue.*

2. Justification

2.1 Problems to be Addressed

The wood-based industries of Ghana have made significant contribution towards the socio-economic development of the country. This is evidenced by the fact that timber and its associated products constitute an important foreign exchange earner for the country.

Conversion of Sawmill Residues to Generate Energy

In order to ensure that timber from Ghana's natural forests can be sustained an Annual Allowable Cut (AAC) has been set at one million cubic metres. However, this figure is always exceeded with the current amount of AAC estimated at 1.5 million cubic metres. The annual allowable cut is exceeded because about 50% of the logs is unutilised and are treated as residues. This is evidenced by the work done at FORIG and sponsored by ITTO which indicates that the sawmill recovery for lumber production for export ranged from 30 to 45%; sliced veneer and rotary dry veneer recovery ranges were 25-39% and 50-70% respectively. These results demonstrate that the wood processing industries generates large volumes of waste and there is the need to find possible use for the residues.

Briquetting

In Ghana sawdust stove is being produced locally. The use of sawdust stove in the homes of Ghanaians is not encouraging because of the powdery nature of sawdust. This therefore calls for the review of sawdust utilisation, hence the need to change its form to make its transportation and handling easy to entice the people in the rural and urban towns to accept it as a source of energy for cooking and boiling water. This will help to reduce the necessity to cut trees as a source of energy and therefore conserve the forest and reduce the degradation of the land and hence help improve watershed systems.

Co-generation

Another possible use of the residue is the generation of the combined heat and electric power [CHP] or co-generation which is recognized as an attractive alternative to the conventional power and heat generating options due to:

- Its relatively lower capital investment
- Shorter gestation period
- Reduced fuel consumption
- Reduced environmental pollution
- And increased fuel diversity

Currently Ghana's total energy generating capacity supplies approximately 65% of the national peak demand which is growing at an annual rate of 15%.
A detailed study of co-generation and its economic viability in the Ghanaian industry has become necessary due to the following:-

- Increased pressure on Government to increase electricity tariff effective May, 2001;
- Constraints faced by Government in financing additional power generating capacities;
- Growing concern to limit the environmental pollution associated with energy generation and use; and
- Increase industrial growth due to Government's increased encouragement of privitization and private sector participation

With the increase in production in wood industry since 1994 and the rising electricity tariff rates and an investment in co-generation having a payback period of less than five years, it has become necessary to examine the economic and the potential of co-generation in the wood industry in order to keep the timber companies from collapse due to energy problems.

Favourable conditions for co-generation implementation are:

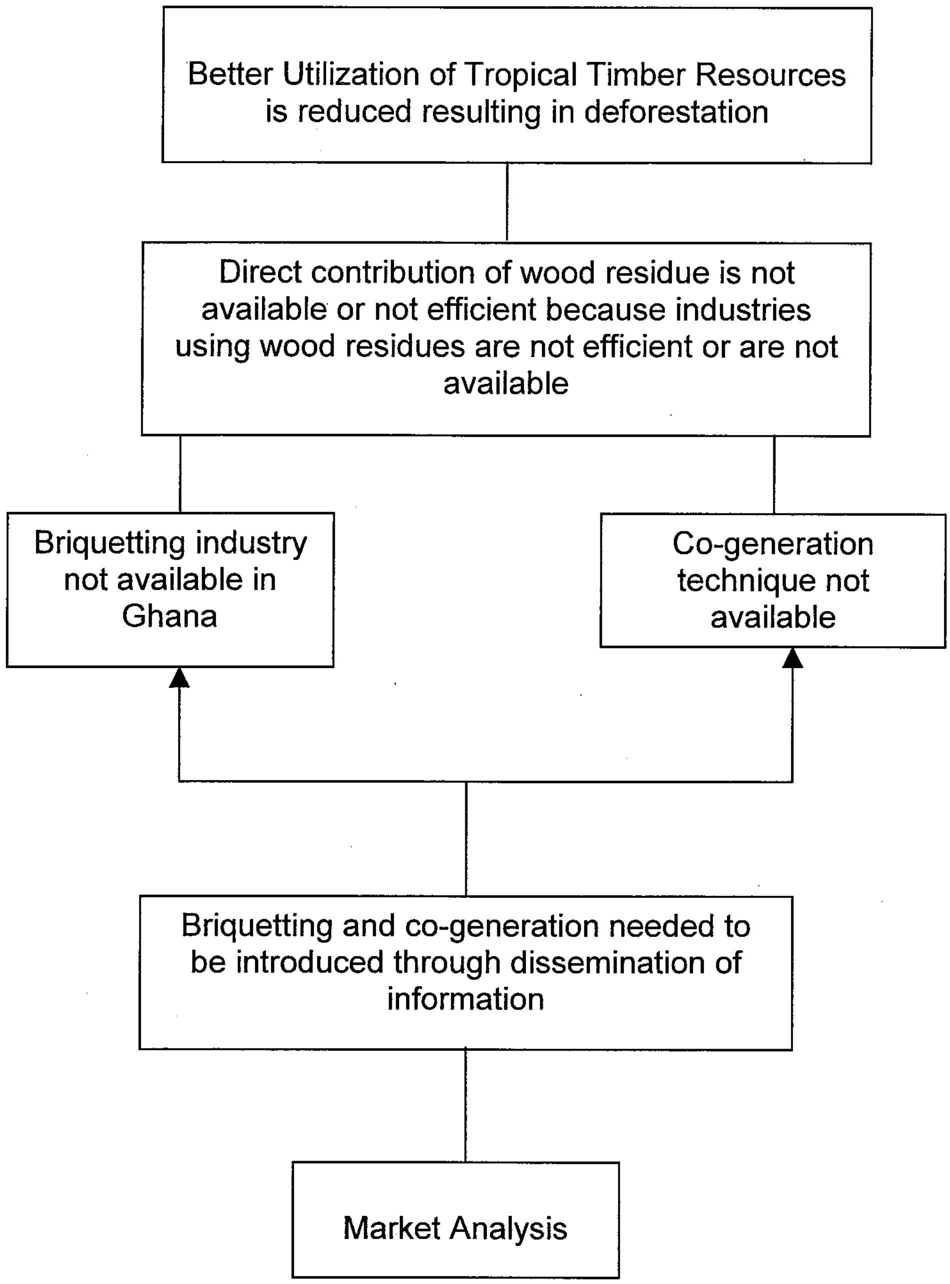
- Reliable power requirement
- Relatively steady electrical and thermal patterns
- Long operating hours
- .inaccessibility to the grid or high price of grid electricity

In Ghana, co-generation has potential application in sawmills, plywood and veneer mills. Thus the use of the residues as a source of energy could provide a solution to current problems of effectively disposing of large volumes of these residues generated at the wood processing centres. Currently, these residues are dumped in piles or burnt generating large volumes of obnoxious gases that pollute the immediate environment and add to global pollution.

Reafforestation and improved biomass energy use in developing countries could be two of the most effective response to global warming but at the moment biomass energy is a major part of the problem rather than the solution. The partial solution is for industrial development to take energy efficiency into account so that a country will be able to spend less on fuel and power as well as releasing fewer green house gases.

If used on a sustainable basis biomass fuels are at least neutral in terms of carbon dioxide emissions. In addition, due to the low sulphur and nitrogen content of wood $S0_2$ and No emissions from biomass fuels are insignificant.

The Problem Tree



2.2 Reasons for a Pre-Project

In 1988 an Energy Sector Management Assistance Project (ESMAP) on sawmill residue utilisation by UNDP and World Bank examined the feasibility of using sawmill residues to generate both heat and electricity for use by the wood processing industries. The study concluded that since all the large mills are connected to the national grid and get low cost electricity at 3.5 US cents/KWh, there was no financial gain in the short term for mill owners to indulge in co-generation.
Since then, there have been tremendous changes in the energy sector. There have been power curtailment and rationing due to drought situations that affected hydropower generation. This has also brought to the front the need to charge economic tariffs for electricity. Consequently there has been a steady rise in the tariffs. It is over 10 years since that study was carried out.

There have also been significant changes in the processing milieu of the industry. Major changes that are likely to have effect on the scenario for co-generation from processing residues include the following:-

- A ban on round log export imposed since 1995;
- Increased processing of lesser-used species;
- Increased emphasis on value-added processing;
- Stricter controls and regulation of log harvesting resulting in a drastic reduction in the annual timber harvest; and
- Institution of levies on the export of green lumber. This has led to an increase in the installed capacity of drying kilns

All these factors do affect wood processing and to some extent the generation wood residues.

Kumasi Wood Village Project

The ITTO is also sponsoring a project in Kumasi which seeks to concentrate all wood workers, mainly carpenters and artisans in the wood industry at one location. This so-called wood village is located at some 15km from the centre of the wood processing industry in Kumasi.

It is anticipated that large quantities of processing residues in the form of wood shavings, sawdust and short pieces of woods would be generated at the village. There is the need to identify more efficient means of disposal for such residues. Their conversion to energy, particularly through co-generation if found worth while should be of great interest.

In the light of the above, the project seeks to re-examine the feasibility of harnessing the wood processing residues for co-generation. Heat from the system could service drying kilns whilst electricity could be sold to the grid or used directly to serve the wood village. This will greatly help to solve the environmental problem posed by the decay and burning of the wood residue.

Briquetting

The accumulation of sawdust poses fire hazard as well as increment in running cost owning to the need to dispose of the accumulated sawdust. However, with the rising cost of fuel in homes and factories it is worth giving sawdust a serious consideration. The consumption of charcoal in Ghana is projected to grow at a rate of 6% annually. This is the result of increasing urbanisation and the shift from the use of firewood to charcoal. This high rate of consumption of charcoal (urban areas) and equally high rate of firewood consumption (rural areas) result in indiscriminate felling of trees. This practice will lead to the problem of deforestation, which will consequently have a negative effect on the energy situation of the country. There is therefore the need to find substitutes and/or supplement for charcoal and firewood.

Most of the previous wood energy experiences in Africa, especially under the World Bank/UNDP ESMAP programmes have concentrated on conversion devices - their designs and efficiencies. These have included cookstove programs in Kenya, Zambia, Botswana and Ghana. Others have focussed on charcoal production efficiencies and kiln modifications. However, very few attempts have been made at examining the briquetting option. These have been very limited in scope. In fact initial attempts in Ghana at commercial briquetting of sawdust was not very successful.

The compaction of sawdust and other forms of wood waste into briquettes for fuel has been successfully carried out in most advanced countries for a number of years. The problem faced in the introduction of this technology to Ghana were marketing, technical, social and economic. It is therefore important to do a comprehensive analysis of both the technical, social and economic factors that affect the production, distribution, marketing and use of briquettes. For example, although in some cases the raw materials required for briquetting will be very low in cost, the market for briquette itself will increase the value of the raw material. This could have negative effects on the distribution of income. In addition, some briquetting materials will have competing uses. Thus the value of the fuel for its various uses must be weighed before any decision is made. Further there are several ways of producing energy from the raw material.

The analysis will examine the distribution cost, social acceptance and the integrity of the product itself overtime. Size of the market, the willingness and the ability of people to pay for the new fuel product, types and requirements of stoves in use in the market area, environmental considerations and availability of credit or subsidy to get the enterprise started. The most effective way of achieving success is to assess the situation from several viewpoints: technicians, women associations, farmers, institutional kitchens, etc. These groups are a good source of information about the social climate, the attitude of local people to innovations and economic and the relevant factors.

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With the increase in production in wood industry since 1994, the rising electricity tariff rates and an investment in co-generation having a payback period of less than five years, it has become necessary to examine the economic and the potential of co-generation in the wood industry in order to keep the timber companies from collapse due to energy problems.

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2.3 Target beneficiaries

With the energy situation in the country becoming acute the timber-related industries as well as non-timber industries must look elsewhere for alternative supply of energy.

Biomass energy supply would be useful for the development of Ghana's growing forestry and manufacturing industries whose benefits would include:-

- fuller utilisation of the nation's cellulose raw material
- development of cheaper industrial and domestic fuel based on indigenous renewable resources
- contributing to the reduction of environmental pollution and increasing awareness in the need for environmentally positive practices
- provision of training in the application of efficient and safe operation of biomass energy systems
- create employment opportunities by consolidating and expanding existing small to large scale forestry industries and encouraging development of new ones.
- Processing industries may have an avenue in which to invest their surplus money by using waste material
- Upgrading the research and advisory capability of FORIG and through it increase the scope for further development in the sub-region.

Other Commercial uses of wood residue

The range of products that could be developed from the residue include fuelwood, paper pulp, and mechanically processed wood. The latter include sawnwood, wafer boards fibre and particleboard, medium density fibreboard, high density hard board, oriented strand board, wood composite, cement board, finger-jointing timber and combination of these and furniture, building components, packaging and other products. The production of these items will add value to the residue and generate further business opportunities for the local industry. It is therefore necessary to investigate the potential of the wood residue for such above-mentioned products.

2.4 **Other Relevant aspects:**

2.4.1 <u>Technical and Scientific Aspect</u>

2.4.1.1 Availability of Raw Material

Before any meaningful studies in co-generation and briquetting could be undertaken it would be important to have a good knowledge of the characteristics of the raw material. Since there are many different technical options available for both co-generation, briquetting and other commercial options, the study of the characteristics of the raw material would enable entrepreneurs to make correct decisions with respect to the choice of technology. From a combustion point of view it is very important to have well blended wood residues with consistent properties.

For the mixture of wood reside to be burnt it is necessary to define a range of properties such as: -

(i) *limits on each fuel stream component - i.e. the percentage range by weight of each wood residue component;*

(ii) *moisture content - maximum, minimum and typical. The moisture content has a major effect on the units thermal efficiency and the selection of the combustion technology*

(iii) *size distribution - i.e. the maximum fuel particle size and an indication of the fines percentage less than say 3 mm*

(iv) *fuel density - both solid density and bulk density. Solid density is used to convert fuel mass to solid volumes and vice versa. Bulk densities are used to assess fuel storage and handling characteristics.*

(v) *Calorific value and ultimate fuel analysis - the ultimate analysis of the fuel is the percentage weight of carbon, hydrogen, nitrogen, oxygen and other trace elements and is normally expressed on a dry ash free basis - i.e. excluding the water and ash content of the "as received" fuel. This is necessary for the estimation of the amount of carbon dioxide produced by combustion and to estimate the thermal efficiency of the unit.*

(vi) *Ash content and chemistry gives an indication of possible combustion side fouling or corrosion issues that might occur. For example, high levels of sodium (salt) in the wood residues are not unusual and can cause problems.*

(vii) *Unusual properties - some wood residues can have unusual properties. They may contain sand that is highly abrasive. They may have high resin content.*

2.4.1.2 Co-generation

The guidelines on co-generation will be: -

Overview of present energy situation: This includes understanding of the historical evolution of the energy sector and the status as well as future prospect for electricity demand and supply. Other aspects are the share and the share of energy use in the timber processing mills and their growth. A major factor determining the financial viability of co-generation progress is the prevailing cost of fuel and electricity. Therefore a good understanding of the energy pricing mechanism and any price distortions such as taxation and cross-subsidization is important for making realistic assumptions of the input parameters of the pre-feasibility studies. Equally important is the need to grasp the various government policies and strategies being formulated for encouraging private sector involvement in power generation in various forms. Based of on the ground reality a critical analysis of strengths and weaknesses of these initiatives is desirable.

Preliminary assessment of the potential for co-generation: Preliminary assessment includes identification of wood processing mills which offer co-generation potential, based on the various technical criteria such as heat-to-power ratio, quality of thermal energy requirements, typical demand patterns of the different forms of energy at the site, availability of fuels, level of system reliability needed etc. Once the mills offering good potential are identified, the technical potential for co-generation can be established on selected sample sites using a standard questionnaire. Base on the outcome from the questionnaire suitable site will be identified where a limited number of pre-feasibility studies can be undertaken.

Pre-feasibility study with good co-generation potential: Pre-feasibility studies involve gathering of additional technical data from the site, including the actual demand pattern as a function, minimum, maximum and average energy demands, annual operating hours, type of fuel in use, and space constraint etc. The above data allow a complete technical evaluation of co-generation and identification of co-generation alternative in order to proceed with the phase, economic and financial evaluation this will then be followed by sensitivity analyses to identify the most important parameters that are decisive to the financial viability of the project.

2.4.2 ***Risk:***

The potential risk to the success of the pre-project may be the lack of co-operation from the timber industry and the local communities. Efforts have been made with four timber industries and local communities in potential pre-project sites to sensitise them about the need for the pre-project for the co-operation and collaboration required from them.

2.4.3 ***Management structure:***

Forestry Research Institute of Ghana would implement the project with the active co-operation and collaboration with staff of Kwame Nkrumah University of Science and Technology (KNUST).

2.4.4 ***Economic aspects:***

The adoption of the pre-project would help to improve the economy of Ghana and other tropical countries. These countries would benefit in that hitherto waste materials would be used to generate useful products. Co-generation technology would improve the profit margins of forest factories that would accept the technology. The result would be expansion of the factories which would lead job creation. Even prices of products from the factories would be improved when the energy source is cheap.

3. Outputs: The pre-project has only one specific objectives and five outputs

3.1: Specific objective: Identification and documentation of domestic and commercial options with the emphasis on co-generation for efficient utilisation of wood residue.

- ***Output 1**: Availability and characteristics of different types of wood residues for energy production determined*
- **Output 2**: *Commercial options for efficient utilisation of wood residue determined.*
- **Output 3**: Size of co-generating plant determined
- **Output 4**: Economics and marketing potential of technology and products enhanced
- **Output 5:** Stakeholders participation for transfer of technology achieved.

4. Activities and Inputs

4.1 Output 1: Availability and characteristics of different types of wood residue for energy production determined

Activities	Inputs/Personnel
4.1.1 Organisation of start up workshop	All project staff, stationery
4.1.2 Literature review	All project staff
4.1.3 Questionnaire preparation	Socio-economist
4.1.4 Collection and classification of residue	Sawmill expert, sieves
4.1.5 Estimation of volume of residue from processing mills and data processing	*Measuring tapes, calipers, sieve, weighing balance. Computer, all project staff.*
4.1.6 Determination of calorific value	*Bomb calorimeter and oxygen*

4.1.7 Determination of moisture content	*Chemical Engineer and Moisture meter*
4.1.8 Determination of ash and chemistry	*Chemist, chemicals and furnace*

4.2 Output 2: *Commercial options for efficient utilisation of wood residue determined.*

Activities	Inputs
4.2.1 Literature review	*All project staff*
4.2.2 Determination of size of markets	*Socio-economist*
4.2.3 Determination of relevant social factors	*Socio-economist*
4.2.4 Determination of environmental factors	*Chemist and Socio-economist*
4.2.5 Identification of suitable technologies	*All project staff*

4.3 Output 3: Size of co-generating plant determined

Activities	Inputs
4.3.1 Identification of sites good co-generation potential.	Electrical Engineer, Project Leader
4.3.2 Determine thermal energy demand profiles.	Electrical Engineer, Project Leader
4.3.3 Determine the electrical energy demand profiles.	Electrical Engineer, Project Leader
4.3.4 Determine the specification for co-generation plants	Electrical Engineer, ABB portable meter, Alpha meter with 3 clamp on CT, Computer & accessories

***4.4 Output 4**: Economics and marketing potential of co-generation plant determined*

Activities	Inputs
4.4.1 Identification of scope for the application of the technology	Economist, Computer, Project staff
4.4.2 Cost of existing energy systems and fuels	Electrical Engineer *and Socio-economist*
4.4.3 Economic viability of the *co-generating plant*	Economist, *Project Leader and electrical engineer*
4.4.4 Carefully selecting the market indicating those which should be targeted as initial adopter of technology.	Economist, *Project Leader and Project staff*

***4.5 Output 5**: Stakeholders participation for adoption of technology*

Activities	Inputs
4.5.*1* Creating awareness of economic benefit of co-generation briquettes (workshop) *and other commercial options*	Project staff
4.5.2 Publication of results in scientific journals	Project staff, *Photocopying & computer*
4.5.3 Preparation of brochure for promotion	Project staff, *Photocopying & computer*
4.5.4 A draft final report	Project staff, *Photocopying & computer*
4.5.5 A final report	Project staff, *Photocopying & computer*
4.5.6 Presentation of findings	Project staff, *Photocopying & computer*

5.0 WORK PLAN

Output/Activities	**Responsible party**	**SCHEDULE (IN MONTHS)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Output 1: *Availability and characteristics of different types of wood residue for energy production determined.*													
ACTIVITIES													
1.1 Organisation of start-up workshop	All project staff												
1.2 Literature review	All project staff												
1.3 Questionnaire preparation	Project Leader												
1.4 Collection and classification of residue	Chemist												
1.5 *Estimation of volume of residue from processing mills and data processing*	Project Leader												
1.6 Determination of calorific value	*Chemical Engineer, Bomb calorimeter and oxygen*												
1.7 Determination of moisture content	*Chemical Engineer and Moisture meter*												
1.8 Determination of ash and chemistry	*Chemist, chemicals and furnace*												
1.9 Determination of fuel density	*Chemist*												
Output 2: *Commercial options for efficient utilisation of wood residue determined..*													
ACTIVITIES													
2.1 *Literature review*	Chemist, Project Leader												
2.2 *Determination of size of markets*	Socio-Economist, Project Leader												
2.3 *Determination of relevant social factors*	Socio-Economist												
2.4 *Determination of environmental factors*	Chemical Engineer												
2.5 *Identification of suitable technologies*	All project staff												

Output 3: Size of co-generating plant determined.													
ACTIVITIES													
3.1 Identification of sites with good co-generation potential	Electrical Engineer, Project Leader												
3.2 Determine thermal energy demand profiles	- do -												
3.3 Determine electrical energy demand profiles	- do -												
3.4 Determine the specifications for co-generation plants.	-do-												
Output 4: Economics and marketing potential of technology and products enhanced													
ACTIVITIES													
4.1 Identification of scope for the application of the technology	All project staff												
4.2 Cost of existing energy systems and fuels	Project Leader, Economist												
4.3 Economic viability of the co-generating plant	Electrical Engineer, Socio-Economist												
4.4 Carefully selecting the market indicating those which should be targeted as initial adopter of technology.	Economist, Project Leader and Electrical engineer												
***Output 5**: Stakeholders participation for adoption of technology.*													
5.1 Creating awareness of economic benefit of co-generation briquettes (workshop) and other commercial options.	All project staff												
5.2 Publication of results in scientific and/or other journals	All project staff												
5.3 Preparation of brochure for promotion	All project staff												
5.4 A draft final report	All project staff												
5.5 A final report	Project Leader												
5.6 Presentation of findings	All project staff												

6.0 PRE-PROJECT BUDGET

6.1 Pre-Project budget by Activity

Outputs and Activities	Inputs: Units and Quality	Inputs: No.	Unit cost	Year	Budget Component	Total Amount
OUTPUT 1:	(1) Project Leader (Chemist)	1	150	1	11.1	150
	(2) Electrical Engineer	1	120	1	11.2	120
Activity 1.1: Organisation of start up workshop	(3) Chemical Engineer	1	120	1	11.3	120
	(4) Socio-economist	1	120	1	11.4	120
	(5) Technicians	4	50	1	13	200
	(6) Director	1	100	1	13	100
	(7) Deputy Director	1	100	1	13	100
	(8) Principal Researcher	3	80	1	13	240
	(9) Senior Researcher	6	60	1	13	360
	(10) Stationery			1	54	850
	(11) Sundry			1	61	200
Activity 1.2: Literature review	(1) Project Leader (Chemist)	1	50	1	11.1	50
	(2) Electrical Engineer	1	50	1	11.2	50
	(3) Chemical Engineer	1	50	1	11.3	50
	(4) Socio-economist	1	50	1	11.4	50
	(5) Stationery			1	54	200
	(6) Sundry			1	61	100
Activity 1.3: Questionnaire preparation	(1) Project Leader (Chemist)	1	150	1	11.1	150
	(2) Electrical Engineer	1	150	1	11.2	150
	(3) Chemical Engineer	1	150	1	11.3	150
	(4) Socio-economist	1	150	1	11.4	150
	(5) Daily Subsistence Allowance	4	100	1	31	400
	(6) Office supplies				54	500
	(7) Sundry				61	1,000
	(8) Transport cost				33	
Activity 1.4: Collection and classification	(1) Project Leader (Chemist)	1	150	1	11.1	150
	(2) Electrical Engineer	1	150	1	11.2	150
	(3) Chemical Engineer	1	150	1	11.3	150
	(4) Socio-economist	1	150	1	11.4	150
	(5) Technicians	4	100	1	13.1	400
	(6) Labourers	2	50	1	13.2	100

Activity 1.5: Estimation of volume of residue from processing mills and data processing.	*(1) Project Leader (Chemist)*	*1*	*150*	*1*	*11.1*	*150*
	(2) Electrical Engineer	*1*	*150*	*1*	*11.2*	*150*
	(3) Chemical Engineer	*1*	*150*	*1*	*11.3*	*150*
	(4) Socio-economist	*1*	*150*	*1*	*11.4*	*150*
	(5) Desk-top Computer	*1*	*2,000*	*1*	*44*	*2,000*
	(6) Office supplies			*1*	*54*	*500*
	(7) Sundry			*1*	*61*	*100*
Activity 1.6: Determination of calorific value	*(1) Chemical engineer*	*1*	*300*	*1*	*11.3*	*300*
	(2) Bomb calorimeter	*1*				
	(3) Oxygen			*1*	*51*	*500*
Activity 1.7: Determination of moisture content	*(1) Chemical Engineer*	*1*	*300*	*1*	*44*	*300*
	(2) Moisture meter	*1*		*1*		*500*
Activity 1.8: Determination of ash and chemistry	*(1) Chemist*	*1*	*300*	*1*	*11.2*	*300*
	(2) Chemicals		*1,000*	*1*	*51*	*1,000*
	(3) Furnace			*1*	*44*	
Activity 1.9: Determination of fuel density	*(1) Chemist*	*1*	*300*	*1*	*11.2*	*300*
OUTPUT 2						
Activity 2.1: Determination of size of market	*(1) Socio-Economist*	*1*	*300*	*1*	*11.1*	*300*
	(2) Project Leader	*1*	*300*	*1*	*11.2*	*300*
	(3) Office supplies		*400*	*1*	*54*	*400*
	(4) Transport costs	*1*	*1,000*	*1*	*33*	*1,000*
Activity 2.2: Determination of relevant social factors	*(1) Socio-Economist*	*1*	*300*	*1*	*11.1*	*300*
	(2) Project Leader	*1*	*300*	*1*	*11.2*	*300*
	(3) Office Supplies		*400*	*1*	*54*	*400*
	(4) Transport costs		*1,000*	*1*	*33*	*1,000*
Activity 2.3: Determination of environmental factors	*(1) Chemical Engineer*	*1*	*300*	*1*	*11.3*	*300*
	(2) Project Leader	*1*	*300*	*1*	*11.1*	*300*
	(3) Electrical Engineer	*1*	*300*	*1*	*11.2*	*300*
	(4) Socio-economist	*1*	*300*	*1*	*11.4*	*300*
	(5) Office supplies		*400*	*1*	*54*	*400*

Activity 2.4: Determination of suitable technology for selected commercial options.	*(1) Chemical Engineer*		*300*	*1*	*11.3*	*300*
	(2) Project Leader		*300*	*1*	*11.1*	*300*
	(3) Electrical Engineer		*300*	*1*	*11.2*	*300*
	(4) Daily subsistence allowance				*31*	*300*
	(5) Office supplies		*100*	*1*	*54*	*40*
	(6) Sundry				*61*	*500*
OUTPUT 3:						
Activity 3.1: Identification of sites with good co-generation potential	*(1) Electrical Engineer*	*1*	*300*	*1*	*11.1*	*300*
	(2) Project Leader	*1*	*300*	*1*	*11.2*	*300*
	(3) Sundry		*400*	*1*	*61*	*400*
	(4) Office supplies		*400*	*1*	*54*	*400*
	(5) Transport cost		*1,000*	*1*	*33*	*1,000*
Activity 3.2: Determination of thermal energy demand profiles	*(1) Electrical Engineer*	*1*	*300*	*1*	*11.1*	*300*
	(2) Project Leader	*1*	*300*	*1*	*11.2*	*300*
	(3) Sundry		*400*	*1*	*61*	*400*
	(4) Office supplies		*400*	*1*	*54*	*400*
	(5) Transport costs		*1,000*	*1*	*33*	*1,000*
Activity 3.3: Determination electrical energy demand profiles	*(1) Electrical Engineer*	*1*	*300*	*1*	*11.1*	*300*
	(2) Project Leader	*1*	*300*	*1*	*11.2*	*300*
	(3) ABB Portable meter	*1*	*4,350*	*1*	*44*	*4,350*
	(4) Sundry		*400*	*1*	*61*	*400*
	(5) Office supplies		*400*	*1*	*54*	*400*
Activity 3.4: Determination the specification for co-generation plants	*(1) Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(2) Electrical Engineer	*1*	*300*	*1*	*11.2*	*300*
	(3) Office supplies		*400*	*1*	*54*	*400*
	(4) Sundry		*400*	*1*	*61*	*400*
	(5) Computer and accessories	*1*	*-*	*1*	*44*	*-*

OUTPUT 4	(1) *Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(2) *Electrical Engineer*	*1*	*300*	*1*	*11.2*	*300*
Activity 4.1: Identification of scope for the application of the technology	(3) *Chemical Engineer*	*1*	*300*	*1*	*11.3*	*300*
	(4) *Socio-economist*	*1*	*300*	*1*	*11.4*	*300*
	(5) *Computer*	*1*	-	*1*	*44*	-
	(6) *Office supplies*		*400*	*1*	*54*	*400*
	(7) *Sundry*		*400*	*1*	*61*	*400*
	(8) *Transport costs*		*1,000*	*1*	*33*	*1,000*
Activity 4.2: Cost of existing energy systems and fuels	(1) *Electrical Engineer*	*1*	*300*	*1*	*11.2*	*300*
	(2) *Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(3) *Office supplies*		*400*	*1*	*54*	*400*
	(4) *Sundry*		*400*	*1*	*61*	*400*
	(5) *Transport costs*		*1,000*	*1*	*33*	*1,000*
	(6) *Computer*		-	*1*	*44*	-
Activity 4.3: Economic viability of the co-generation.	(1) *Socio-economist*	*1*	*300*	*1*	*11.1*	*300*
	(2) *Electrical Engineer*	*1*	*300*	*1*	*11.2*	*300*
	(3) *Project Leader*	*1*	*300*	*1*	*11.3*	*300*
	(4) *Office supplies*		*400*	*1*	*54*	*400*
	(5) *Computer*	*1*	-	*1*	*44*	-
	(6) *Sundry*		*400*	*1*	*61*	*400*
	(7) *Transport costs*		*1,000*	*1*	*33*	*1,000*
Activity 4.4: Carefully selecting the markets indicating those, which should be targeted as initial adopter of technology.	(1) *Socio-economist*	*1*	*300*	*1*	*11.1*	*300*
	(2) *Project Leader*	*1*	*300*	*1*	*11.2*	*300*
	(3) *Electrical Engineer*	*1*	*300*	*1*	*11.3*	*300*
	(4) *Office supplies*		*400*	*1*	*54*	*400*
	(5) *Sundry*		*400*	*1*	*61*	*400*
	(6) *Transport costs*		*1,000*	*1*	*33*	*1,000*
	(7) *Computer and accessories*	*1*	-	-	*44*	-

OUTPUT 5 *Activity 5.1: Creating awareness of economic benefit of co-generation briquettes and other commercial options.*	*(1) Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(2) Electrical Engineer	*1*	*300*	*1*	*11.2*	*300*
	(3) Chemical Engineer	*1*	*300*	*1*	*11.3*	*300*
	(4) Socio-economist	*1*	*300*	*1*	*11.4*	*300*
	(5) Technicians	*4*	*200*	*1*	*11.5*	*800*
	(6) Office supplies		*400*	*1*	*54*	*400*
	(7) Sundry		*400*	*1*	*61*	*400*
	(8) Transport costs		*1,000*	*1*	*33*	*1,000*
Activity 5.2: Publication of results in scientific journals	*(1) Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(2) Electrical Engineer	*1*	*300*	*1*	*11.2*	*300*
	(3) Chemical Engineer	*1*	*300*	*1*	*11.3*	*300*
	(4) Socio-economist	*1*	*300*	*1*	*11.4*	*300*
	(5) Office supplies	*1*	*400*	*1*	*54*	*400*
	(6) Computer and accessories	*1*	-	*1*	*44*	-
	(7) Sundry		*400*	*1*	*61*	*400*
	(8) Transport costs		*200*	*1*	*33*	*200*
Activity 5.3: Preparation of brochure for promotion	*(1) Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(2) Electrical Engineer	*1*	*300*	*1*	*11.2*	*300*
	(3) Chemical Engineer	*1*	*300*	*1*	*11.3*	*300*
	(4) Socio-economist	*1*	*300*	*1*	*11.4*	*300*
	(5) Office supplies		*400*	*1*	*54*	*400*
	(6) Computer and accessories	*1*				
	(7) Transport costs		*400*	*1*	*33*	*400*
	(8) Sundry		*400*	*1*	*61*	*400*
	(9) Technicians	*4*	*200*	*1*	*11.5*	*800*
Activity 5.4: A draft final report preparation.	*(1) Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(2) Electrical Engineer	*1*	*300*	*1*	*11.2*	*300*
	(3) Chemical Engineer	*1*	*300*	*1*	*11.3*	*300*
	(4) Socio-economist	*1*	*300*	*1*	*11.4*	*300*
	(5) Office supplies		*400*	*1*	*54*	*400*
Activity 5.5: A final report preparation	*(1) Project Leader*	*1*	*300*	*1*	*11.1*	*300*
	(2) Electrical Engineer	*1*	*300*	*1*	*11.2*	*300*
	(3) Chemical Engineer	*1*	*300*	*1*	*11.3*	*300*
	(4) Socio-economist	*1*	*300*	*1*	*11.4*	*300*
	(5) Office supplies	-	*400*	*1*	*54*	*400*
	(6) Computer and accessories	*1*	-	*1*	*44*	-

Activity 5.6: Presentation of findings	*(1) Project Leader* *(2) Electrical Engineer* *(3) Chemical Engineer* *(4) Socio-economist* *(5) Office supplies* *(6) Computer and accessories*	*1* *1* *1* *1* - *1*	*300* *300* *300* *300* *400* -	*1* *1* *1* *1* *1* *1*	*11.1* *11.2* *11.3* *11.4* *54* *44*	*300* *300* *300* *300* *400* -
Non-Activity Based Expenses *(1) Auditing*	*(1) Auditor*	*1*	*500*	*1*	*62*	*500*

6.2 Total ITTO Project Budget (Project Duration: 1 year)

	Budget Component	*Total*
10	***Project Personnel***	
	11. National Experts	*20,210*
	13 Other Labour	*3,700*
	19 Component Total	***23,910***
30	***Duty Travel***	
	13. Daily Subsistence Allowance	*700*
	33. Transport Costs	*11,600*
	39. Component Total	***12,300***
40	***Capital Items***	
	44. Capital Items	*6,850*
	49. Component Total	***6,850***
50	***Consumable Items***	
	51. Raw Material (Chemicals)	*1,500*
	54. Office Supplies	*9,250*
	59. Component Total	***10,750***
60	***Miscellaneous***	
	61. Sundry	*5,500*
	62. Auditing	*500*
	69. Component Total	***6,000***
70.	*Executing Agency Management Cost*	*8,971*
	79. Component Total	***8,971***
	SUB-TOTAL	***68,781***
80	*ITTO Monitoring, Evaluation and Administration*	
	81. Monitoring and Review Costs	*5,000*
	83. Programme Support Costs	*4,427*
	89. Component Total	***9,427***
100	***Grand Total***	***78,208***

6.3 OVERALL PROJECT BUDGET BY ACTIVITY

Outputs/activities + Non-Activity Based Expenses	*BUDGET COMPONENTS*					
	10. Project Personnel	***30. Duty Travel***	***40. Capital Items***	***50. Consumable Items***	***60. Miscella-neous***	***GRAND TOTAL***
OUTPUT 1: Availability and characteristics of different types of wood residue for energy production determined.						
Activity 1.1: Organisation of start up workshop	*2,110*			*850*	*200*	*3,160*
Activity 1.2: Literature review	*200*			*200*	*100*	*500*
Activity 1.3: Questionnaire preparation	*600*	*1,400*		*500*	*200*	*2,700*
Activity 1.4: Collection and classification	*1,000*					*3,200*
Activity 1.5: Data processing	*600*		*2,000*	*500*	*100*	*800*
Activity 1.6: Determination of calorific value	*300*			*500*		*800*
Activity 1.7: Determination of moisture content	*300*		*500*			*1,300*
Activity 1.8: Determination of ash and chemistry	*300*			*1,000*		
Activity 1.9: Determination of fuel density	*300*					*300*
Subtotal 1	*5,810*	*1,400*	*2,500*	*3,550*	*600*	*13,860*
OUTPUT 2: Commercial options for efficient utilisation of wood wide determined.						
Activity 2.1: Determination of size of market	*600*	*1,000*		*400*		*2,000*
Activity 2.2: Determination of relevant social factors	*600*	*1,000*		*400*		*2,000*
Activity 2.3: Determination of environmental factors	*1,200*			*400*		*1,600*
Activity 2.4: Determination of suitable technology for selected commercial options.	*900*	*300*		*400*	*500*	*2,100*
subtotal 2					*500*	*7,700*
OUTPUT 3: Size of co-generating plant determined	*600*	*1,000*		*400*	*400*	*2,400*
Activity 3.1: Identification of sites with good co-generation potential						
Activity 3.2: Determination of thermal energy demand profiles600	*600*	*1,000*		*400*	*400*	*2,400*
Activity 3.3: Determination electrical energy demand profiles	*600*	*1,000*	*4,350*	*400*	*400*	*6,750*

Activity 3.4: Determination the specification for co-generation plants	*600*			*400*	*400*	*1,400*
subtotal 3	*2,400*	*3,000*	*4,350*	*1,600*	*1,600*	*12,950*
OUTPUT 4: <u>Economics and marketing potential of co-generation plant determined.</u>						
Activity 4.1: Identification of scope for the application of the technology	*1,200*	*1,000*		*400*	*400*	*3,000*
Activity 4.2: Cost of existing energy systems and fuels	*600*	*1,000*		*400*	*400*	*2,400*
Activity 4.3: Economic viability of the co-generation.	*900*	*1,000*		*400*	*400*	*2,700*
Activity 4.4: Carefully selecting the markets indicating those, which should be targeted as initial adopter of technology.	*900*	*1,000*		*400*	*400*	*2,700*
subtotal 4	*3,600*	*4,000*		*1,600*	*1,600*	*10,800*
OUTPUT 5: <u>Stakeholders participation for adoption of technology.</u>						
Activity 5.1: Creating awareness of economic benefit of co-generation briquettes and other commercial options.	*2,000*	*1,000*		*400*	*400*	*3,800*
Activity 5.2: Publication of results in scientific journals	*1,200*	*200*		*400*	*400*	*2,200*
Activity 5.3: Preparation of brochure for promotion	*2,000*	*400*		*400*	*400*	*3,200*
Activity 5.4: A draft final report preparation.	*1,200*			*400*		*1,600*
Activity 5.5: A final report preparation	*1,200*			*400*		*1,600*
Activity 5.6: Presentation of findings	*1,200*			*400*		*1,600*
subtotal 5	*8,800*	*1,600*		*2,400*	*1,200*	*14,000*
Non-Activity Based Expenses *(2) Auditing*					*500*	
Subtotal 6					*500*	*8,500*
Subtotal (ITTO)	*23,910*	*12,300*	*6,850*	*10,750*	*6,000*	*59,810*
Subtotal (E. Agency)	*6,525*	*-*	*2,625*	*513*	*31*	*3,470*
TOTAL	*30,435*	*12,300*	*9,475*	*11,163*	*6,031*	*63,280*

6.4. PROJECT BUDGET - E. Agency/Host Government (Duration of Project is One Year)

Budget Components	***Total***
10. Project Personnel	*6,525*
30. Duty Travel	*-*
40. Capital Items	*2,625*
50. Consumable Items	*413*
60. Miscellaneous	*31*
EXECUTING AGENCY/HOST GOVERNMENT TOTAL	***9,594***

PART III: TROPICAL TIMBER FRAMEWORK

1. Compliance with ITTA objectives

This proposal complies with three out of the eight ITTO objectives. This project will:

(i) Contribute to research and development with a view to improving forest management and wood utilisation. The fact that wood waste will be used shows that management of the forest will be improved in terms of the felling in the long term and help in the forest conservation. It may be possible to use lesser-known and lesser-used species which are normally destroyed and/or left over in the forest to rot when economic species are extracted.

(ii) Encourage and increase further processing of tropical timber in producer member countries. Energy from wood processing residues could be used to raise process heat for:

(a) steaming peeler logs and more efficient processing
(b) drying of lumber an activity essential to down stream processing

(iii) Waste from processing mills could be used to generate energy and this reduce the mills dependency on conventional energy

(iv) Improved marketing and distribution of producer's exports of tropical timber export of dried lumber and value-added processing ensure higher returns to producer.

Products are protected against agents of biodeterioration. This will reduce claims against producers.

2. Compliance with ITTO Action Plan

(i) The proposal is related to elements and priorities on:-

(a) Putting in place measures to improve industrial efficiency and discourage wasteful and harmful practices.

(ii) Support for industrial trials and pilot production

(iii) Promoting the integrated development of sustainable forest management and industrial use of wood waste and lesser use species

(iv) Adequate resources are allocated towards further R&D to identify equipment and processes which will be robust, and adaptable to conditions expected at the locations where there would finally be installed

3. ANNEX A - PROFILE OF THE EXECUTING AGENCY

3.1 Expertise of the Executing Agency

The mission of FORIG which is a forestry research institute and which is the executing agency is to conduct use focused research that generates scientific knowledge and appropriate technologies which enhance the sustainable development conservation and efficient utilisation of Ghana's forest resources; and also disseminate the information for the improvement of social, economic and environmental well being of the people of Ghana.

Completed and ongoing ITTO assisted projects are as found at Annex C page 34.

3.2 Infrastructure of the Executing Agency

The Institute's permanent offices and laboratories are located at Fumesua, near Kumasi. It has research centres at Bobiri and Amantia both in the moist, semi-deciduous forest zone, Benso in the Wet Evergreen Zone, Pra-Anum Area, Main Northern Grassland and Bia Tano and Asenanyo. The laboratories of the Institute have a wide range of equipment for research and development. They include impregnation plants, seasoning kilns, wood testing machines, microscopes, growth chamber, UV spectrophotomer and Instron machine.

The Institute's library facilities include a CD-Rom workstation and the CD compiled by CAB International.

3.3 Personnel

(a) Total staff	-	283
(b) Quantitative experts with post graduation degrees (Ph.D.)	-	17
(c) Quantitative experts graduation degrees (M.Sc./M.Phil.)	-	15
(d) Quantitative experts graduation degrees (B.Sc./B.A.)	-	12
(e) Research grade	-	45
(f) Quantitative Middle Level Technicians	-	33
(g) Administrative personnel	-	21
(h) Supporting staff	-	184

ANNEX B

CURRICULUM VITAE OF DR. DANIEL SEKYERE

PERSONAL PARTICULARS

FULL NAME : Daniel Sekyere
TOWN OF BIRTH : Old Tafo
COUNTRY OF BIRTH : Ghana
DATE OF BIRTH: 21st September,1949
NATIONALITY : Ghanaian
PRESENT POSITION: Senior Research Institute
PRESENT ADDREESS: Forestry Research Institute of Ghana; University, P. O. Box 63, Kumasi, Ghana

QUALIFICATIONS:

B.Sc (ed) Chemistry (Major) Biology (Minor) and Education
University of Cape Coast, 1973.

Maitrise (C4) Macromolecular Chemistry
Universite Scientifique et Medicale de Grenoble, (U.S.M.G) France, 1978

Diplome Etude Approfondie (DEA)
Spectroscoppy Methods
USMG (France) - 1979

Doctorat 3ieame Cycle : Pulp & Paper Engineering
Institute National Polytechnique de Grenoble; (I.N.P.G.) France - 1981

Recent Conferences

i. xxi IUFRO Congress (2000), Kuala Lumpur, Malaysia, August 6th - 13th
ii. International Conference on value-added processing and utilization of lesser-used timber species, (ITTO & TEDB, FORIG) Kumasi, Ghana 1998.

Selected Publications

i. Jetua, F. K. , Tando, J. K. and Sekyere, D. (2000): "Utilization of tannin from bark of Acacia nilotica for formulation trials of tannin-phenol-formaldehyde adhesive", Ghana Journal of Forestry vol. 9 p21-26.

ii. Sekyere, D. (1997): "Pulping characteristics of *Gmelina arborea* and *Musanga cecropiodes*". Ghana Journal of Forestry vol. 4 p63-68.

iii. Sekyere, D. Pla, F. and Robert (1983) "Delignification of *Pinus caribaea*" Holzforschung und Holzverwertung 35, 6, p135-139.

iv. Sekyere, D. Pla F, and Robert (1983) "Pulping of *Pinus caribaea* in sodium hydroxide with addition of Anthraquinone acid treatment and oxygen/alkali delignification" Holzfurschung und Holverwertung 35, 6 p140 -145.

Position & Relevant Work undertaken recently

- .Head of Chemistry and Chemical Technology Division, FORIG - 2001
- Visiting Senior Lecturer for three years, Kwame Nkrumah University of Science & Technology, Kumasi, Ghana, - 1998 - 2001
- Project leader Ghana Government priority project on appropriate technologies for pulping and production of paper products 1993 - 1997

CURRICULUM VITAE OF DR. PHILIP YAW OKYERE

PERSONAL PARTICULARS

NAME	Philip Yaw Okyere
Present Position	Senior Lecturer - Head of Department (1997-1998)
Address	Dept. of Electrical & Electronic Engineering - KNUST, Kumasi
Nationality	Ghanaian
Date of Birth	13th February, 1955

QUALIFICATIONS

(i) Dr-Ing in Electrical - Higher National School of Electrical Engineering (ENSIEG) GRENOBLE, France - 1985

(ii) D.E.A. ("Mention Bien") in Electrical Engineering - Higher National School of Electrical Engineering (ENSIEG), GRENOBLE, France - 1985

(iii) B.Sc. (First Class) in Electrical Engineering, University of Science and Technology (KNUST), Kumasi, Ghana - 1979

Selected Research and Development

- Finding an efficient method of building a linearised model for a large multi-machine power system - 1986
- Partitioning a large interconnected power system into sub-systems taking into consideration the dynamic interaction among the system components - 1988
- Improving the modal technique of equivalent external system for transient stability study of large interconnected power system - 1990
- Development of electronic products for photovoltaic systems 1995/1996 Teamwork. Project sponsored by CIDA-Mechanical Engineering Solar Laboratory
- Development of a Geographic Information System for Electricity Company of Ghana's Network Assets and Customer Records - 2001-2002 Teamwork

Publications

1. Okyere P.Y. "Inversion of Y-matrix occurring in a linearised multi-machine power systems for dynamic studies", Journal of University of Science and Technology, Vol. 13 No. 1pp 21-32 February, 1993.

2. Okyere P.Y. "Methods for constructing optimal and sub-optimal aggregated models" The Ghana Engineer, Vol. 14 No. 1, pp. 43-49, March, 1994.

3. Okyere P.Y. "The use of aggregation technique in power system stability studies" The Ghana Engineer Vol. 14, No. 1, pp 51-60, March, 1994.

Papers read at Conferences

1. OKYERE, P.Y., ANIPA, D., DANKU, M., GBOLOO-TEYE, M.K.: "Microcomputer-based alarm system", Annual General Conference of Ghana Institution of Engineers, 30th March 1996.
2. OKYERE, P.Y., ANIPA, D., DANKU, LAMPTEY, J.D.: "Design and construction of Uninterruptible Power Supply (UPS) for Personal Computers", Annual General Conference of Ghana Institution of Engineers, 30th March, 1996.
3. AGODZO, S.K., OKYERE, P.Y., KUSI-APPIAH, K: "The use of Wenner Configuration to Monitor Soil Water Content", EnrAgEng, AGENG, WARWICK 2000, Paper No. 00-SW-018.

CURRICULUM VITAE OF DR. OSEI ABORAMPA KUFOUR

PERSONAL PARTICULARS

NAME: Dr. Osei Aborampa Kufour
PRESENT POSITION: Lecturer
ADDRESS: Department of Economics and Industrial Management, Kwame Nkrumah University of
Science and Technology (KNUST) Kumasi, Ghana
NATIONALITY: Ghanaian

QUALIFICATIONS

(i) Ph.D. (1981): Resource Development, Planning Management and Policy; Community and Resource Development World, Michigan State University, East Lansing, U.S.A.
(ii) M.A. (1976): Quantitative Methods in Economics, Development Economics; Industrial Organisation, University of Michigan, Ann Arbor, U.S.A.
(iii) B.A. (1973): Geography, Economics and Education, University of Cape Coast

TEACHING EXPERIENCE

(i) Visiting Lecturer, JFE (AERC), Nairobi - Kenya Environmental Economics
(ii) Adjunct Assistant Professor, University of Liberia, Monrovia, 19: 85-1990.
(iii) Visiting Assistant Professor, Central Michigan University - U.S.A, 1981-1982.
(iv) Department of Economics and Industrial Management, KNUST, Environmental Economics - 1991-2002.

CONSULTANCY

(I) Bank of Ghana - IMF Project (1982-1983): A Socio-Economic Baseline Survey of Rural Bank, Biriva.
(II) ADB-IMF Project on Energy Systems (1994-1995)
(III) UNDP (1986-1987): Fertility Differential among some Ethnic Groups in Liberia.

ON-GOING RESEARCH

Lending under Structural Adjustment-Programme (SAP): The Debt Burden of African Economic.

OTHER EXPERIENCES

(I) Acting Head and Co-ordinator of M.A. Programmes, Department of Econs. & Industrial Management, KNUST, Kumasi (1993-1997).
(II) Examiner, Institute of Chartered Accountants (Ghana), up-to-date.
(III) Examination Moderator, West African Exams, Council, up-to-date

SELECTED PUBLICATION

(i) 1998 - African Debit Burden and Economic Growth, Seminar
(ii) Prof.Berg E. & Osei A. Kuffour (1976-77): Production and Marketing of Cereals in Gambia
(iii) Prof. Kimball and Osei A. Kuffour (1978-1979): "Michigan Landuse Report and Statistics.
(iv) Osei A. Kuffour (1979): An Analytical Framework for Land Protection Policy in Michigan, USA.

MEMBERSHIP

(I) American Academy of Political and Social Sciences (AAPSS)
(II) American Agricultural Economics Association (AAEA)
(III) Community Development Society of America (CDSS)
(IV) Economic Society of Ghana
(V) Member, Editorial Board, Economic Bulletin of Ghana

CURRICULUM VITAE OF MR NKETIAH KWABENA SAMUEL

A. PERSONAL DATA

NAME: *Nketiah Kwabena Samuel*
NATIONALITY: *Ghanaian*

B. ACADEMIC QUALIFICATIONS

M.Sc. Wood Science (Wales), M.Sc. Wood Technology and Industrial Management, Kwame Nkrumah University of Science and Technology (KNUST, Ghana), B.Sc. Chemical Engineering (KNUST, Ghana).

C. RELEVANT EMPLOYMENT RECORD

February 1999: Date head, Business Development and Information Division, Forestry Research Institute of Ghana.

April, 1993-1994: Deputy General, Manager, Ghana Veneer Processing Company Limited, Kumasi (on secondment).

May-November 1988: National Co-ordinator, UNDP-Study on the charcoal cycle in Ghana.

D. RELEVANT RESEARCH EXPERIENCE

1992: Prospects for commercial charcoal production from logging residues. Work carried out for the Ministry of Energy.
1990: Pilot study on industrial fuelwood consumption by the Palm Oil Industry
1988: Feasibility studies on the production marketing and use of sawdust briquette in Kumasi, Ghana.
1988: UNDP-sponsored baseline study of the charcoal cycle in Ghana
1984: Feasibility study for commercial charcoal production from clear-felled site for open-cast mining at Awaso, Ghana.

E. SELECTED REPORTS, PAPERS AND PUBLICATIONS

1. *Nketiah, K.S. (1995). The use of coconut industry waste for energy. Country paper for Ghana, presented at International workshop by UNIDO in Bali, Indonesia - 6^{th} - 10^{th}, 1995.*

2. *Nketiah, K.S. (1992). Report on the prospects of commercial charcoal production from logging residues 65pp.*

3. *Nketiah, K.S. and Asibey, E.O.A. (1989). Alternatives to woodfuel as household source of energy 15 pages.*

4. *Nketiah, K.S., Hagan, E.B. and Addo, S.T. (1988). The charcoal cycle in Ghana. A baseline study. 128pp.*

ANNEX C

Key Staff

1. Dr. Daniel Sekyere - Project Leader/Chemist
2. Dr. Philip Yaw Okyere - Electrical Engineer
3. Mr. Nketiah Kwabena Samuel - Chemical Engineering/Energy Specialist
4. Dr. Osei Aborampa Kufour - Socio-Economist

Dr. Daniel Sekyere: Project leader - Forestry Research Institute of Ghana (FORIG). Execution and Co-ordination of all aspects of the project. Collection and collation of project reports for all participating scientists.

Dr. Philip Yaw Okyere (Electrical Engineer) - Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (KNUST). He will be responsible for the co-generation.

Mr. Nketiah Kwabena Samuel - Chemical Engineering/Energy Specialist will be responsible for environmental issues and fuel analysis.

Dr. Osei Aborampa Kufour - Socio-Economist will be responsible for Economic Analysis.

ANNEX D: CHANGES IN RESPONSE TO SPECIFIC RECOMMENDATIONS

1. The study should be limited to identifying and documenting commercial options for the utilization of forest and wood waste and further business opportunities for the local Ghana industry.

   Reaction: *Output 2 and its activities have been redefined as highlighted on page 14 to meet this requirement. The justifications of output 2 have been highlighted on page 11.*

2. The specific objective as stated in section 3.1 should be more clearly formulated and focus on documenting the opportunity for biomass co-generation that addresses domestic energy consumption.

   Reaction: *The specific objective has been reformulated and the outputs and activities have been amended to fulfil the objective. The specific objective has been highlighted on pages 5 and 13 and the modifications of the outputs and activities on pages 13 and 14.*

3. The technical and scientific aspect should note the need to assess and document the thermal characteristics of the residues. As such, Output 1 (determining availability of wood residues) should be clearly linked to the technical and scientific aspects.

   Reaction: *A brief description of the characteristics has been given under the technical and scientific aspect section. This has been highlighted on pages 11 and 12. The output 1 and its activities have been amended to include the assessment of the characteristics of the residue. Please refer to page 14 for the change, which has been italicised.*

4. The budget should more closely and carefully follows the ITTO budget format.

   Reaction: *The budget has been modified to conform to ITTO budget format. Please refer to pages 17-27.*

5. The briquetting option should be re-evaluated within the pre-project design.

   Reaction: *The development of appropriate stove technology and the testing of the binding strength of properly dried non-carbonized briquetting have been removed. Rather a comprehensive analysis of both the technical, social and economic factors that affect the production, distribution, market and use of briquettes has been emphasised (Please refer to Pages 9 and10). The study of briquette technology will be considered alongside other commercial options as indicated by output 2 and its activities. See page 14.*

Others

The amendments made in reaction to the specific recommendations have resulted in changes in the budget. ITTO contribution has fallen from $85,507 to $63,100 US dollars. The Ghana Government's contribution has increased $10,700 to $13,064 US dollars. Please refer to page 1.

In the light of the above changes, the Agricultural Engineer and Machining Expert (Product Development Technologist) has been replaced by Chemical Engineer/Energy Specialist. Please see page 35 for his CV.