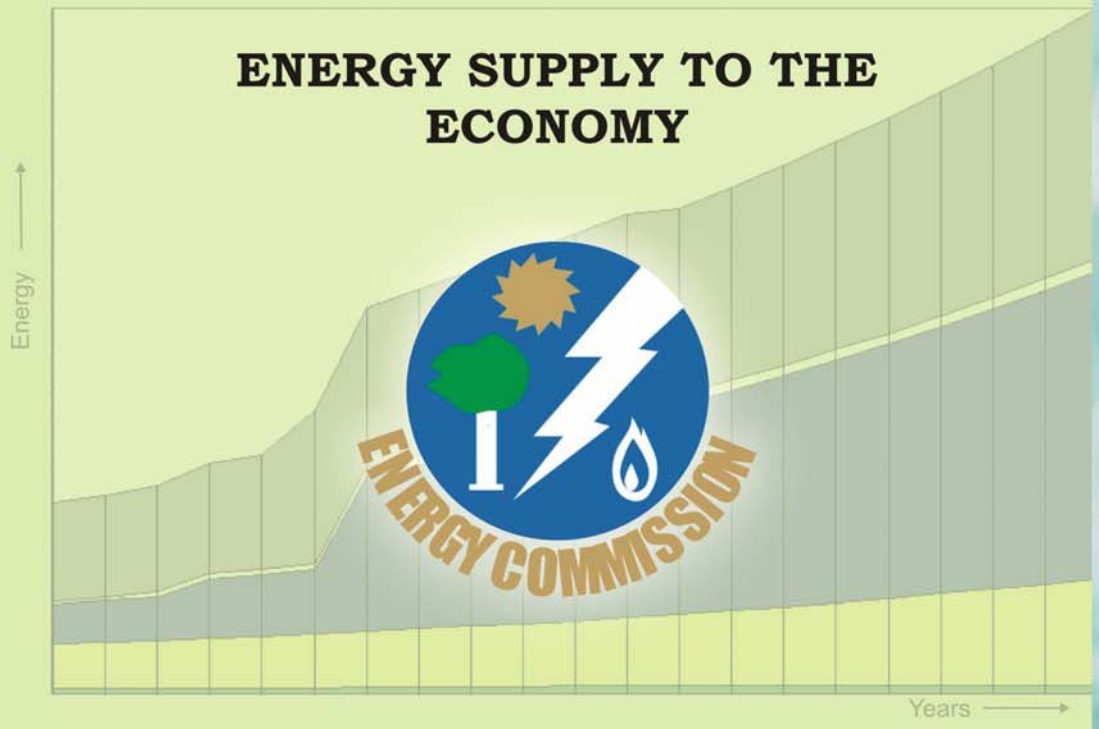
Strategic National Energy Plan

2006 - 2020



Annex IV of IV

WOODFUELS AND RENEWABLES

Energy Commission, Ghana

July, 2006

Strategic National Energy Plan 2006 – 2020

Annex Four of Four

ENERGY SUPPLY TO THE ECONOMY

Woodfuels and Renewables

Energy Commission
July, 2006

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PREFACE

THE ENERGY COMMISSION is required by law to prepare, review and update periodically indicative national plans to ensure that all reasonable demands for energy are met in a sustainable manner. In conformity with this mandate, the Commission has developed and elaborated a Strategic National Energy Plan (SNEP) for the period 2006 - 2020.

The goal of SNEP is to contribute to the development of a sound energy market that would provide sufficient, viable and efficient energy services for Ghana's economic development through the formulation of a comprehensive plan that will identify the optimal path for the development, utilisation and efficient management of energy resources available to the country.

In developing and elaborating the SNEP, the Energy Commission has since 2000 conducted empirical studies and workshops. Series of stakeholders' consultative meetings were held where Working and Issue discussion groups were formed for the various energy and economic sectors. Members of the discussion groups were drawn from major institutions representing the various sectors of the economy. For sectors where data were not available or outdated, consultants were engaged to collect the data to update and as well fill the missing gaps. Based upon an assessment of the existing institutional framework and energy demand and supply situation, issues papers on the various energy sub-sectors were also prepared by consultants which served as discussion documents at stakeholders' consultative meetings. Consultants' reports were reviewed at the Working Group level and finally by a Technical Committee.

The energy sector is broadly divided between demand for energy and supply of energy to the economy. The draft SNEP document was therefore divided into two volumes to facilitate ease of discussion:

" Volume One covered the Demand Sectors of the Economy, namely Residential (household); Commercial & Services; Agriculture & Fisheries; Industry and Transport*

" Volume Two covered the supply-side of the energy sector, namely, electricity; petroleum; woodfuels and renewables. Volume Two was further divided into three parts; Part I - Electricity; Part II - Petroleum; and Part III - Woodfuels and Renewables.

The SNEP documents were placed at the website of the Energy Commission to solicit for comments from the wider general public. Key stakeholders were further invited to discuss the

* Within the national economic statistics framework, Transport is a subsector of Commercial & Services. However, the energy utilisation in the transport sector has a significant impact on the economy necessitating it to be treated as a separate demand sector.

draft documents and provide comments as well. The Stakeholder meeting for the Volumes Two Part 1 - Electricity was held on February 15, 2005. It was followed by stakeholder meetings for the Volumes Two Part III - Woodfuels & Renewables and Volumes Two Part II - Petroleum held on 18 January and 26 January, 2006 respectively. Volume One was discussed alongside Volume Two.

About 49 key organisations cutting across the related sector ministries and governmental committees, agencies and regulatory bodies, private and state enterprises, non-governmental institutions, trade unions, consultancy and advocacy groups, educational and research institutions participated in the stakeholder meetings. Individual expects in their personal capacities also attended the meetings. Besides, the specialised stakeholders and the individual experts, the cross-section of the press representing the print and electronic media and from both the public and private media houses actively participated in all the deliberations.

The list of institutions which participated in the SNEP process including the press is also available as an Appendix to the SNEP document.

All comments have been incorporated in the main unified SNEP document titled STRATEGIC NATIONAL ENERGY PLAN AND POLICY RECOMMENDATIONS. The previous Volumes One and Two have been reorganised and presented as Annexes to the main document as follows:

" Annex I of IV: SNEP Energy Demand Sectors of the Economy
" Annex II of IV: SNEP Electricity Plan
" Annex III of IV SNEP Petroleum Plan
" Annex IV of IV: SNEP Woodfuels & Renewables Plan

The Energy Commission acknowledges the financial support, expert guidance and advice that it received from the Royal Danish Government through DANIDA# in the early stages of the development of the SNEP. The Danish support, which ended in 2003, was administered by Ramboll, a Danish consultancy firm.

The efforts of the Ramboll and the core professional staff of the Energy Commission who worked on the SNEP are hereby acknowledged.

The Energy Commission acknowledges the financial support provided by UNDP Household Energy Programme for the printing of the Annex IV of IV

Executive Secretary

Danish International Development Agency

Background

Woodfuels[1]

1. Woodfuels account for more than 60 percent of total energy used in Ghana (figure 1). It is the traditional energy source of Ghana. The bulk of the country's primary energy supply comes from wood, i.e. biomass. 14-16 million tonnes (around 25 - 28 million cubic metres) of wood were consumed as fuel annually between 2000 and 2004. Woodfuel is renewable and sustainable if supply could increase to meet demand.

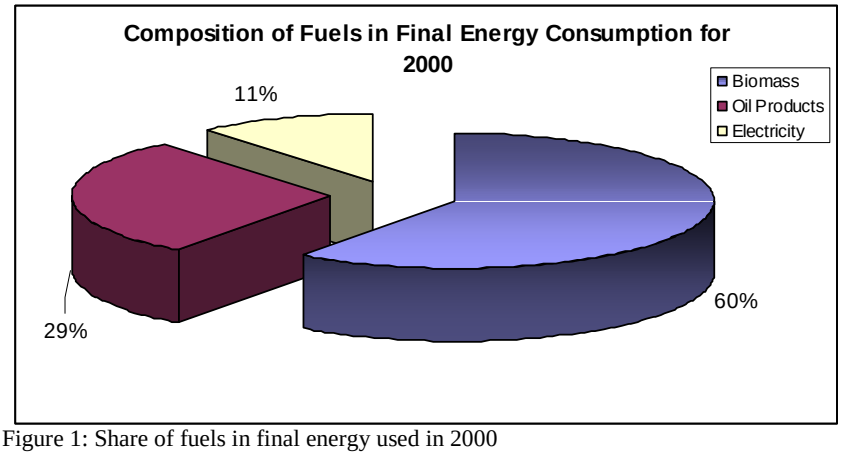

Figure 1: Share of fuels in final energy used in 2000

2. Woodfuels provide the bulk of the energy needs for most informal enterprises such as bread-baking, processing of oil-palm, brewing of local drinks, tobacco curing, traditional textiles (tie and dye, batik), traditional soap making, fish smoking, etc.

3. The woodfuel subsector is the only energy subsector where the cooking appliances and almost all the production equipment with the exception of chainsaws, are produced locally. It is estimated to contribute about 2 percent of the Gross Domestic Product and indirectly supports the livelihood of over three million Ghanaians, mostly engaged in the informal, commercial and service sectors. Woodfuel production involving fuel collection and charcoal burning is itself a source of income for the rural population. It has been estimated that more than 65 percent of the people engaged in the woodfuel business are women.

Woodfuel Supply-Demand Balance

4. In 2000, the national wood stock for fuel was estimated as 813 million tonnes. Average annual wood production is about 30 million tonnes and the potential woodfuel supply is estimated at 18 million tonnes per annum. Sources of the wood are from about 87 percent of the country's landmass of around 24 million hectares with most of them being traced to farmlands and the Savannah.

[1] Energy Commission is the only public institution mandated to develop the country's renewable energy resources

5. The woodfuel balance for 2000 - 2004 is as follows:

		2000	2001	2002	2003	2004
WOODFUEL BALANCE						
Supply Requirement						
A	Average wood supply for fuel	30.7 million tonnes per annum				
B	Potential primary woodfuel supply	18.0 - 20.0 million tonnes				
Consumption		Million tonnes				
C	Wood used as firewood	7.1	8.0	8.3	8.6	8.7
D	Wood for charcoal[2] production	5.0 - 7.5	5.2 - 7.8	5.4 - 8.1	5.6 - 8.4	5.8-8.5
C+D	Total primary woodfuel consumed	**12.1 - 14.6**	**13.2 - 15.8**	**13.7 - 16.4**	**14.2 - 17.0**	**14.5 - 17.2**
Percentage shares of Demand Sectors						
	Residential	*72.3*	*71.8*	*71.3*	*70.8*	*71.0*
	Agriculture and fisheries	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
	Industry	*24.5*	*25.9*	*25.4*	*25.8*	*25.7*
	Commercial & Services	*3.1*	*3.2*	*3.2*	*3.2*	*3.2*

6. Total charcoal export in 2001 was about 2,770 tonnes, increasing to almost 4,600 tonnes in 2003. However, some of the charcoal exported used to come from natural forest, but with regulations and administrative order effected by the Energy Commission, charcoal export from natural forest has officially been stopped. Only charcoal produced from woodwastes and owned plantations is permitted and the quantity exported in 2004 fell to 2,900 tonnes.

7. About 90 percent of the woodfuels are obtained directly from the natural forest and the savannah woodlands. The remaining 10 percent is obtained from logging and sawmilling waste.

8. The transitional and savannah zones of Ghana are the major sources of woodfuels preferred by most Ghanaian homes.

9. There are signs that some preferred species for woodfuel production are disappearing and are resulting in producers having to travel longer distances in search of the desired species.

10. Charcoal production requires a lot of raw wood; between four to six units of wood are needed to produce one unit of charcoal, depending upon the quality, type of wood and the type of kiln used.

11. However, almost all the kilns in the country are the traditional earthmound, which is least efficient in terms of charcoal yield.

[2] Based on the assumption that between 4 - 5 units of wood is required to produce one unit of charcoal. 4 units of hard wood yields about a unit of charcoal, whilst 6 units of soft wood yields about a unit of charcoal.

12. Besides, not all parts of the felled tree are used for charcoal production; for every tree felled about 20 - 30 percent goes into 'waste'[3] .

Woodfuel Pricing and cost

13. The pricing of woodfuels is purely by demand and supply. There is no price regulation authority for woodfuels and neither is there an association of suppliers responsible for pricing of woodfuels.

14. Most woodfuels produced in the savannah woodlands of the north, are transported as charcoal to the south, mainly Ashanti and Greater Accra Regions.

15. Wholesale retailing is in maxi jute bags and of average weight between 45 - 50 kilogrammes. Production cost of charcoal is about US $16 equivalent per tonne in the Savannah zone and about US $50 equivalent per tonne in the forest zone. Weighted average cost of production is about US $23 equivalent per tonne. Production costs of charcoal produced from sawmill residue is between US $5 - 6 equivalent per tonne .

16. Charcoal produced in the Savannah zone is usually sold at an average price of about US$ 78 equivalent per tonne on reaching the southern Ghana market. Firewood is retailed at US $23 equivalent per tonne in the south.

17. Comparatively, LPG costs US $313-350 per tonne and kerosene has been US $277-300 per tonne between 2003-2005, making woodfuels the financially least expensive of all the cooking fuels.

18. Secondly, whilst the prices of petroleum products have been erratic, the price of charcoal when indexed to the US dollar had been stable for more than a decade.

19. Traditional charcoal stove popularly called 'coalpot' sells at about US$1.5-3 equivalent per stove depending upon the quality of metal used in the fabrication. Efficient charcoal cook stoves such as Ahibenso which saves 35-40% of charcoal usage compared with the traditional 'coal pot' that sells from US $ 5 - 10 equivalent per stove depending upon the size of the stove.

Renewable Energy

20. Renewable energy resources are diverse. They include solar, biomass, wind, hydro, geothermal and tidal, and varies from country to country. Ghana's known renewable energy resources are solar, biomass, wind and hydro. Discounting traditional woodfuel biomass, Ghana's renewable energy resources are largely untapped except for the large hydropower plants of Akosombo and Kpong.

[3] There are suitable for charcoal burning so are used for other purposes which include direct use as firewood.

21. The development of the country's renewable energy resources has been seen as a credible option that has the potential of relieving the energy needs of the poor and securing the country's energy supply. Solar energy has been used for electricity production, crop drying and water heating over the years. For instance, a survey of villages fitted with stand-alone solar home systems for lighting, radio and television between 2001-2002 indicated that when compared with the period before the solar projects:

i. More than 50 percent of adults could now watch television and listen to radio or play cassette.

ii. Television acquisition of Solar Home Systems (SHS) has increased threefold.

iii. Commercial activities in the evenings have increased by 30-50 percent.

iv. With access to solar power in off-grid areas, emergency health cases like child delivery could be well attended to at night in better lighting, and preservation of vaccines improves with solar powered electric refrigeration.

22. Solar energy in the form of sunlight is still the main energy for drying of cloths and farm produce in the country. About 7,000 tonnes of oil equivalent of solar energy was utilised in drying the nation's cocoa production in 2004 (table 1).

23. Even though, Solar Water Heaters have been known and their potential has been tested and demonstrated over the past two decades, their market penetration in the country is very low. The main problem that has limited the wider application of solar water heaters is their high initial cost compared to electric water heaters and apparent high import tariff.

24. Both natural convection and forced convection solar dryers have been field tested for the past two decades in the country and have been used for the drying of mainly crops and wood. An experimental one tonne capacity dryer for cereals and pepper was tested at Agona Asafo in the Central Region for two years with proven results. The economics of solar dryers for large-scale applications seem favourable for export crops.

25. Biomass based energy, apart from the direct use of firewood and charcoal, has been exploited to a very limited extent in Ghana. Biomass used for the generation of electricity, biogas or liquid fuels remains largely untapped. Some biomass-fired co-generation projects have been implemented in the oil-palm industry, but are under-utilised. Two key factors have hindered their exploitation especially in wood processing industry even though there seem to be some potential for it. Firstly, potential co-generators have access to lower cost grid power. Secondly, there are virtually no financial or fiscal incentives neither is there a regulatory framework that would encourage them to generate and sell electricity to the grid.

26. Biogas technology has been demonstrated for cooking in households, direct lighting, small power generation, and bio-sanitation. The use of biogas technology for cooking in residential households and small power generation has not been successful. Indeed, most of the household biogas plants built in the country have been abandoned. The average cost of electricity generated from biogas is about 50 US cents per unit of electricity compared to diesel and gasoline based generation (13-20 US cents per unit

of electricity). A very interesting development in the use of biogas technology, however, has been in the area of bio-sanitation projects for schools, slaughterhouse, hospitals, etc. Bio-latrine is now being romoted throughout the country. Biogas from sanitation wastes is being piped to kitchens for use as cooking fuel in at least three mission hospitals in the country.

27. Biofuels are liquid formulae derived from plants. The properties of biodiesel are similar to standard diesel and thus are capable of substituting the latter. Most biodiesel can be blended with standard diesel. Bio-diesel as a supplement to regular diesel for powering grain mills in off-grid communities is already being experimented in some villages in the country. The results obtained so far indicate promising prospects to substitute for regular diesel in remote areas for applications like milling.

28. The biofuel substitute for petrol is alcohol. Although, the most promising plant is sugarcane, cassava holds another promise and perhaps integrating alcohol production into the on-going Presidential Special Initiative (PSI) on cassava starch could improve the economic viability of the PSI.

Renewable Energy Utilisation

29. Solar energy accounted for the sun-drying of cocoa; cereals consisting of maize, paddy rice, sorghum and millet; vegetables consisting of groundnuts and pepper (export component only); and other exportable commodities requiring drying, namely sheanuts, coffee robusta, cashew nuts, kola nuts and cocoa wastes. About 15,000 tonnes of oil equivalent (TOE) was used in 2000 for the drying of cocoa and cereals rising to almost 18,000 TOE by 2004 (table 1)[4].

Table 1 Solar Energy used for drying of farm produce 2000 – 2004

FARM PRODUCE	*2000*		*2001*		*2002*		*2003*		*2004*	
	Produce Tonnes	**Energy TOE**	**Produce Tonnes**	**Energy TOE**	**Produce Tonnes**	**Energy TOE**	**Produce Tonnes**	**Energy TOE**	**Produce Tonnes**	**Energy TOE**
Cocoa	**437**	**4,342**	**390**	**3,877**	**341**	**3,388**	**497**	**4,941**	**737**	**7,327**
Cereals	**1,711**	**10,493**	**1,648**	**10,520**	**2,155**	**12,641**	**2,042**	**11,722**	**1,828**	**10,494**
Total		**14,835**		**14,397**		**16,029**		**16,663**		**17,821**

30. Solar energy for the production of electricity ranged from 1.3 - 1.8 Gigawatt-hours which translate into about 140 tonnes of oil equivalent (table 2)[5].

[4] The basket for the computation of commercial solar energy will be expanded in future as more reliable data become available Cereals were a basket of maize, paddy rice, sorghum, millet.

[5] In terms of numbers, solar energy used for largely home lighting is the most populous, numbering over 5,000 systems. In terms of system capacity, the telecom and the water pumping systems are the largest,

Table 2: Inventory of Solar Photovoltaic applications in Ghana as of 2004

SOLAR SYSTEMS	Installed Capacity	Generation
	Kilowatt	Gigawatt-hour
Rural Solar home systems	450	0.70 - 0.90
Urban solar home systems	20	0.05 - 0.06
Systems for schools	15	0.01 - 0.02
Systems for lighting health centres	6	0.01 - 0.10
Vaccine Refrigeration	42	0.08 - 0.09
Solar Water Pumps	120	0.24 - 0.25
Telecommunication	100	0.10 - 0.20
Battery charging stations	10	0.01 - 0.02
Grid connected systems	60	0.10 - 0.12
Solar streetlights	30	0.04 - 0.06
Total	**853**	**1.34 - 1.82**

31. Apart from solar energy for electricity generation via photovoltaics and for drying of some commercial farm produce, there has not been any inventory of solar energy for water heating since the beginning of the decade[6].

32. Wind and biomass power generation systems have been spotted in the country, but yet to be captured in the electricity balance, due to lack of data. The most significant biomass co-generation plants identified are:

Plant location	Installed capacity	Average annual production
Kwae Oil Mills	420 kW	1.50 GWh
Benso oil mills	500 kW	1.90 GWh
Twifo Oil mills	610 kW	2.10 GWh
Juaben Oil mills	424 kW	1.50 GWh

Renewable energy pricing and cost

33. There is presently no price regulation for renewable energy products. Imported renewable energy components such as solar modules are however exempted from payment of duty and VAT. Users of renewable energy electricity generators[7] unlike their grid-connected counterparts do not enjoy any tariff subsidies.

34. Solar technologies particularly PV systems appear favourable in terms of number of systems installed since it is relatively portable and simple to install and use, even though, it costs more per unit electricity generated. Biomass/biogas systems appear complex to install but are more economic in terms of per unit cost of electricity capacity installed.

[6] The last inventory of solar crop dryers and water heaters was in the mid 1990s carried out by the technical wing of the Ministry of Energy.
[7] Excluding hydro from Akosombo and Kpong hydroelectric plants.

35. Cost of solar PV systems including installation range from US $10-20 per Watt peak depending upon the PV technology and complexity from simple home systems to grid connected systems. Average cost of solar PV electricity ranges from US $22 - 75 per kWh.

36. The cost of solar powered refrigerators for domestic use range from US $700-900 compared with conventional refrigerators of similar sizes selling at US $300-400.

37. 150 - 200 litre solar water heaters in the country are retailed at US $800-900 compared with insulated storage electric water heaters of the same size, which sells at US$60-200 per unit.

Woodfuel Projections and Shortfall

38. The projected future demand for wood for use as firewood and for the production of charcoal is as follows:

	2008	2012	2015	2020
GPRS High Economic growth scenario in million tonnes				
Wood for use as firewood	17.5	20.8	23.7	29.4
Wood required for charcoal	15.7 - 23.6	16.9 - 25.4	19.3 - 29.0	24.1 - 36.1
Total wood required	33.4 - 41.2	37.9 - 46.4	43.2 - 52.9	53.7 - 65.7

	2008	2012	2015	2020
Moderately High Economic growth scenario in million tonnes				
Wood for use as firewood	13.9	16.4	18.6	22.8
Wood required for charcoal	11.3 - 16.9	12.4 - 18.7	14.1 - 21.2	17.5 - 26.2
Total wood required	25.2 - 30.8	28.8 - 35.0	32.7 - 39.8	40.2 - 49.0

	2008	2012	2015	2020
Business-as-usual economic growth scenario in million tonnes				
Wood for use as firewood	10.3	12.0	13.4	16.2
Wood required for charcoal	6.8 - 10.2	8.0 - 12.0	8.6 - 12.9	10.8 - 16.3
Total wood required	17.2 - 20.6	20.0 - 24.0	21.6 - 26.0	27.2 - 32.6

39. The woodfuel data was estimated from projections based on the 2000 National Population Census and 2002 woodfuel field survey data collected by the Energy Commission. Even though, there has been the general assumption that woodfuel consumption is indexed to the population growth, field data is needed to validate present growth rate, otherwise the projections are estimated to be about 4 percent per annum.

40. In any case, to meet any of the supply requirements, the national wood stock should expand from the existing 813 million tonnes to the following:

Year	BAU or low economy growth scenario	Moderate high economy growth scenario	GPRS High economy growth scenario
		National Wood Stock in tonnes	
2008	864 million	932 million	1 billion
2012	939 million	1.2 billion	1.5 billion
2015	970 million	1.4 billion	1.8 billion
2020	1 billion	1.6 billion	2 billion

41. Meeting the plantation requirements under the business-as-usual growth is not impossible but quite challenging due to competition for land for other economic activities.

42. The high economic growth scenarios are however going to put immense pressure on woodfuel supply and consequently, lead to relatively high prices of woodfuels. Doing nothing however, could lead toserious deforestation. Importing woodfuels is not a sustainable option either.

Options for Meeting the Woodfuel Demand

Plantations

43. It is possible to meet the wood demand required for firewood and charcoal production under business-as-usual growth scenario by expanding the nation's artificial forest plantations from the current 750,000 hectares to:

i. About 1 million hectares in 2008;

ii. over 2.5 million hectares in 2012 and

iii. over 6.5 million hectares by 2020.

And complemented by nationwide promotion of energy efficient stove and conservation programmes to reduce the wood demand by one - two million tonnes every year.

Fuel substitution strategies

In the informal Industrial and Commercial/Service Sectors

44. The astronomical wood demand for energy by the GPRS high economic growth scenario is driven by the energy demand of the informal industrial and commercial/service subsectors of the economy.

45. Encouraging these informal industries and commercial/service entities to switch to alternative fuels like LPG will lessen the pressure on the country's forests.

46. The total LPG requirements for the industrial and commercial/service sectors to substitute for the woodfuels though, will be immense and are as follows:

2008	4 million tonnes
2012	5 million tonnes
2015	6 million tonnes
2020	7 million tones

47. This LPG demand will practically be impossible to achieve in the short-to-medium term and will put immense pressure on the country's refinery capacity. Nonetheless, it will encourage the private sector to invest in refinery topping plants (secondary conversion units) configured to produce largely LPG and cracked RFO.

48. The industrial opportunity for gas cylinder manufacturing will also be immense. The alternative otherwise, is to import the LPG.

49. However, since wood remains the least expensive heating/cooking fuel, it is likely that significant proportion of the informal industries and commercial/service entities will be reluctant to make a switch unless the LPG supply is supported with some kind of incentives.

50. Promotion of improved firewood stoves to reduce indoor pollution and firewood consumption in the informal industries and commercial/service subsectors should be considered in greater depth.

Residential Sector

51. Encouraging a shift from firewood to charcoal and then to other cooking fuels such as LPG, kerosene and electricity will depend on cost.

52. Even though, there is no initial capital investment in making a three-stone or mud firewood stove particularly, in rural areas, it is more expensive to use when compared with improved charcoal stove in cases where firewood is purchased.

53. Otherwise, the three-stone or mud firewood stove is the least expensive cooking device and has the lowest life-cycle cost as well.

54. Costs involved in the various cooking modes are as follows:

Device	Initial Investment cost US Dollars	Total cost per year US Dollars[8]
Three stone -mud firewood stove	0	44 - 62
Traditional charcoal stove	1.5 - 3	67 - 80
Improved 'Ahibenso' charcoal stove	10	37 - 43
LPG (one-two burner) cooker	30 - 50	83 - 98
Electric (one-two burner) cooker	20 - 50	81 - 93
Kerosene (one-two burner) cooker	17 - 25	138 - 161

55. For health reasons however, it will be wise to encourage a switch from firewood stove to charcoal stove usage but that involves an initial capital investment.

56. On the environmental front, charcoal usage consumes more wood than firewood and for that matter not an attractive option for CDM and other large climate change related financial facilities. Charcoal usage leads to higher greenhouse gases (here methane) emissions because it takes between four - six units of wood to make a unit of charcoal, whilst firewood is used directly from the field.

57. A nationwide promotion of more efficient improved charcoal stoves such as Ahibenso could shave off the wood demand by half. Even though, investment cost of average improved charcoal stove is about three times that of the traditional charcoal stove, the total expenditure per year is US $20 equivalent or less.

58. A switch from woodfuel usage to kerosene for cooking is the most expensive option in terms of annual expenses. Secondly, kerosene is a fossil fuel and so the shift is not environmentally attractive.

59. A switch from woodfuel to electricity for cooking presents the cleanest option in terms of indoor pollution. However, it is not global-warming friendly, if the electricity

[8] This is life cycle cost per year. Lifetime, efficiency and fuel cost have been considered in the calculation.

is thermal-based generation. Carbon dioxide emission from woodfuels is neutral in terms of global warming whilst emissions from fossil fuels are non-biogenic. There is also the issue of availability since national electricity coverage is still less than 50 percent as of 2004.

60. From the financial point of view, life cycle cost resulting from a switch from woodfuels to LPG is about the same as electricity. A switch from charcoal to LPG use will make the capital investment of the former insignificant and consequently, require a subsidy of US $30 - 50 per appliance. Incremental cost per year will be about US $20 per appliance on the average. A switch of all urban charcoal users to LPG gas will require total incremental cost of at least,

i. US$ 17- 18 million a year up to 2008; then

ii. 18 - 19 million a year from 2008 - 2012;

iii. 19 - 20 million a year from 2012 - 2015; and

iv. 20 - 22 million a year by 2020.

61. The LPG required to substitute for the woodfuel will be as follows:

i. 500 thousand to 1.8 million tonnes by 2008;

ii. 650 thousand to 1.9 million tonnes by 2012; and

iii. 950 thousand to 2.8 million tonnes by 2020.

Where the low figure is business-as-usual and the high figure is the GPRS high economic growth.

62. This additional LPG demand is likely to put a lot of pressure on the crude oil refining capacity of the country as well as the configuration of potential refineries, unless the LPG shortfall is imported. On the positive note, it is an opportunity to increase the refinery capacity of the country. It will as well boost gas cylinder manufacturing in the country.

63. Introducing LPG to rural users however will require an efficient distribution network and back-up support to combat potential gas accidents associated with it and occasional shortages due to distances from retailing centres.

64. Mobile LPG retailers exist but have higher premium than stationary retailers. For rural areas, it will be a significant extra payment to make, unless rural supplies are targeted and subsidised.

65. Promoting cultivation of energy forest plantations, re-introduction of improved charcoal stove programme[9], and improved charcoal production kilns will create massive jobs for rural communities involved in the plantations. It will also create jobs for artisans involved in the fabrication of charcoal and firewood stoves. In other words such a programme promotes sustainable development and will stand a greater chance of attracting CDM and other climate change related funding to the country.

[9] Woodstove programme was first launched in 1990 by the erstwhile National Energy Board, but was abandoned by mid 1990s.

Challenges

Woodfuels

66. The main challenges facing the woodfuel subsector are:

i. How to ensure sustainable production, marketing and consumption of woodfuels.

ii. How to modernise and as well formalise the woodfuel industry to make it attractive to medium and large scale private investment.

iii. How to formalise and include woodfuel consumption in the mainstream commercial energy accounting and consequently, in the national economic statistics.

iv. How to develop and introduce a sustainable pricing formula for woodfuels.

Renewables

67. The main challenge for the development of renewable energy in Ghana is:
- **How to increase the use of renewable energy in the national energy mix.**

Formalising the informal

68. Ghana as a developing country will still have wood as the most widely used fuel for the foreseeable future, even if the country achieves a middle-income status in the next decade.

69. Charcoal production accelerates wood consumption; one unit of charcoal requires 4 - 6 units of raw wood.

70. Wood or forest plantations are sinks for greenhouse gases.

71. The use of improved charcoal and firewood stoves are greenhouse gas abating technologies.

72. In spite of the relative importance of the traditional fuel, the woodfuel subsector has not received any significant direct public investment and there has not been any major direct policies targeted at its growth and development over the last ten years. There is relatively little investment made to formalise the woodfuel sub-sector compared to the electricity and the petroleum sub-sectors.

73. The woodfuel subsector operates as an informal sector, it lacks human resource capacity at all levels of governance to develop, implement and monitor policies on woodfuels and there are poor institutional linkages among the various agencies involved in this traditional energy sub-sector.

74. Regularizing the subsector will allow the sector to be regulated and be monitored in a sustainable manner.

75. In summary, formalising the subsector by setting up a dedicated agency like a National Woodfuel office to manage the traditional fuel subsector and to ensure a sustainable woodfuel industry is highly desirable.

Emerging Technologies

Prospects for biomass-fuelled cogeneration based on BIGCCC

76. Ghana has around 39% of forest cover and a further 37% of woodland[10] . The extraction and processing of wood from the forest generate large quantities of wood wastes, which could serve as fuel for power generation. An estimate of wood processing residues from sawmill put the amount of the residue at approximately, 1.0 million m^3 per annum. This includes slabs, sawdust, off-cuts, peeler cores and edgings. Secondly, Ghana's economy is mainly based on agriculture. The country therefore generates large quantities of crop residues in the form of husk, shells (from coconut and oil palm), palm nut waste and corncobs, which can provide fuel to meet energy needs.

77. The potential to generate power from biomass in Ghana is thus very high. The most encouraging technology to utilise the biomass resources into useful energy is through Combined Heat and Power (CHP) projects - ccogeneration based on Biomass Integrated Gasification Combined Cycle (BIGCC).

78. CHP plants are attractive technologies for generating power because up to 85-90% of the energy in the fuel can be utilized. The plants also provide several environmental benefits by making use of waste heat and waste products.

79. CHP based on wood waste are found in some large sawmills such as Samatex Ltd and STP Ltd, but the efficiencies of the existing biomass combustion technologies range from 4-25% for electricity production. BIGCC plants have efficiencies above 45% for electricity generation.

80. Carbon dioxide emission from the combustion of wood is considered to be biogenic and consequently neutral[11]. There is however enormous amount of nitrogen oxides emitted due to the presence of nitrogen compounds in the biomass chemistry. Sulphur dioxide emitted however is about 100 - 1000 times lower than emissions from coal. The ash from biomass plants could be used as fertilisers or simply be buried.

Power generation based on municipal solid wastes

81. The use of municipal waste as fuel to generate power is becoming increasingly attractive due to the increasing environmental concern regarding waste disposal in the country. The two main technologies employed to generate power from municipal waste are incineration to produce high pressure steam and anaerobic decomposition to generate gas at landfill sites.

[10] FAO Forestry Report on Ghana, Dec, 2000.

[11] A CO2 emission factor of zero is therefore assumed for all the biomass fuelled technologies

Landfill Gas to Power Technologies

82. Landfill gas-to-power systems use landfill gas to generate electricity. The landfill gas, which is the natural by-product of anaerobic decomposition of waste, is biogas, which is essentially methane. Landfill gas-to-power systems have three basic components:
    - The gas collection system, which gathers the gas being produced within the landfill,
    - The gas processing unit, which cleans the gas
    - The conversion system, in which the gas is burnt to generate electricity.

83. Operating landfill gas-to-power systems provides significant environmental benefits. The plants consume gases that if not collected and used, pose serious odour, safety and environmental hazards. Methane, the main energy component of landfill gas, is a particularly potent "greenhouse" gas, having roughly 21 times the global warming effect of carbon dioxide.

84. Some engineered landfills are being constructed in the country. Five sites are under construction in Accra (Kwabenya), Tema, Kumasi, Sekondi-Takoradi and Tamale. Construction time is between 1 - 2 years[12] and will take some years to fill up and close (sealed). Power extraction of landfill is 1MW on the average.

Waste Incineration Power Plants

85. This technology involves the burning of principally, solid municipal waste to produce high-pressure steam for power generation. A typical waste incineration power plant otherwise called Waste-to-energy thermal power plant would have the following components:
    - Waste storage chamber
    - Incinerator or boiler
    - Steam Turbine and Generator
    - Flue gas cleaning system and Chimney
    - Residue treatment system

86. Though the cost of electricity from waste incineration power plants is relatively high, the plants provide other environmental benefits that make them worth constructing and operating. Waste incineration reduces the volume and weight of waste by 90% and 70% respectively. In view of this, the average cost of power generated from these plants, can be significantly reduced if concessionary loans that attract low discount rates and grants are sourced to finance such projects.

87. The potential adverse impacts of waste incineration power plant are the air emission (Nitrogen oxides, Sulphur dioxide, Carbon monoxide, dioxins and particulate matter), and toxic residue.

Wind farms

88. Wind turbine technology is one of the fastest growing renewable energy technologies for power generation in the world today. Worldwide, there is over 10,000 MW or more than 50,000 operating wind turbines. Wind turbine sizes vary from small stand-alone

[12] If funding is fully secured.

turbine with less than 50 kW rated capacity to large commercial wind turbines of 0.3 - 2 MW. Higher rated turbines now exist but they are hardly commercial. Wind turbines ratings of 600-1000 kW are the working horses of the industry. These turbines are typically installed in arrays known as wind farms, although installations of single large turbines are not uncommon.

89. A wind energy system usually needs an average annual wind speed of at least 5 metres per second (m/s) to be practical. Typical annual average wind speed of wind farms is usually between 6-7 m/s.

90. A challenge of the wind turbine technology is that it depends on natural force, which cannot easily be controlled. In order to be able to tie the wind energy system directly to the utility grid network, the grid system must be large enough to be able to withstand fluctuations in the wind power. For now, Ghana's potential is confined to the coastline and the most economic exploitation based on current technology is at 50 metre-height with average wind speeds between 6.0 - 6.3 metres per second (m/s).

Medium to Small scale hydropower plants

91. Medium scale hydro resource of capacities less than 100 MW sums up to about 1,237 MW with potential annual generation of about 4,500 GWh.

92. Small scale hydro power sites of capacities of 10 MW or less sites had been identified in the 1980s based on analysis of available data including topographical sheets. The total potential of all the promising sites was estimated at 24.5 MW. The probable energy output was not assessed. The most recent assessment however revealed that condition at most of the sites identified in the early 1980's, have changed dramatically and the potential is much lower.

93. Identified Mini hydro resource sites are about 3 MW with corresponding annual generation potential of about 15 GWh.

Fuel Cell

94. Fuel cell utilises hydrogen as fuel and the only by-product is water vapour. Fuel cell comes in both central and distributed power plants. Distributed fuel cell plants ranging from 100-250kW are available and modular units can also be put together to scale-up the output to meet desired power demand up to 2 MW so far. Commercially available units are however between 5 - 10 kW for high temperature and acid fuel cells and about 100 kW for the low-temperature proton-exchange (polymer electrolyte) membrane (PEM) types. The target for the high temperature or acid fuel cells is for stationary applications whilst the PEM is targeted largely for vehicular use.

95. Interest in fuel cells arises not only from their essentially zero pollutant but also from their efficiency, about 50% and has the potential to rise in the near future. Package cost of typical commercially available fuel cell power units is between US$3,000 - 5000 per kW, which means their average initial cost is about the same or little less than that of crystalline solar photovoltaics, however, operational and maintenance cost could be higher. Also, the life spans of the technologies are still

debatable and no where near that of average solar photovoltaic modules. Phosphoric acid fuel cells (PAFCs) are the most proven for stationary power production.

Water Heating

96. Solar water heating is becoming an increasingly attractive demand-side management alternative because it has no fuel cost. Though the initial cost of solar water heating systems is higher than that of conventional water heaters, they provide substantial energy savings. A solar water heater of interest is a flat-plate (single or double glazed), thermosyphon type with a storage tank.

97. Solar water heaters unlike the electric water heaters have high initial investment costs. They however provide potential savings in energy cost which can be used to payback the high initial purchase price of the systems. After the payback period, the savings can still be accrued over the lifetime of the system, which can range from 15-20 years depending on the type of system and how well it is maintained.

POLICY RECOMMENDATIONS

Strategic Plan for the Woodfuels and Renewable Energy Subsector

Strategic targets:

The strategic targets earmarked for the renewable energy subsector are as follows:

a) To reduce the wood intensity of charcoal production (ratio of wood input to charcoal) from existing 4:1 to 3:1 in the Savannah zone and from 5-6:1 to 4:1 in the Forest zone by 2015.

b) To ensure that the energy share of traditional biomass (woodfuels) in the national final energy mix is reduced from about 60 percent at present to at least 50 percent by 2015 and subsequently to 40 percent by 2020.

c) To increase the supply of renewable energy and modern biomass in the Ghanaian final energy supply to achieve at least 10 percent penetration by 2020.

In order to achieve the targets, the following policies have been recommended.

Woodfuels

Immediate Objective: To ensure sustainable production, marketing and consumption of woodfuels.

Promotion of sustainable production

Policy

1. It is recommended that

Government supports promotion and development of sustainable management of the country's natural forests and woodlands for sustainable supply of wood including woodfuels.

Implementation measures

a) Survey, map, register and gazette all sustainably managed woodfuel areas outside the forest reserves.

b) Government through public and private agencies encourage and assist local community groups or individual entrepreneurs to establish woodlots or plantations to ensure sustainable supply of wood.

c) Introduce woodfuel production contracts, which allow the utilization of timber off-cuts from the forest reserves for the production of woodfuels.

d) Define rights and responsibilities of fringing landowning communities in forest reserve management and in the harvesting and sale of the woodfuels.

e) Establish standards and registration requirements for woodfuel producers

and registration of all commercial woodfuel producers to be given trading rights.

f) Investigate ways to address the issues of bushfires and salvaging wood in connection with large construction works such as roads and hydro dams, especially, with the impending construction of the Bui hydroelectric project.

g) Revise the current woodfuel taxation system to ensure that taxation of wood from sustainably managed areas is less than from unsustainably managed ones and that a substantial part of the tax revenues is used for reforestation and support of sustainable management of woodlands.

h) The Energy Commission, the Forestry Commission, the District Assemblies and the traditional authorities would decide the revision and agreement on collection and redistribution of taxes.

i) Standardize the woodfuel trading. Trade in charcoal should be done in bags with official seals.

j) Review the system of allowing exploitation of forest resources for production of commercial woodfuels. The number of permits issued should reflect the 'sustainable production' levels in that area.

Establishment of a National Woodfuel Office within the Energy Commission

Policy

2. It is recommended that

Government establishes an institutional framework to enhance and coordinate woodfuel related activities as an integral part of national energy development strategy.

Implementation measures

a) Involve all institutional agencies associated in the woodfuel industry in the planning, implementation and monitoring of activities in the subsector.

b) Energy Commission sets up a National Woodfuel Office with working linkages with the Forestry Commission, the Local Government institutions and other identifiable stakeholders.

Regulation of the woodfuel industry

Policy

3. It is recommended that

Government regulates the woodfuel transportation, marketing and Export system to encourage more sustainable practices.

Implementation measures

a) Energy Commission should liase with the District Assemblies to license the following categories of woodfuel traders: Commercial and Bulk Producers, Commercial and Bulk Transporters, Wholesalers and Bulk retailers.

b) All commercial woodfuel transporters should be in possession of an information sheet specifying the origin of the load, the destination of the load with due signature of the District Assembly Revenue Collectors and the Woodfuel Transporters Association at the destination point.

c) Energy Commission will collaborate with the relevant institutions to ensure safety measures are applied on bulk transportation of charcoal.

d) Energy Commission will strengthen its licensing framework for exporters of woodfuels. As part of the licensing requirement all exporters will be obliged to submit shipping documents indicating the quantity, source and origin of the woodfuel and destination to the Energy Commission for endorsement. Exports will only be allowed from waste wood and wood from planted energy forests.

Energy efficient production and use of woodfuels

Charcoal production in the country is still largely based on the rudimentary earth mound technology which is low yielding consuming between 4 - 6 tonnes of wood per every tonne of charcoal produced. Market forces regulate the trade and uncontrolled demand could pose a high environmental risk to the resource base. The production of charcoal in this manner releases a lot of methane gas and other greenhouse gases.

Woodfuel utilisation in the home was responsible for about 68 percent of carbon monoxide (CO), over 50 percent of methane (CH4) and about 68 percent of nitrous oxide (N2O) emissions of the country, all global warming gases.

In late 80's two major programmes were instituted to address the issue of inefficient end-use devices used for cooking. These were the:

i. Promotion of LPG as a means of achieving energy conservation through fuel shifting to more efficient LPG stoves; and

ii. Nationwide promotion of the Ahibenso improved charcoal cooking stove, which was meant to replace the traditional "coalpot" .

The Ahibenso Improved stove was introduced on the market in 1989. This improved coal pot saves between 35-40% of charcoal over and above the traditional coalpot. Furthermore an expenditure survey conducted among households indicated that it saved between 15-20% of the amount of money normally spent on charcoal. The woodfuel efficiency programme however fizzled out by the mid 1990s after the Ministry's funding ended.

Policy

4. It is recommended that

Government supports development and introduction of improved technologies and higher levels of efficiency in the production and consumption of woodfuels.

Implementation measures

a) Register all traditional and commercial charcoal producers and train them in improved carbonisation process.
b) Undertake continuous Energy Efficiency and Conservation Awareness campaign targeting all levels of consumers.
c) Monitor the health impact of woodfuel production and use especially, on women and children and feed the information to stove designers and for policy formulation.

Manpower development

Woodfuel being the most important energy source for the country cannot be left in the hands of inefficient charcoal producers, if the country wishes to see a sustainable production and consumption in the foreseeable future.

The industry will only see modernisation when regulations and professionalism is introduced. Tertiary institutions should be assisted to run courses and programmes in Woodfuel Technology.

Policy

5. It is recommended that

Government supports training in Woodfuel Technology in tertiary and other learning institutions.

Implementation measures

a) Energy Commission should sensitise and assist the tertiary institutions to establish a curriculum for Woodfuel Technology.

b) Include woodfuel technology in existing Agriculture Extension Officer courses.

c) Government support agencies in-charge of technical and vocational training in the country to develop courses in modern woodfuel technologies.

Renewable energy

Objective: To increase the use of renewable energy sources to 10 percent of the national energy mix by 2020.

Regulatory framework for grid-connected renewable energy power generation

Perhaps the single most important policy intervention that will accelerate the development and use of renewable energy for electricity generation is the establishment of a tariff regime that is friendly to Renewable Energy and is backed by a regulatory framework that allows such generation plants to be connected to the national grid.

Since all wind farms and most RE projects are embedded generation, the feed-in tariffs could be established within the context of the embedded generation costs as in the PURC Electricity Rating Setting Guidelines[13].

Policy

6. It is recommended that

i. The Government through the Energy Commission develops the necessary Renewable Energy Technology regulatory framework.

ii. The Government through the Energy Commission develops Technical Regulations, including standards and codes of generation and interconnection to the grid especially on network voltage range, voltage fluctuations, harmonics, thermal ratings, etc. to facilitate the development of grid-connected Renewable Energy Technologies.

iii. The Government through the PURC sets favourable feed-in tariffs for electric power from Renewables in particular and embedded generation in general.

Implementation measures

a) Government supports capacity building programmes for the regulatory and the utility agencies.

b) Increase collaboration between the regulatory bodies and sister institutes inadvanced countries to improve technical know-how.

Overcoming the barrier of high initial cost

The initial high costs of Renewable Energy Technologies have been a major barrier to their widespread deployment. The key problem that any innovation market delivery model has to deal with is the high upfront cost of Renewable Energy Technologies and in the case of the solar photovoltaic systems the additional cost of replacing the balance of system components such as batteries, controllers and the direct current (d.c) lamps.

Policy

7. It is recommended that

i. Government investigates innovative capital subsidy arrangements to assist rural communities acquire Renewable Energy Technologies.

[13] The Embedded Generation Cost is defined as the avoided cost of procuring electricity supply directly from the Market

ii. Government rationalises the fiscal regime regarding import duty and VAT on renewable energy technology equipment in order to help lower the upfront RE-equipment costs.

iii. The current tax exemption regime for Renewable Energy Technologies would be expanded beyond wind power and solar energy equipment to include import duty and VAT exemption for other renewable energy utilisation equipment, appliances and system components.

iii. Government supports the promotion of local manufacturing of renewable energy devices and equipment in the medium-to-long term.

Implementation measures

a) The Ministry of Energy tasks the Energy Commission to investigate innovative financial schemes including capital subsidy arrangements and micro-financing. The Ghana Investment Promotion Council (GIPC) Investment Code, for example, should make provision for tax exemptions for Renewable Energy manufacturing. In addition, wind powered and solar energy generating sets, plants, machinery, equipment or parts for the establishment of manufacturing facility are exempt from import duty, VAT and excise duties.

b) Government encourages Ghanaian industrialists to partner with popular brand manufacturers to set up branches of production and assembly lines in the country.

Ensuring good quality equipment and installations

A system of certification and standardisation needs to be developed in order to ensure high quality installation and performance:

Policy

8. It is recommended that

The Energy Commission establishes and enforces certification and licensing of dealers in Renewable Energy Technologies based on predetermined requirements.

Implementation measures

a) The requirements for receiving a license should include: Evidence of competence of technical staff; Track record; Evidence of certification from principals; Evidence of capacity to provide after sale service; Evidence of financial capacity to offer services.

b) Licensing will be made a precondition for local dealers applying for public grant, subsidies and contracts.

Role of Government and the Private Sector

The rural electrification has largely been by grid and driven by donor support. It would be extremely difficult to achieve 100 percent national electrification without the inclusion of distributed systems.

The Government alone may not be able to implement projects covering both the public and private sectors due to limited funding sources.

Policy

9. It is recommended that

i. *Government focuses on provision of decentralised renewable energy power systems for public communal facilities and needs.*

ii. *Government supports the private sector to provide decentralised renewable energy systems for individual and commercial needs.*

Implementation measures

a) The Government focuses on provision of decentralised power for public social amenities such as health centres, schools and potable water. Support the training of manpower and research. Create the necessary market environment such as tax rebates, equipment certification.

b) Private enterprises focus on provision of systems for homes, commercial and industrial entities. Government support could include arranging concessionary credits for the local dealers.

c) There will be public -private sector partnership in large-scale centralised power projects through shared costs.

ANNEXES

Appendix: List Of Participants

LIST OF INSTITUTIONS REPRESENTED AT THE STAKEHOLDER MEETINGS[14]

	SNEP AREA PARTICIPATED		
	Electricity	**Petroleum**	**Renewables**
Ministries and Governmental Committees			
1. Ministry of Energy	•	•	•
2. Ministry of Finance & Economic Planning	0	•	•
3. Ministry of Environment and Science	•	•	•
4. Parliamentary Select Committee For Mines & Energy	•	0	0
5. Power Sector Reform Committee	•	0	0
6. Bui Hydro Development Committee	•	0	Not invited
Public Sector Bodies, Enterprises & Commissions			
1. Board of the Energy Commission	•	•	•
2. Public Utility Regulatory Commission (PURC)	•	0	0
3. National Petroleum Authority	Not invited	•	•
4. Environmental Protection Agency	•	•	•
5. Bank of Ghana	0	•	•
6. National Development Planning Commission	•	•	0
7. Ghana Atomic Energy Commission	•	Not invited	Not invited
8. Ghana National Petroleum Corporation	0	•	0
9. Bulk Oil Storage & Transport Company	0	•	0
10. Ghana Statistical Services	0	•	0
11. Electricity Company of Ghana	•	0	0
12. Volta River Authority	•	0	0
13. Tema Oil Refinery	•	•	0
Private sector (non-oil) energy companies			
1. NEK Ghana Ltd	0	Not invited	•
2. AESSEL Development Group Ltd	Not invited	Not invited	•
3. GHAESCO	Not invited	Not invited	•
4. Wilkins Engineering Ltd.	0	Not invited	•
5. Deng Solar Ltd.	0	Not invited	•
6. 'Pluck the Day' Solar Company	Not invited	Not invited	•
7. A1 Quality Engineering	0	•	Not invited
8. AngloGold Ashanti Ltd	•	0	Not invited
9. Volta Aluminium Company	•	0	Not invited
Oil Marketing Companies (OMCs)			
1. OMC Coordinator	0	•	0
2. Ghana Oil Company (GOIL)	Not invited	•	Not invited
3. Vanco Ghana Ltd.	Not invited	•	Not invited
4. Tema Lube Oil	Not invited	•	Not invited
5. Nasona Oil Company, Ltd	Not invited	•	Not invited
•	***Attended***		
0	***Absent***		

[14] Name of individuals are available at the Energy Commission.

LIST OF INSTITUTIONS REPRESENTED	Electricity	Petroleum	Renewables
NGOs/ Consultancy/Unions/Advocacy groups			
1. Ghana Private Road Transport Union (GPRTU)	Not invited	•	Not invited
2. Ghana Chamber of Mines	•	•	Not invited
3. Association of Ghana Industries	•	0	0
4. Energy Foundation	•	•	•
5. KITE	Not invited	•	•
6. Energy Research Group - Ghana	•	•	•
7. Ghana Solar Energy Society	•	0	•
8. Sustainable Environment Group	Not invited	0	•
9. Jeavco	Not invited	0	•
10. AESSEL Development Group Ltd.	Not invited	•	•
11. Ghana Institution of Engineers	•	0	0
Educational & Research Institutions			
1. Resource Center for Energy Economics & Regulation /ISSER	0	•	•
2. Institute of Industrial Research of CSIR	•	0	•
3. Dept of Physics, University of Ghana	0	•	•
4. Dept of Physics, University of Cape Coast	•	0	0
5. College of Engineering, KNUST	•	0	0
The Press			
Television			
1. GTV - Ghana Broadcasting Corporation	•	•	Not invited
2. TV3	•	•	Not invited
Print Media			
3. Daily Graphic	•	•	•
4. Ghanaian Times	•	•	•
5. Business & Financial Times	•	•	•
6. Daily Guide	•	•	•
Radio and FM stations			
7. Ghana Broadcasting Corporation Radio	•	•	•
8. JOY FM	•	•	•
9. CITI FM	•	•	•
10. TOP Radio	•	•	•

• ***Attended***

0 **Absent**

Note Names of experts attending in their individual capacities are not included here but available at the Energy Commission

Bibliography

Energy Sector Technology Catalogue (Energy Commission publication, 2004).
A catalogue of both qualitative and quantitative descriptions of present and projected future energy technologies and appliances for Ghana's economy. The Catalogue is one of the key outputs of the SNEP and is to provide a reliable and acceptable technology database for planning exercises as well as a credible reference for the energy market in Ghana.

Least Cost Assessment of Power Generation Technologies and Demand-Side Appliances
An Integrated Resource Planning approach (Energy Commission publication, 2004)
Assessment of power generation technologies and demand-side appliances using the Integrated Resource Planning (IRP) methodology. IRP is a planning tool that looks at the entire energy supply-demand chain on one scale. It allows both the supply-side technologies and Demand-Side Management programmes to be combined and ranked on one scale in the order of least cost option. Balancing the demand side with the supply side options provides an overview of the cheapest way to satisfy the need for energy services.

Indigenous Resource Catalogue (Contract carried out by the Dept. of Mechanical Engineering, Kwame Nkrumah University of Science and Technology for the SNEP, 2003)
This resource catalogue contains qualitative descriptions and quantitative estimates of the known energy resources of Ghana that could be exploited up to the year 2020. It is a database on reserves and production as well as technical, environmental and socio-economic features of each resource that could serve as a reference for policy planning.

Energy Balance and Environmental Impact Assessment Report (Contract carried out by the Dept. of Economics, University of Ghana for the SNEP, 2002)
An analysis of baseline data on primary energy production, import, conservation and usage. The results were used to prepare the energy balance of the base year and the disaggregation of the economic sectors for inputting into LEAP, the computer-modelling tool used for the projections. Also included in the report is an EIA of the Akosombo hydroelectric project.

Estimation of Woodfuel Demand in the Household Sector of Ghana (Contract executed by the BRRI of CSIR, for the SNEP, 2003)
A compilation and analysis of woodfuel consumption data for the household sector. The report provided the household sector input for the LEAP. The Building and Road Research Institute (BRRI) carried out the exercise for SNEP.

Economic Analysis of the Energy Sector (Contract undertaken by Prof. Bartholomew Armah, a visiting researcher of the Institute of Economic Affairs, Ghana, 2003)
This report provides the economic context for the formulation of the SNEP. The first part of the report describes the economic structure of Ghana and is followed by an analysis of the contribution of energy to the Ghanaian economy. The report also discusses the implications of the nation's development policies, namely the Ghana Poverty Reduction Strategy (GPRS) and the Coordinated Programme of Economic and Social Development (CPESD) on the country's long-term energy demand.

Policy Framework for Ghana's Energy Sector (Ministry of Energy, 2001)
A policy framework document outlining the vision of the Ministry of Energy and its main objectives for the energy sector.

ENERGY & GHANA'S SOCIO-ECONOMIC DEVELOPMENT: Issues, Strategies and Programmes in the Energy Sector under the Economic Recovery Programme (National Energy Board/Ministry of Fuel and Power, 1989, revised July, 1990)
A policy document outlining the vision of the National Energy Board and the Ministry of Fuel and Power.

An Energy Roadmap for Ghana: from Crisis to the fuel for 'Economic Freedom (USAID, August, 1998)
A report by a United States Government Interagency Team in response to a request from His Excellency the Vice President John Attah Mills, On behalf of the Government of Ghana. The team was in the country in 1998 during the power crisis that year.

2000 Population & Housing Census, March 2002
Special reports on Ghana's 2000 population census by the Ghana Statistical Services.

VRA Generation and Transmission System Master Plan (Final Report -three volumes, July 2001)
A document prepared by the Acres International for the Volta River Authority (VRA), the power generation utility of Ghana. It provides power generation projections and capacity expansion largely based on thermal options from 2000 - 2020. Transmission expansion plans for VRA are also discussed. VRA owns and operate the national transmission network in addition, even though the latter is to be hived off into an independent transmission utility company under Ghana's Power Sector Reform.

The State of the Ghanaian Economy, 2000, 2001, 2002, 2003, 2004, 2005
A yearly publication by the Institute of Statistical, Social and Economic Research (ISSER) of the University of Ghana. Each year's edition is a commentary and or analysis of the performance of the economy during the previous year.

Sustainable Energy Scenarios for Ghana's Long -Term Development Plan (Vision 2020)
(Essandoh-Yeddu, Joseph and Johansson, Daniel, Chalmers University of Technology / Gothenburg University, Sweden, Department of Physical Resource Theory, 2001)
A Master of Science thesis that looks at sustainable energy pathways for Ghana's long term development.

The Economist Pocket World in Figures (Edition 2001, 2002, 2003, 2005)
An annual pocket editions published by The Profile Books Ltd of UK in association with The Economist. The annual booklet provides rankings on more than 200 topics and detailed statistical profiles of the world's major economies.

Tools and Methods for Integrated Resource Planning (UNEP Collaborating Centre on Energy and Environment, RISØ National Laboratory[15], Denmark, 1997)
A teaching material on energy efficiency, end-use analysis, demand-side management and integrated resource planning (IRP).

[15] Now called UNEP Risoe

LEAP
LEAP (Long range Energy Alternative Planning) is an integrated software developed by the Stockholm Environment Institute for energy and environment planning. It is an accounting modelling tool that can be used for energy projections as well as creating energy balances of production and usage for a given economy or region. It has a Microsoft DOS version (LEAP95) and a WINDOWS version (LEAP2000). For more information visit
http://forums.seib.org/leap.

RETscreen ® International, Natural Resources Canada
RETSCREEN is a trademark for RETScreen International and is a renewable energy awareness, decision-support and capacity building tool developed by the CANMET Energy Diversification Research Laboratory (CEDRL) of Natural Resource - Canada with major support from UNEP and the World Bank. The core of the tool consists of a standardised and integrated renewable energy project analysis software that can be used world-wide to evaluate the energy production, life-cycle costs and greenhouse gas emission reductions for various types of renewable energy technologies. Renewable energy technology (RET) projects are not routinely considered by planners and decision-makers at the critically important initial planning stage. The RETScreen® Renewable Energy Project Analysis Software has been developed to help address this barrier. For more information visit www.retscreen.net/ang.

MESSAGE (IAEA, Austria)
MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impact) is a model designed for the optimisation of energy system. The model was originally developed at International Institute for Applied Systems Analysis (IIASA) but the latest version of the model has been acquired by the International Atomic Energy Agency (IAEA). For more information contact the IAEA, P.O. Box 100, Wagramer Strasse 5, A-1400 Vienna, Austria.
Email Official.Mail@iaea.org.

Links to Energy Sector Regulatory Bodies in Ghana
Public Utilities Services Commission, www.purc.com.gh
Energy Commission, www.energycom.gov.gh.
National Petroleum Authority *(website not available yet)*……..