

Strategic National Energy Plan

2006 - 2020

Annex I of IV

ENERGY DEMAND SECTORS OF THE ECONOMY



Energy Commission, Ghana
July, 2006

Strategic National Energy Plan 2006 – 2020

Annex One of Four

ENERGY DEMAND SECTORS OF THE ECONOMY

***Energy Commission
July, 2006***

LIST OF ABBREVIATIONS

Abbreviation	Meaning
ATK	Aviation Turbo Kerosene
Bbl	Barrel
Billion	1,000,000,000 (10 to the power 9)
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CPESD	Coordinated Programme for Economic and Social Development
DANIDA	Danish International Development Assistance
ECG	Electricity Company of Ghana
ECOWAS	Economic Community of West Africa States
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
GNPC	Ghana National Petroleum Corporation
GPRS	Ghana Poverty Reduction Strategy
GWh	Gigawatt-hour (million units of electricity)
ICT	Information Communication Technology
IRP	Integrated Resource Planning
KWh / kW	Kilowatt-hour (one unit of electricity) / kilowatt
LEAP	Long Range Energy Alternative Planning
LCO	Light Crude Oil
LPG	Liquefied Petroleum Gas
MoE	Ministry of Energy
MWh / MW	Megawatt hour (thousand units of electricity) / Megawatt
NES	National Electrification Scheme
NGO	Non Governmental Organisation
NPA	National Petroleum Authority
NOx	Oxides of Nitrogen
OMCs	Oil Marketing Companies
PV	Photovoltaic (solar cell)
REDP	Renewable Energy Development Programme
RFO	Residual Fuel Oil
SNEP	Strategic National Energy Plan
Sox	Oxides of Sulphur
TAPCO / Tapco	Takoradi Power Company
TICO / Tico	Takoradi International Company
TOE	Tonnes of Oil equivalent
TOR	Tema Oil Refinery
US \$	US Dollar
VALCO	Volta Aluminium Company
VRA	Volta River Authority
WAGP	West African Gas Pipeline
WAPP	West African Power Pool

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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

* See Appendices 4 and 5

* 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 experts 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.

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* See Appendices 4 and 5

[#] Danish International Development Agency

FOREWORD

As the economy grows and becomes more complicated, the adoption of long-term planning approach for energy development is required.

The Energy Commission in 2000 initiated the development of the SNEP as part of its mandate provided under the Energy Commission Act 541, 1997. Specifically under section 2 (2a-d) the Energy Commission is to¹:

- a. Recommend national policies for the development and utilisation of indigenous energy resources;
- b. Advise the Minister on national policies for the efficient, economical and safe supply of electricity, natural gas and petroleum products having due regard to the national economy;
- c. Prepare, review and update periodically indicative national plans to ensure that all reasonable demands for energy are met;
- d. Secure comprehensive data base for national decision making.

The first attempt to formulate an overall framework for the development of the Energy Sector in Ghana was made in 1990 by the erstwhile National Energy Board (NEB), which was established in the mid-1980s to undertake energy planning and policy development for the country. The Energy Board was envisioned at a time when fuel imports accounted for 30-40 percent of the nation's hard currency earnings. The document: “**Issues, Strategies and Programmes in the Energy Sector under the Economic Recovery Programme**” outlined an Action Programme covering five broad areas: Renewable Energy development, LPG promotion, Electricity Sector, the Petroleum Sector and Energy Efficiency and Conservation. The Action Programme was to a large extent implemented in the first half of the 90s, but lost momentum and weakened with time, following the dissolution of the Board in 1991.

In the absence of the Energy Board, ad-hoc and stop-gap measures were taken to sustain the policy direction of the country. The need for the development of a Strategic National Energy Plan for Ghana was necessitated by the power crisis in 1997/98, which occurred at a time when the country's energy supply had been restricted by an over dependence on hydro-power for electricity which failed due to poor rainfall in the catchment areas of the Volta reservoir. This crisis further exposed the absence of a comprehensive energy policy framework. Consequently, the Government of Ghana sought the assistance of the United States Government for an objective analysis of the electricity crisis and recommend actions to put the sector on a successful path to recovery.

A report “**An Energy Road Map for Ghana**”² was submitted to Government in 1998 and this resurrected the process of identifying an energy policy framework for Ghana. The report

¹ For a copy of the Act, visit Energy Commission website www.energycom.gov.gh.

² An Energy Roadmap for Ghana: from Crisis to the fuel for ‘Economic Freedom’. A report by a United States Government Interagency Team in response to a request from the Government of Ghana, August 1, 1998.

made several recommendations, notable amongst them, the continuation and strengthening of regulatory institutions under the power sector reform programme, which had been initiated in 1994 with the insistence of the World Bank and the need for an independent institution to undertake and develop an integrated energy planning and policy for the country. This major step accelerated the processes of developing a coherent long-term strategy, streamlining the major policy goals of Government and putting them together as a coherent whole that addresses the issues and challenges facing the energy sector.

Upon a request from the Ghanaian Government in 1998 the Danish Government agreed to support the development of such a Strategic National Energy Plan for Ghana. The work took off in 2000 and the Danish support ended in April 2003.

SNEP – Strategic National Energy Plan 2006 - 2020

Conventionally, top-down approach has mostly been used for energy planning and there have been tendencies to make long term forecast based on the supply side projections. However, activities on the supply-side do not necessarily arise as a result of demand and vice-versa. For instance, increasing demand does not necessarily call for investment in generation and transmission without first considering the option of energy efficiency. It thus requires an optimal blend. Moreover, conventional planning has placed more emphasis on commercial grid electricity and imported fossil fuels, relegating to the background the potential of renewables and particularly, woodfuels which comprised over 60 percent of the nation's energy utilisation. A paradigm shift in energy policy and planning was thus necessary. Broadening the sources and types of energy supply and integrating them into high quality utility service for the total growth of the economy is mainly what SNEP is about.

SNEP is thus a comprehensive way of looking at the available energy sources and resources of the country and how to tap them economically and timely to ensure a secured and adequate energy supply for sustainable economic growth now and into the future.

Energy efficiency measures have also been emphasized in the SNEP and major sectors for energy conservation have been examined in this respect.

Specific objectives of SNEP are to:

- Establish an effective national infrastructure for energy planning; and
- create a consensus reference framework for the development of the energy sector.

The goal of energy supply and demand planning under SNEP is extended into the long term since most capital investments in the energy sector are relatively high with lifetime of 20 years or more on the average.

In the case of Ghana, except for woodfuels, almost all the components of the energy technologies are imported. Thus the long-term nature of the SNEP provides the opportunities

for the development of viable local industry for the production of components and systems locally, to meet future spare-parts requirements of future investments thereby making savings and ensuring sustainability.

Forecasting and planning tools used for SNEP

Two main computer-based planning tools the LEAP (Long-range Energy Alternative Planning) and IRP (Integrated Resource Planning)³ were used for the SNEP analysis.

An analysis of the energy sector starts with the identification of the various demand and supply activities. In depth knowledge of issues in the various energy sectors is crucial for policy formulation, since it helps to unearth the key challenges that must drive the policy. The forecast for energy demand and supply have been carried out using the LEAP computer-based model. LEAP was adopted for the SNEP for its comparatively user friendliness in addition to having sub-programmes to handle both supply-driven and demand-driven forecast at the same time and for ease of comparison.

Almost all the energy related institutions in the country are familiar with LEAP since their representatives had received training in its use or seen demonstration of its capabilities during the SNEP process.

The forecast was primarily based on the projection into the future of economic (demand) sector/subsector outputs and the energy intensities of the end-uses and/or appliances, thus the SNEP uses a ‘bottom up approach’ to energy planning.

Time series analysis was applied for sectors with known planned future production outputs and committed power plants to be commissioned or retired in the future.

Regression analysis was used for projecting sectors with limited data.

Historical data on Prosperity index (inverse of poverty index) of the country was used to project the demand of the Residential sector for the high economic growth scenario.

The principal result of the demand analysis with LEAP was the net final energy demand forecast, that is after bulk transportation or transmission and distribution (retailing) losses have been deducted from the gross energy production.

The IRP methodology was used to rank the supply technologies and the demand-side appliances in terms of generation/production cost, job creation potential and emission of air pollutants. With the aid of the IRP, the generation costs of various electricity production technologies have been documented for the SNEP.

³ Apart from the LEAP and IRP, two other application programmes – RETSCREEN and MESSAGE were used in some instances for crosschecking and fine-tuning of some of the outputs of the LEAP and IRP.

VRA and ECG provided support in the analysis for the transmission and distribution expansion scenarios.

The SNEP period covers two decades. Ghana's political elections come off every four years and so the planning period makes it possible for individual political parties to relate the SNEP to fit their terms of office. The years, 2008, 2012, 2015 and 2020 were selected as default for the following reasons:

- 2008 had been the milestone of the Ministry of Energy's petroleum Sector strategic plan since 2003.
- 2012 was originally the government's middle-income target year for Ghana.
- 2015 is currently the government's middle-income target year for Ghana and the milestone for the UN Millennium Development Goals.
- 2020 marks the end of two decades and has been the planning period selected by most international agencies. Ghana's 100 percent universal electrification is set for 2020. A number of countries of which Ghana has been comparing her middle-income development objectives such as Malaysia have 2020 as their development milestone.

The choice of 2000 as the base year was influenced by the fact that in 2000, a national Population and Housing Census was undertaken and that provided a wealth of reliable data on the country's demographics which were very essential inputs for the modelling.

1. INTRODUCTION

1.1 *Energy and Development Nexus*

1. The rapid economic development of any economy requires the injection of large amounts of energy. Empirical evidence from both developing and developed economies shows a close correlation between the rates of economic growth and energy demand. Other statistics exist that show however that the rate of energy demand growth in the developing economies especially in Africa with respect to economic growth rates are far higher than the norm. The rate of growth of Ghana's Gross Domestic Product (GDP) since 1985 has been between 3.5 – 6 percent, yet over the same period, the demand for electricity had grown at the rate of 10 – 14 percent per annum.
2. Ghana's energy challenge is manifested in her expanding economy and the growing population. Ghana's population was 18.9 million in 2000 and it is projected to reach about⁴:
 - 29 million in 2015, the target year for the Millennium Development Goals; and
 - 31-32 million by 2020.
3. Based on data released by the Ghana Statistical Services, the corresponding number of households and urbanisation would rise from 3.7 million households and about 34 percent urban share in 2000 to about:
 - 5.7 million households and 43 percent urban share in 2012;
 - 6.4 million households and 45 percent urban share in 2015; and
 - 7.7 million households and 48 percent urban share by 2020.
4. In recognition of the need to spur economic growth and reduce poverty, the Government of Ghana initiated the Ghana Poverty Reduction Strategy (GPRS) in year 2001 as a framework with the requisite strategies to achieve the twin objectives of poverty reduction and economic growth. In the medium to long term, the Government has launched a series of programmes to transform the country's economy from the low-income status of less than US \$400 per capita in 2000 to a middle-income status with US \$1,000 per capita by end of the next coming decade. Total real GDP was about US \$7 billion in 2000.
5. The energy sector generates both outflows and inflows to the economy. Ghana is a non-oil producing country and crude oil imports is an important component of its trade basket, equivalent to for approximately 25% of export earnings, 18% of imports or 13% of total revenue and grants in 2001–2002. Crude oil imports accounted for

⁴ Intercensal growth rate between 1984 – 2000 was 2.67%. The National Development Planning Commission (NDPC) forecasts with 2.5% population growth.

approximately 80% of the trade deficit in 2001⁵. In 2004, the oil import constituent of trade increased to 28% of export earnings, but its share of trade deficit dropped to about 54%.

6. With respect to inflows the energy sector contributes to the GDP indirectly through its use as inputs for production. Such inputs are used in varying proportions across all the sectors of the economy.
7. The energy sector also contributes directly to the GDP through its contribution to tax revenues. Such taxes accrue largely in the form of petroleum taxes⁶.

GPRS High Economic Growth Scenario

8. For the high economic growth scenario based on the Government's socio-economic development goals as contained in the GPRS to achieving a real GDP per capita of US \$1000 by 2015, the GDP per capita was expected to grow at the rate of 8.2 percent per annum from about US \$390 per capita in 2000.
9. The GPRS high economic growth rate would have yielded about:
 - US \$19.5 billion by 2008 equivalent to about US \$815 per capita;
 - US \$25.6 billion by 2012 equivalent to the US \$1000 per capita;
 - US \$34 billion by 2015 equivalent to about US \$1226 per capita; and
 - US \$60 billion by 2020 equivalent to almost US\$2000 per capita.
10. The structure of the economy would shift from agro-based to more of a mix of industrial and services by 2015. For the SNEP, the expected sectoral shares in 2015 are assumed to be the same for 2020 and are as follows:

	2000	2015	2020
Industry	25 %	31 %	31 %
Commercial Services	30 %	39 %	39 %
Agriculture & Fisheries	36 %	24 %	24 %
Net indirect taxes	9 %	6 %	6 %

⁵ Economic Analysis of Energy Sector by Prof. Bartholomew Armah, 2003, Energy Commission publication.

⁶ Economic Analysis of the Energy Sector by Prof. Bart Armah, Institute of Economic Affairs Energy Commission publication, 2003

Business-as-usual Economic Growth Scenario

11. Business-as-usual (BAU) economic growth means that the average GDP growth rate of 4.18 percent from the 1990s to 2000 would remain the same and eventually up to 2020.
12. The total GDP would grow from about US \$7.3 billion in 2000 to about:
 - US \$10 billion by 2008 equivalent to about US \$422 per capita;
 - US \$12 billion by 2012 equivalent to the US \$466 per capita;
 - US \$14 billion by 2015 equivalent to about US \$485 per capita; and
 - US \$17 billion by 2020 equivalent to almost US\$552 per capita.

Moderately High Economic Growth Scenario

13. However, the Government of Ghana estimates the country's prevailing GDP per capita to be over US \$500 per capita implying that the BAU economic growth scenario has been exceeded. It therefore provides the need to look at Moderately-high Economic Growth (MEG) scenario. It is assumed that the structure of the economy would still shift from predominantly agro-based to industrial and services but not as significant as in the GPRS High Economic Growth scenario. The MEG scenario is assumed to be the average between the GPRS-High Economic Growth and the Business-as-usual Economic Growth scenarios and that the real GDP per capita of US \$1000 is achievable in 2015 based on the prevailing real GDP per capita of US\$600⁷.

1.2 Energy Sector Overview

14. Total primary energy produced in Ghana in 2000 was 6.2 million tonnes of oil equivalent⁸, about eleven and half times the yearly average energy generated at Akosombo and Kpong hydroelectric plants (table 1.1).

⁷ Government's Annual Budgets for 2004-2006. World Bank gives US\$330, US\$380 and US\$450 as Ghana's GNI per capita (*current using Atlas Method*) for 2000, 2004 and 2005 respectively based on total population of 19.9 million for 2000, 21.7 million for 2004 and 22.1 million for 2005.

⁸ About 69,000 Gigawatt-hour

Table 1.1 Total National Energy Balance for 2000 - 2004⁹

TOTAL ENERGY BALANCE		2000	2001	2002	2003	2004
Primary indigenous energy production	Thousand TOE¹⁰	6,196	6,447	6,505	6,645	7,640
	<i>Percentage biomass</i>	90.2	90.0	92.8	94.5	93.9
	<i>Percentage hydro</i>	9.6	9.8	7.0	5.3	6.0
	<i>Percentage solar</i>	0.2	0.2	0.2	0.2	0.1
Net Energy imports	Thousand TOE	1,897	1,946	2,306	2,444	2,600
	<i>Percentage electricity</i>	2.1	0.7	2.0	1.2	0.7
	<i>Percentage petroleum</i>	18.4	15.9	15.2	16.3	10.0
	<i>Percentage crude oil</i>	79.5	83.4	82.8	82.5	83.0
Net Energy exports	Thousand TOE	0	0	0	0	0
Primary energy supply	Thousand TOE	8,093	8,383	8,814	9,089	10,240
	<i>Percentage petroleum</i>	23.0	23.0	25.7	27.0	20.5
	<i>Percentage hydropower</i>	7.3	7.0	5.1	3.9	4.3
	<i>Percentage biomass</i>	69.4	69.9	68.9	68.9	75.0
	<i>Percent import electric</i>	0.2	0	0.3	0.1	0.1
	<i>Percentage solar energy</i>	0.1	0.1	0.1	0.1	0.1
Secondary or final energy supply	Thousand TOE	5,968	6,101	6,265	6,326	7,100
	<i>Percentage electricity</i>	9.9	10.3	9.7	7.5	6.0
	<i>Percentage woodfuels</i>	62.1	63.0	63.7	65.5	66.9
	<i>Percentage petroleum</i>	27.7	26.5	26.4	26.8	27.0
	<i>Percentage solar</i>	0.2	0.2	0.2	0.2	0.1
Consumption	Thousand TOE	5,968	6,101	6,265	6,326	7,100
	<i>Percentage shares</i>	49.7	50.1	50.4	51.6	50.4
Residential		1.5	1.4	1.4	1.4	1.6
Agriculture & Fisheries		2.9	3.3	3.4	3.6	3.0
Commercial & Services		22.3	21.3	21.3	21.9	22.0
Transport		23.6	23.9	23.5	21.5	23.0
Industry ¹¹		26.2	27.1	28.8	30.2	30.7
Energy Losses	Percent	26.2	27.1	28.8	30.2	30.7
CO₂ emissions due to energy¹²	Million tonnes	7.7	8.1	9.5	9.2	9.2

15. The indigenous primary energy production grew at an average rate of 2.4 percent between 2000 and 2004. It rose from 6.1 million tonnes of oil equivalent in 2000 to 6.8 million tonnes of oil equivalent by 2004.

16. Carbon dioxide emissions as a result of the energy usage rose from about 7.7 million tonnes of carbon dioxide equivalent in 2000 to 9.5 million tonnes in 2002 but dropped

⁹ Woodfuel estimates for 2003 and 2004 are based on 2000 census and field surveys conducted in 2002.

¹⁰ TOE is tonnes of oil equivalent. 1 TOE is equivalent to about 11.6 thousand units (kWh) of electricity.

¹¹ VALCO and informal industrial subsector inclusive.

¹² Estimated. It however does not include emissions caused by international air travel in accordance with IPCC computations. Also, direct emissions from industries are not included.

to 9.2 million tonnes in 2003-2004 with reduction in thermal generation at Aboadze (near Takoradi) evidently due to the suspension of VALCO smelting operations in those years.

17. The primary indigenous energy comprised 90-95 percent woodfuels (generally called biomass), 5-10 percent hydroelectricity and less than one percent solar energy. The hydroelectricity was supplied from Akosombo and Kpong hydroelectric dams.
18. Sun-drying of crops; mainly 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 accounted for the solar energy¹³. Solar energy for production of electricity was relatively negligible; about 150 tonnes of oil equivalent¹⁴.
19. Net energy import was about 1.9 million tonnes of oil equivalent in 2000 increasing to 2.6 million tonnes of oil equivalent by 2004. It comprised 80–83 percent crude oil and about 15-19 percent petroleum products.
20. The primary energy production and the net import make up the primary energy supply and totalled about 8.1 and 10.2 million tonnes of oil equivalent in 2000 and 2004 respectively.
21. Biomass was the most dominant primary energy supplied, averaging 69 percent over the period, followed by oil comprising crude oil and products averaging 25 percent.
22. Electricity imports and solar energy comprised about 0.2 and 0.1 percent on the average respectively during the period.
23. Final energy supply, i.e., the energy finally reaching the consumer after transportation and transmission was about 6 million tonnes of oil equivalent in 2000 and about 7.1 million tonnes in 2004.
24. Energy losses totalled about 26 percent of the total primary supply in 2000 but increased to about 30 percent in 2004.
25. Biomass in the form of firewood and charcoal still dominated the final energy reaching the consumer, averaging 64 percent over the period. Petroleum products and electricity followed with 27 percent and about 9 percent respectively.

¹³ The basket for the computation of commercial solar energy will be expanded in future as more reliable data become available

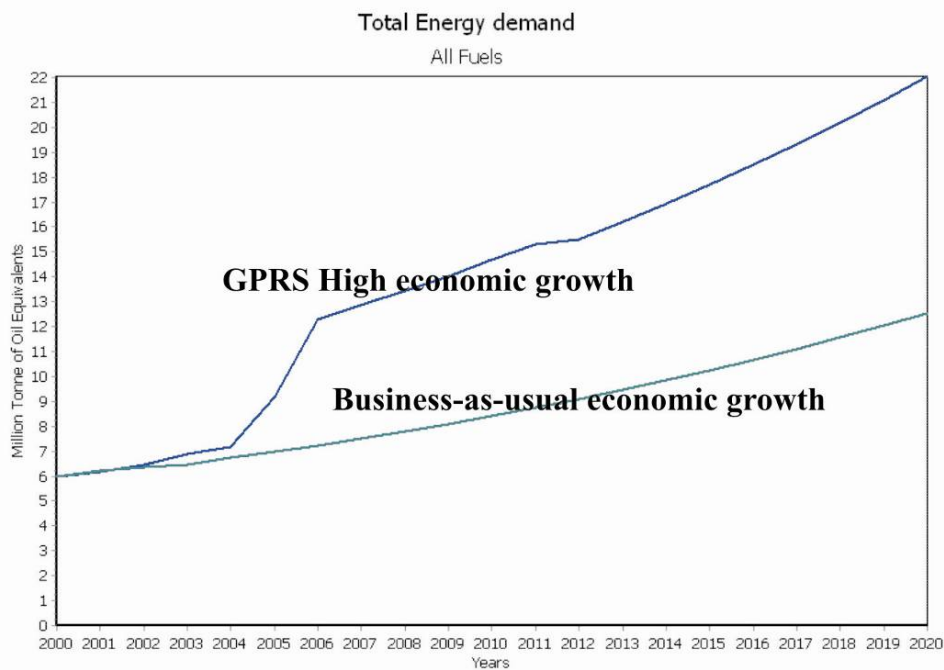
¹⁴ In terms of numbers, solar energy used for largely home lighting is the most populous, numbering over 5,000 systems. In terms of system capacity, the telecom and the water pumping systems are the largest, between one to two kilowatt peak power per system. The largest single installation however is the 50 kilowatt peak solar electric-grid system on the premises of the Ministry of Energy in Accra.

26. The residential or household sector of the economy accounts for almost 50 percent of the country's energy consumption. The significant residential sector share of the nation's energy demand is due to the high usage of woodfuels comprising mainly firewood (almost 76 percent) and charcoal.

High economic growth scenario

27. Should the Ghana Poverty Reduction Strategy (GPRS)¹⁵ targets to usher the country into a middle income range of US\$1,000 per capita in 2015 be realised, consumption of woodfuels would grow from about 14 million tonnes in 2000 to 38-46 million tonnes by 2015, and 54 – 66 million tonnes by 2020 but would put the nation's dwindling forest under undue stress which could culminate into serious deforestation, with serious consequences on climate change, agriculture and water resources, if no significant action is taken.
28. Total petroleum fuel demand is projected to rise from about 1.6 million tonnes in year 2000 and could exceed 3 million tonnes in 2015 and reach 4.5 million tonnes by 2020.
29. Net final grid electricity consumed in economy would grow from about 6,900 Gigawatt-hour in 2000 to about 18,000 Gigawatt-hour by 2015, reaching about 24,000 Gigawatt-hour by 2020.
30. Ghana imports crude oil and a quantum jump in demand could severely affect the nation's balance of payment.
31. The existing installed electricity generating capacity of 1,760 Megawatt would have to be at least doubled by 2020 should the nation be assured of secure electricity supply.
32. The total energy demand would grow from 6.2 million TOE in 2000 to about 22 million TOE by 2020 (figure 1.1).

¹⁵ GPRS II



1.3 Energy Supply – Consumption Continuum¹⁶

33. Biomass in the form of firewood and charcoal, Petroleum products in the form of gasoline, diesel etc, and Electricity make up the Energy Supply. The integrated energy supply feeds the economy comprising Residential, Commercial & Services, Agricultural & Fisheries, Transport and Industries. The Energy Supply Sector of Ghana thus comprises Biomass, Petroleum and Power (Electricity), whilst the Energy Demand sectors of the Economy are the Residential, Commercial & Services, Agricultural & Fisheries, Transport and Industries (figure 1 and table 1). See Appendices 1 and 2 for further information.

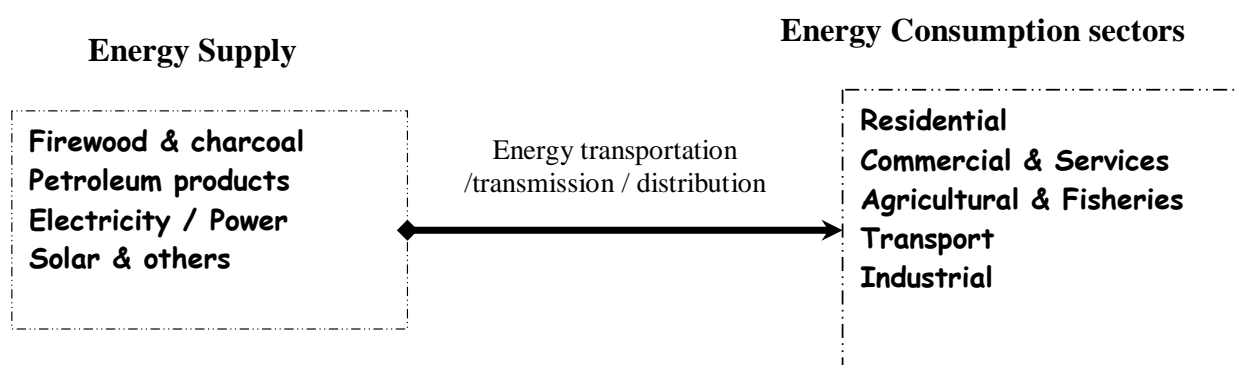


Figure 1 Energy supply-consumption continuum

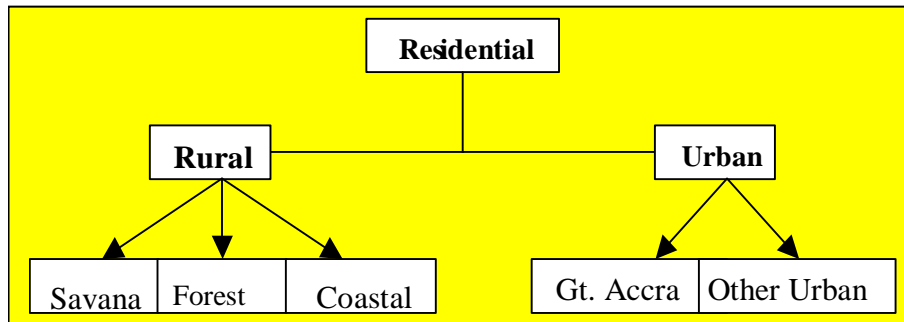
¹⁶ This section is to facilitate easy reading of the subsequent chapters.

Table 1 Current Energy Supply and the Energy Demand Sectors of the Economy

ENERGY SUPPLY SECTOR	ENERGY DEMAND SECTORS OF THE ECONOMY	
	Economic Sectors	Sub-sector classification
Woodfuels / Biomass	Residential	Urban, Rural
	Commercial and Services	Tourism, Health, Defence, Education, ICT, Offices, Stores, Informal (vendor cooking, etc), Others
Petroleum.	Agricultural and Fisheries	Irrigation, Land Preparation and Harvest, Spraying and Logging, Post Harvest Processing, Livestock, Fisheries.
	Transport	Road, Rail, Maritime, Air
Power/ Electricity	Industries	Manufacturing, Mining, Utilities, Construction, VALCO

2. THE DEMAND SECTORS OF THE ECONOMY

2.1 The Residential Sector



2.1.1. Description of the Sector¹⁷

Structure

34. Total number of households in Ghana was about 4 million in 2000 and is expected to reach between 5 – 6 million by 2020. Urbanisation is expected to increase from the 40 percent in 2000 to about 55 percent in 2015 and eventually 60 percent by 2020. A little more than a third of the urban population lives in Greater Accra and is expected to reach around 40 percent by 2020. About 50 percent of the rural households are found in the forest zone and this is not expected to change significantly by 2020.
35. Energy sources in urban areas are more diversified than in rural areas, since access to alternative (modern) fuels and appliances are higher in the urban areas than in the rural areas.

Energy for cooking

36. In Ghana, over 90 percent of rural households depend on fuelwood for cooking. Charcoal on the other hand is the dominant cooking fuel used in the urban areas. About 61 percent of urban households use charcoal as their main fuel for cooking.
37. LPG use in the country on the other hand accounts for only 4-6 percent of the residential sector. This is concentrated in the urban areas among the middle and higher income groups¹⁸.

¹⁷ Disaggregation of the Residential Sector is based on Ghana Statistical Services' classification.

¹⁸ According to Ghana Living Standard Survey GLSS 4 (2000, Ghana Statistical Services) and the Ghana Population Census (2005, Ghana Statistical Services), LPG serves as cooking fuel for about 4 – 6 percent of households in the country; 10% households in the urban areas and only 0.6% households in rural areas. Kerosene is the main fuel for lighting for 82 percent and 22 percent of households in the rural and urban areas respectively.

38. The use of electricity is negligible although small electric stoves are popular among students and the unmarried youth.

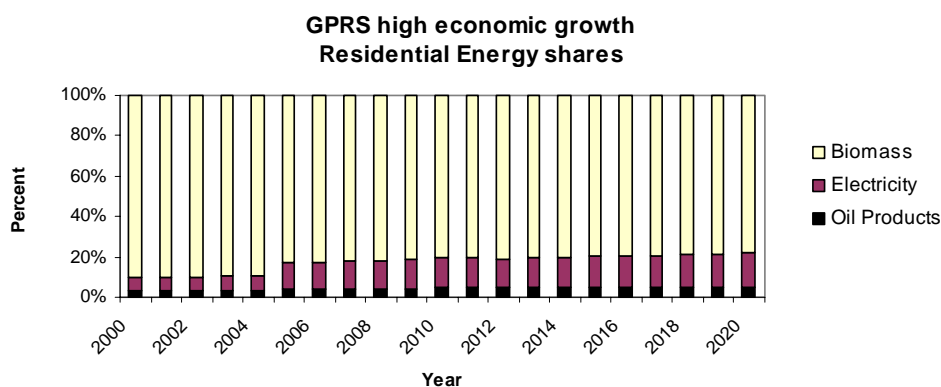
Energy and fuel for lighting and other purposes

39. Energy for lighting purposes is obtained from two sources, kerosene and electricity. About 52 percent of the population use kerosene for lighting. Kerosene is used mainly in rural areas with 82 percent of rural population depending on it for lighting. Nevertheless, its use is associated with high levels of indoor air pollution. Electricity, a high quality lighting source on the other hand, is used extensively in the urban areas of the country where the higher and middle-income groups are the major consumers.
40. About 48 percent of households in the country use electricity for lighting and other purposes in the country. Urban households accounted for 88 percent of electricity usage, whilst rural households accounted for the remaining 12 percent. Refrigeration accounted for about 20 percent of the urban electricity consumption.
41. All the regional capitals have been connected to the grid. In 2000, the electricity usage in the rural areas was estimated to be higher in the coastal (27 percent) and forest (19 percent) ecological zones, than in the savannah (4.3 percent) areas of the country.

2.1.2. Energy and fuel projections for the Residential Sector

42. Biomass share of residential energy averaged 90% from 2000-2004. Electricity share was about 6.6% whilst petroleum product share averaged 3.2% per annum over the period.
43. Biomass in the form of woodfuels would still be the dominant fuel in the residential sector varying between 85 – 88 percent from 2015 to 2020. Electricity is expected to increase its share from 6.5 percent in 2000 to about 9 percent by 2015 and around 11 percent by 2020. Penetration of petroleum products mainly kerosene, is not expected to increase significantly in terms of shares (figure 2.1).

Figure 2.1



Liquefied petroleum gas

44. Total liquefied petroleum gas (LPG) consumption by the Residential sector was about
 - i. 27, 000 tonnes (*about 1.7 million filled regular-size domestic cylinders¹⁹*) in 2000 and
 - ii. 49,000 tonnes (*roughly 2 million and 160,000 filled regular-size domestic cylinders*) in 2004.
45. For the high GPRS economic growth scenario, the LPG demand is expected to
 - i. exceed 126,000 tonnes in 2015 requiring over 9 million domestic regular-size cylinders; and
 - ii. reaching about 300,000 tonnes requiring over 22 million regular-size domestic cylinders by 2020.
46. The estimated long-term sectoral growth rate in the LPG demand is between 8.5 – 10 percent per annum.

Kerosene

47. Kerosene consumption in the residential sector was almost 64,000 tonnes (or 79 million litres) in 2000 and 72,000 tonnes (or 89 million litres) in 2004.
48. For the high GPRS economic growth scenario, the demand for kerosene will be
 - i. about 79,000 tonnes (97.7 million litres) in 2008,
 - ii. exceeding 87,000 tonnes (108 million litres) in 2012 and
 - iii. reaching 109,000 tonnes (134 million litres) by 2020.
49. The estimated long-term sectoral growth rate in the kerosene demand is between 7 – 8 percent per annum.

Electricity

50. The electricity demand of the residential sector is expected to exceed:
 - i. 7,000 Gigawatt-hours for high economic growth by 2008
 - ii. 12,000 Gigawatt-hours for high economic growth, by 2015
 - iii. 24,000 Gigawatt-hours for high economic growth, by 2020.
51. The sectoral demand growth rate could be between 10 – 15 percent per annum if adequate electricity is made available.

¹⁹ 14.5 kg LPG cylinder.

2.1.3. National Electrification scheme

52. The national electrification scheme (NES) targets 100 percent electricity penetration by 2020. So far the electrification has been mainly by grid extension and about 43.5 percent of the population has gained access to grid electricity by 2000. As more communities qualify to be provided with grid electricity, the financial requirements of the scheme will continue to increase.
53. To sustain the ongoing rural electrification, the sale of power in the communities that benefited from the scheme has to generate enough revenue to finance the maintenance and extension of the network to other communities.
54. In 1988/89 about 3.8 million rural inhabitants in communities with less than 500 persons per community were excluded in the national electrification scheme as the scheme was initially planned to supply electricity to communities having populations of 500 or more²⁰. Assuming 2 percent annual population growth, the excluded rural communities would result in about 7 million inhabitants by 2020. This is an indication that about 24 percent of the population will still not have access to the grid electricity even if all funding is secured.

2.1.4. Sectoral Challenges

Compound house effect²¹

55. Electricity billing of compound houses has still not been resolved by the electricity tariff structure as of 2006. Unlike the 1990s however, many of the residents in compound houses now do have the option of getting individual meters. The issue of sharing metering facilities invariably cause the units consumed by compound house class of customers who largely happen to be in the poorer and low-income group to fall within the high tariff brackets of the existing progressive tariff structure. Most of them are transferred above the 50 unit price margins into relatively expensive tariff blocks.
56. In addition, compound houses do pose problems both to the power utilities and to the occupants in terms of timely bill payments. There are delays in payments by some occupants, reasons include, some not ready with cash at the time bill payments are being collected.
57. The challenge is how to make the internal systems in compound houses more equitable.

²⁰ National Electrification Planning Study (1990), Ministry of Fuel and Power, Government of Ghana.

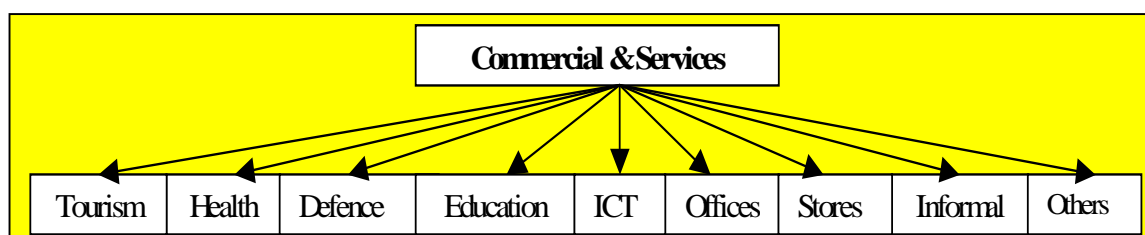
²¹ PSIA Study of the Electricity Sector (2003), , World Bank support activity for NDPC prepared by KITE.

Sensitivity to Fuel Price Changes

58. A recent PSIA study²² suggest that the fuel consumption patterns of high income groups and urban dwellers tend to be relatively more petroleum-intensive than rural dwellers and other low-income groups. Given the importance of kerosene as a source of lighting among rural dwellers, the latter tends to be more vulnerable to changes in the price of kerosene than grid-connected residents. Furthermore, rural dwellers tend to cut spendings on pharmaceuticals and other household needs particularly in response to a change in kerosene prices.
59. The PSIA study found LPG a luxury fuel among *rural* and *other urban* dwellers. As a result both categories of consumers exhibit high price and income sensitivity to changes in LPG prices. In effect, they are more likely to switch from LPG to other alternatives in the event of a price hike. There were evidences of consumer expenditure switching away from LPG and kerosene to charcoal following the petroleum price hike in 2003.
- 60. The key energy related issues in the residential sector are:**
- i. Meeting the woodfuel requirements of the residential sector in a sustainable way.
 - ii. Increasing LPG share of residential energy profile.
 - iii. Besides the challenge in meeting the LPG demand, there would also be the need to meet the high cylinder requirement particularly by 2020, since the existing cylinders would have to be replaced by then.
 - iv. Providing off-grid communities with high or grid-quality electricity in order to ensure 100 percent universal electrification by 2020.
 - v. Lack of coordination among utility and physical planning agencies culminating in uneven distribution of power networks.
 - vi. Communal use of meters increases electricity bills of users, particular for the poor mainly due to the prevailing electricity tariff structure.

²² Poverty and Social Impact Assessment (PSIA) Study; Distributional Impact and Effects of Ghana's Petroleum Pricing Policy, February, 2005. Prepared by Armah and Associates for National Development Planning Commission (NDPC) and United Nations Development Programme (UNDP), Ghana.

2.2 Commercial & Services Sector



2.2.1 Description of the Sector²³

Structure

61. The Commercial and Services Sector also referred to as the tertiary sector is regarded as the facilitator of economic growth. It has been the fastest growing sector of the economy over the past decade and continues to increase its share in the nation's gross domestic product (GDP)²⁴. Sectoral share in the GDP and the annual growth rate between 2000 and 2004 have averaged 32.1 percent and 5.0 percent respectively. The Information Communication Technology (ICT) subsector is one of the three main targets identified by the government to drive the GPRS high economic growth.

Sectoral shares of energy

62. The sector's share of total national energy use has on the average been less than 3 percent per annum since 2000.
63. The informal subsector comprising chop-bars and street selling or vendor cooking has had the largest share (over 55%) of energy use by the Commercial and Services Sector since 2000, followed by the Tourism (10–11%) and then, the Education subsector (~5%).

Fuel shares

64. Most of the energy used in this sector had come from woodfuels (over 65 percent in 2000). Electricity follows with about 30 percent share, and then petroleum products, about 9 percent share.
65. Firewood forms the bulk (about 86 percent) of the woodfuel consumption in the Commercial & Services sector and it explains the relative large percentage share of the informal sector. Vendor cooking / street-selling is responsible for over 85 percent of the woodfuels consumed by the sector. Restaurants and chop bars on the average

²³ Dis aggregation adopted from the LEAP model classification

²⁴ The State of the Ghanaian Economy, ISSER, University of Ghana, 2005

have between 3 - 6 percent share of the woodfuel consumption annually due to a major shift to LPG as their main cooking fuel in the 1990s.

66. LPG is the main (99 percent) petroleum product consumed by the Commercial & Services sector. Restaurants are responsible for over 75 percent of LPG consumed by the sector. Chop bars take on the average about 13 percent shares every year.
67. Kerosene use in the sector is relatively negligible. Diesel supply to the sector is also negligible but about 100 times larger than kerosene. Diesel is largely used as fuel for standby power generators and is mainly taken up by the hotels and restaurants with the former consuming the largest share of about 90 percent.
68. The largest share (almost 50% per annum) of the electricity consumed by the Commercial & Services sector is by shops and other miscellaneous activities. The subsector's demand for electricity has been growing at 6.8 percent on the average every year since 2000.
69. Office operations follow as the next largest consumer of electricity; almost 20 percent on the average, per year.
70. Defence and security together is the third highest consumer of electricity, though the share has fallen from about 15 percent in 2000 to a little less than 10 percent per annum in recent times.
71. The Education subsector comprising the tertiary and secondary institutions, etc reduced its share of electricity from 10% in 2000 to around 5% on the average by 2004.

2.2.2 Energy and fuel Projections for the Commercial and Services Sector

72. Diesel LPG, and woodfuel use in the Commercial & Services sector averaged about 16, 16,000 and 380,000 tonnes per annum respectively (table 2.1)

Table 2.1 Fuel used in the Commercial & Services Sector from 2000 – 2004

	2000	2001	2002	2003	2004
	Tonnes				
LPG ($\pm 40\%$)²⁵	15,000	16,000	15,000	15,000	16,000
Diesel	15	14	16	16	18
Woodfuels	387,000	348,000	364,000	380,000	410,000

²⁵ Commercial & Service Sector dis-aggregation is the most difficult so far. Some activities classified as commercial are considered as industrial by some literature. This discrepancies account for 20% of the error margin. The remaining 20% accounts for other ambiguities between Residential and Commercial/Service sectors; Some commercial activities are disguised as residential and so are accounted as such.

73. Electricity consumption averaged rose from about 444 GWh in 2000 to about 900 GWh by 2004.
74. For the GPRS high economic growth scenario, firewood demand is expected to grow at reduced rates due to potential shift to charcoal and LPG. For the high GPRS economic growth scenario, projections are as follows:
75. Electricity demand in the Commercial & Service sector could exceed 1,500 GWh by 2008, 3000 GWh in 2015 and reach about 4,000 GWh by 2020. As quality of electricity supply improves, diesel as fuel for standby generators will not be significant.

Fuels	2008	2015	2020
Firewood	356,000 tonnes	380,000 tonnes	430,000 tonnes
Charcoal	40,000 tonnes	45,000 tonnes	80,000 tonnes
LPG	30,000 tonnes	45,000 tonnes	55,00 tonnes

76. The informal subsector will still dominate in the share of energy demand due to high demand for woodfuels.
77. LPG demand is still dominated by the Restaurants and the Chop bars, apparently for cooking.

2.2.3 Sectoral challenges

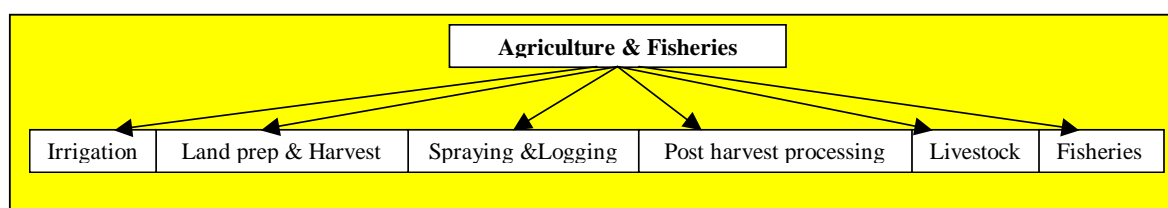
78. A survey in 2002²⁶ listed poor utility services as one of the major hindrances (60 – 70 percent) to Ghana’s international competitiveness on the global market.
79. Meanwhile, the Commercial/Services Sector is expected to contribute significantly to the realisation of the US\$1000 per capita GDP expected in 2015. The key drivers of growth in this sector are expected to include investments in ICT. Growth in ICT will impact significantly on the electricity demand.
80. The high growth in the Tourism subsector, will put a lot of pressure on LPG supply. Bottlenecks in the supply of LPG could push up the demand for charcoal. The prevailing high growth in the Tourism subsector however may not lead to long term high demand for electricity, mainly owing to the keen interest shown by the hospitality industry in energy saving measures to reduce cost in order to make services attractive.
81. A number of chop bars in their attempt to increase their market share of the growing tourism industry will put in efforts to improve their services thereby upgrading their status which is likely to culminate in a shift from largely firewood to more charcoal and LPG.

²⁶ Survey on cost of Doing Business in Ghana, sponsored by GIPC/World Bank/FIAS/USAID, November 2002

82. The electricity demand of the Defence and the Education subsectors will continue to predominate, if left unchecked.
83. In the Education subsector, increasing penetration of electrical appliances could have multiple and telling effects on electricity demand.
84. Economic analysis carried out by the Energy Commission indicates that solar water heaters, if seriously promoted could provide substantial savings in energy cost and it will as well take about half the systems' operational lifetimes to recover their investment costs²⁷.
- 85. The key energy related issues in the Commercial and Services sector are:**
- i. Ensuring that LPG supply is stable and accessible throughout the country.
 - ii. Meeting the training needs of the anticipated large number of LPG plant distributors and attendants in order to maintain satisfactory safety standards.
 - iii. Reducing the high demand for woodfuels by restaurants, chop bars and educational institutions.
 - iv. Reducing pressure on charcoal demand by supplying the fuel in a sustainable way without significant negative impact on the forest.
 - v. Reducing indoor pollution in the commercial kitchen environment due to prolong use of woodfuels by promoting alternative cleaner fuels and improved woodstoves.
 - vi. Ensuring high quality power supply at the consumer (mains) level.
 - vii. Reducing the electricity demand by the Defence and Educational subsectors.

²⁷ Least Cost Assessment of Power Generation Technologies and Demand-Side Appliances, (2004), Energy Commission IRP Analysis, Ghana.

2.3 Agriculture & Fisheries Sector



2.3.1 Description of the Sector²⁸

Structure

86. The share of the Agricultural & Fisheries sector in total GDP has been between 36-40 percent from the 1990s to date. It was 36 percent in 2000.
87. The Agriculture & Fisheries sector also contributes to the energy sector immensely by producing and supplying woodfuels. However, the final energy use by the sector is very small, accounting for less than two percent of total energy use in 2000.
88. Fisheries cover to a large extent energy for fishing and preservation. The main fuels for the Fisheries subsector are diesel and premix gasoline. Trawlers and tuna vessels use diesel. Premix fuel is used both in the farming and fishing activities. It is used as fuel for spraying pesticides largely in cocoa plantations and in canoes fitted with outboard motors for marine and in-land fishing.

Sectoral shares of energy

89. The fisheries subsector accounts for over 90 percent of the energy use in the Agriculture & Fisheries sector, followed by Post-harvest processing (3.1 percent). The rest have shares averaging one percent or less each.

Fuel shares

90. Total energy used by the Agriculture & Fisheries sector was about 234 tonnes of oil equivalent in 2000 increasing to about 380 tonnes of oil equivalent by 2004. Diesel consumption took the largest share of the energy used.
91. Solar energy accounted for over 12 – 15 percent of the Agriculture & Fisheries sector energy share during the period 2000 - 2004. Solar energy in its dispersed and diffused state is utilised in commercial sun-drying of most cereals, cocoa and exportable dried farm produce such as kolanuts and pepper. The solar energy computation here covers the drying of locally produced maize, paddy rice, sorghum, millet and groundnut.

²⁸ Disaggregation of this Sector adopted from the LEAP model classification

2.3.2 Energy and fuel Projections for the Agriculture and Fisheries Sector

	2008	2015	2020
		Percentage shares	
Fuelwood	5.5- 6.0	6.4 – 6.8	8.1 - 8.6
Premix	37 – 41	36 - 40	36 – 40
Diesel	52 – 56	52 - 55	52 – 55
Electricity	1.2	2.0	4.0

2.3.3 Sectoral Challenges

93. In general, the growth of energy use in the Agriculture & Fisheries sector will have little impact on the national demand due to its historical low penetration.

Encouraging Irrigation

94. The Agricultural & Fisheries sector's dependence on rainfall for production remains a major constraint in sustaining seasonal outputs and it is as well a major risk that discourages regular large-scale investments. Irrigation as a measure of counteracting the dependence on rainfall is not adequately pursued, since only 0.02 percent of total cultivated land is under irrigation.
95. For instance, Ghana needs about 450,000 tonnes of rice annually. About 200,000 – 300,000 tonnes had been imported annually in the past, even though, import fell to about 120,000 tonnes in 2002. Besides, 75 percent of the rice produced locally depends on rains, about 5 percent is produced under valley water but just around 10 percent is produced via irrigation.
96. The development of irrigation has not been encouraging. A target was set in 1984 to achieve 180,000 hectare irrigated land by 1990. However, as of 2004, only about 8,000 hectares could be irrigated of which around 2,000 hectares is mechanised. Comparatively, Senegal, a country of about the same land size as Ghana and within the West Africa sub-region has 600,000 hectares of land under irrigation.
97. The GPRS adopts a two-pronged approach to irrigation. One approach emphasizes micro and small irrigation while the second focuses on medium to large-scale irrigation.
98. Medium and large-scale irrigation will involve the construction of major dams, pumping stations and long distance conveyance pressure pipe systems for commercial investors. Large-scale grid irrigation is capital and energy intensive. The poor performance of the existing large-scale dams has been attributed to high electricity cost.

99. The micro approach, unlike the large-medium scale irrigation is relatively less capital intensive and suggests more of gravity fed irrigation development, thus less commercial energy. Maximising the number of micro dams however, is still likely to lead to increasing energy input, since conditions necessary for gravity-fed development is seldom going to be available in the long term.
100. Increasing use of irrigated facilities in non-grid areas will also increase the demand for diesel. However, as the remote areas get connected to the national grid, diesel facilities are likely to be replaced by grid-powered mechanical irrigation pumps.
101. GPRS' emphasis on agricultural modernisation will also imply increased mechanisation, which could increase the demand for diesel fuels.

Increasing Cocoa output

102. The high agricultural sector growth in 2003-2004 was attributed largely to the unusual growth rate of 16.4 percent of the cocoa subsector. Cocoa was the second highest foreign exchange earner in 2003 after gold, accounting for almost 35 percent of the year's total revenue. The substantial cocoa output is attributed to the mass spraying exercise launched in the 2001-2002 season.
103. Cocoa output is likely to reach new heights as a result of price incentives in the past few years and the control of cocoa pests and diseases through the mass spraying exercise. Cocoa production was 736,900 tonnes in 2003-2004 cocoa-season from 340,600 tonnes in the 2001-2002 season. It fell however to about 583,100 in 2005. The sector ministry has targeted an average of 700,000 tonnes per annum by 2009-2010.
104. The largest world producer of cocoa in 2000 was la Cote d'Ivoire with about 1.1 million tonnes. Ghana therefore could target an average of one million tonnes by 2020 assuming the prevailing attractive world market price is sustained. Such future long-term optimistic outputs however, will require significant input of premix gasoline to sustain the mass spraying exercise, taking cognisance that this fuel is "subsidised"²⁹.

Increasing Livestock output

105. The poultry population in the country was around 19 million birds in 2000, i.e. about 1 bird per capita during the census year. The bird population was around 29 million in 2003/4. Average annual growth in the 1990s was 9% but dropped to about 6 percent in 2003/4. Ghana's continued importation of large quantities of frozen poultry meat and other livestock is an indication that the existing level of livestock and poultry population is still inadequate.

²⁹ Premix gasoline has significantly reduced taxes compared to regular gasoline.

106. Energy use in the poultry industry is mostly electricity and LPG for hatchery, feed-milling, lighting to provide heat for birds. Large-scale or most commercial poultry farms are energy intensive to the extent that almost all the registered commercial farms are producing below their capacities as a result of comparatively high production cost. Meeting the livestock needs of the country will require increased use of mainly electrical energy.

Increasing fishing output

107. The fisheries subsector is the second largest component of the agricultural sector, however, its average growth rate appears to have stagnated at a very low level of 1 – 3 percent over the years.
108. Ghana's annual fish catch averages 400,000 tonnes, which is inadequate since the country imports almost the same quantity every year. Marine fishing however, is not likely to grow significantly in the foreseeable future due to indications of over-fishing in the nation's seas³⁰.
109. The GPRS strategy thus places more emphasis on inland fishing as opposed to marine fishing. Consequently, aquaculture is given greater priority. The development of aquaculture will include the development of hatcheries and production of fingerlings and the construction of ponds, pens and cages. The focus on aquaculture may not have any significant impact on the agricultural sector's demand for energy in the long term.

Reducing post-harvest losses

110. Post harvest losses of cereals were estimated at 15-20 percent per annum in the early 1990s and were targeted for reduction to 10-15 percent by 2000. Post harvest preservation of most cash crops including cereals in this country is mainly by drying and cold storage.
111. Cold storage is by refrigeration, which is accomplished effectively through electricity. Electricity could be provided by grid, generator (diesel/gasoline) and by solar (photovoltaic).
112. Drying is either by mechanical or solar drying. Mechanical drying is accomplished either by generator-power or grid electricity whilst solar drying is by natural sunshine (sun-drying) or engineered solar dryers.
113. Mechanical drying however, accounts for less than 5 percent of national produce. Most of the drying of the country's cereals, cocoa and coffee is by natural sun-drying. About 14 thousand tonnes of oil equivalent of sun-drying was utilised for the drying of the national production of cereals, cocoa and coffee in 1997. The solar energy

³⁰ A Fisheries Division source, 2002.

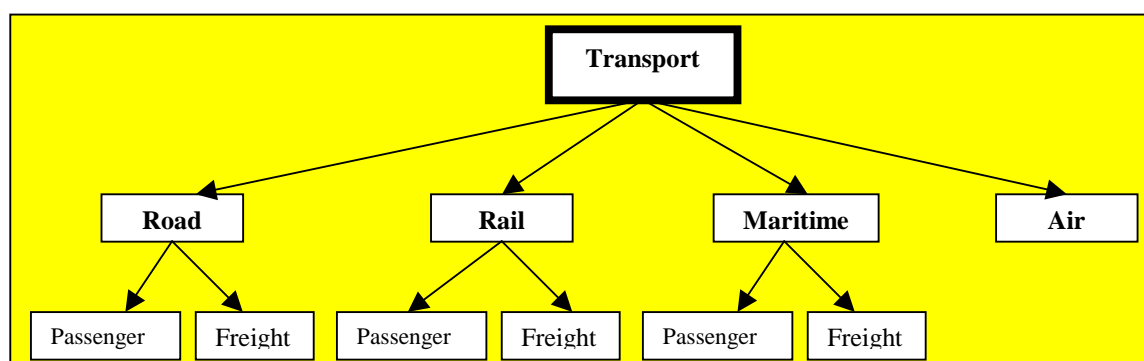
utilised was almost equivalent to the net electricity imported in the year 2000 to supplement local demand.

114. The key energy related issues in the Agriculture & Fisheries Sector are:

- i. Designing a special attractive power tariff for the Agricultural & Fisheries sector that will induce large-scale irrigation and livestock production.
- ii. Meeting premix gasoline demand for the growing cocoa subsector and the fishing subsector in the light of the government's continued "subsidises" for premix³¹.
- iii. Increase utilisation of solar energy to supplement large-scale drying of cash crops in order to reduce the nation's post-harvest losses.

³¹ Reduced taxes compared to regular gasoline.

2.4 Transport Sector



2.4.1 Description of the Sector³²

Structure

115. An efficient transportation system is critical to growth in all sectors of the economy. For instance, the level of post harvest losses in the agricultural sector depends on an efficient marketing and distribution system anchored by a dependable transportation system.
116. The Transport sector is thus, traditionally listed under the Service Sector, but its significance as a consumer of fuel necessitates separate categorisation under the SNEP; it is the largest consumer of petroleum products.

Road

117. Road transport handles over 95 percent of national freight and 97 percent of the passenger traffic. The national road net work increased from about 42,000 kilometres in 2000 to about 64,000 kilometres in 2004. The size of vehicular fleet in Ghana has increased by about 61 percent from 1995 - 2000. The pattern of growth in vehicular population has seen higher growth in private cars, pick-ups and minibuses than in freight vehicles and mass transport systems, comprising taxis and buses³³.
118. Vehicular availability on the road is estimated to be 60-70 percent. Commercial vehicles like taxis and 'trotros' are the most frequently used in comparison with other modes of transport. Trucks are by far the less used.³⁴

³² Dis-aggregation based on Ghana Statistical Services and Ministry of Finance classifications.

³³ Ministry of Transportation (2005) and Driver & Vehicle Licensing Authority (DVLA) data source (2004) and analysed by the Energy Commission.

³⁴ Ministry of Road & Transport, 2002.

Rail

119. Ghana Railway Company (GRC) is the only entity that provides rail transport in Ghana. Its mainstream activity is the haulage of bauxite and manganese ores, round logs, cocoa, etc. to the seaports for export.
120. Ghana railway network is 950 kilometres of mostly single track of 1.067 metre (3ft 6inch) gauge and located in southern Ghana; forming a triangular-like network comprising Tema/Accra in the East, Kumasi in the north and Sekondi/Takoradi at the West. The network carried about 2.3 million tonnes of freight and 8 million passengers in 1965. However by 1990, both freight and passengers carried had dropped to less than one million and further to about thousand tonnes and thousand passengers by 2005. The number of people as well as the mileage covered by passenger trains further decreased by 47 percent and 33 percent respectively from 1995 - 2000. The average annual kilometres has ranged from 430,000 – 500,000 kilometres with load factor hovered around 300 tonnes until year 2000 when it rose to about 384 tonnes. Thus more people use road for their transport needs, a situation that could lead to higher energy consumption since rail transport is more fuel efficient in comparison with road.
121. The Ministry of Ports, Harbours and Railways was created in 2003 to facilitate the development of ports and harbours in order to boost the level of rail and maritime transport. Passenger levels have increased from below one thousand in year 2000 to over thousand by end of 2004 as prevailed in the mid 1990s. Freight by the end of 2004 has also doubled those of 1990s³⁵.

Air³⁶

122. Air transport handles about 15 percent of the country's international merchandise trade. Ghana has only one international airport located in Accra. International air traffic expressed in terms of aircraft movements, passenger and freight carried has increased steadily since 1995 and is expected to quadruple by 2020. An average of 800,000 passengers and 50,000 tonnes of freight per annum have been reported. The volume of domestic flights however, has been very low.
123. Average growth in air traffic from 1997 – 2001 was 10.4 percent per annum and is expected to increase to 12.2 percent in the medium to long term. Annual average growth in freight in the late 1990s was 4.6 percent increasing to about 7 percent per annum from 2000 – 2005, but this is expected to grow further to about 13.4 percent by 2008. GCAA is undertaking an expansion project code-named Airport City Project in accordance with the authority's air traffic projections.

³⁵ Sourced from Driver and Vehicle Licensing Authority (DVLA)), 2003

³⁶ Sourced from Ghana Civil Aviation Authority (GCCA), 2003.

124. Aviation turbine kerosene (ATK) consumption is basically driven by international flights and has increased from about 62 million litres (40,161 tonnes) in 1990 to almost 120 million litres (96,344 tonnes) by 2000. It was 107,233 tonnes in 2004.

Maritime – ocean faring

125. Ghana has two seaports, Takoradi and Tema at western and eastern coasts of the country respectively. The two ports with a capacity of 15 million tonnes between them handle over 85 percent of the country's international merchandise trade. Tema seaport handles of the bulk of imports whilst the Takoradi seaport has mainly been used for export.
126. Annual cargo has exceeded 8 million tonnes, growing at 4.0 percent per annum on the average during the last decade. As a result of political crisis in the West African sub-region, Ghana has become a preferred entry point for the imports of the landlocked northern neighbours. Transit goods increased from almost 145,000 tonnes in 2000 to over 855,000 by 2004.
127. Bunkering services are provided at the ports to boats, medium vessels and fishing trawlers. Large ocean-going merchant freight vessels, usually referred to as ocean liners, practically do not refuel in Ghana.

Maritime - freshwater³⁷

128. The navigable waterway of Volta Lake covers about 224 nautical miles (or 415 km) from Akosombo to Buipe in the North. The Lake Transport is operated by the Volta Lake Transport Company (VLTC), a wholly-owned subsidiary of the Volta River Authority (VRA).

Sectoral shares of energy

129. The Road subsector accounted for 92 – 93 percent of energy use by the Transport sector from year 2000 to 2004. This was followed by Air (6 – 7 percent). Energy use by the Rail and the Maritime subsectors is comparatively negligible, averaging 0.3 percent and 0.1 percent respectively.
130. The transport sector accounted for about 99.7 percent of gasoline consumption in the economy, with the remaining 0.3 percent going into industry for general use as solvent. Almost all the gasoline going into the transport sector was used as fuel for road transport.
131. Most (about 85 percent) of the diesel supplied to the economy was also taken up by the transport sector, whilst the remaining 9 percent and 5 percent went to Industry and the Agriculture & Fisheries sectors respectively.

³⁷ Sourced from Ministry of Roads and Transport, 2002

132. 99.3 percent of the diesel going into the transport sector was used by road transport. The rail and the maritime subsectors took the rest; 0.6 percent and 0.1 percent respectively. This does not include the diesel used by fishing and tuna vessels since they are already accounted for by the Fisheries subsector under Agriculture & Fisheries sector. The fuel consumption by the maritime subsector was mainly for inland or freshwater transport.
133. LPG use fuel in the transport sector during 2000 – 2004 was relatively negligible.
134. All jet kerosene went to air transport.

2.4.2 Energy and fuel Projections for the Transport Sector

135. Road transport will continue to be the dominant fuel consumer in the Transport sector, followed by air transport. Influence of marine transport and railways on fuel demand will still not be significant, unless there are dramatic policy changes that will see significant expansion of marine and railway patronage in the country.
136. For year 2000 – 2004, growth rate for diesel was 10 – 13 percent per annum and that of gasoline was 6 – 9 percent per annum. The transport sector demand for diesel will continue to grow higher than gasoline on the average for 2006 - 2020.

2.4.3 Sectoral Challenges

137. Energy intensity of the transport sector, that is, ratio of energy consumption to the national GDP was found to be twice those of some middle-income developing countries. For instance, it is about twice that of Thailand, whilst the latter country is trying to achieve a 1:1 ratio by 2007³⁸.
138. Fuel consumption per annum has between 1.8 – 1.4 more than the national GDP growth since 2000 and the gap is projected to widen, if corresponding GDP growth rate is not achieved. Increasing fuel intensity will increase the public burden on energy procurement as well as the risk of supply disruption and price instability since Ghana imports petroleum fuels with hard currency.
139. Keeping the fuel demand growth rate at par with the GDP growth on the other hand will lead to energy savings equivalent to
- about 100,000 tonnes of gasoline per annum between 2006 – 2008;
 - increasing to about 120,000 tonnes of gasoline per year from 2009 – 2012

³⁸ Sourced from Strategic Energy Plan for Thailand 2004 – 2007

- 145,000 tonnes of gasoline per annum between 2013 – 2015; and
- almost 200,000 tonnes of gasoline by 2020.

140. The key issues in the Transport Sector related to energy thus include:

Road

- Higher than average fuel consumption per kilometre travelled.
- A sharp increase in road bulk haulage vehicles, in preference to the rail system.

Rail

- iv. Significant modal shift from rail to road transport for freight haulage due to service problems, such as consistently late trains and frequent accidents, leading to loss of public confidence in this mode as a means of transport. Reversal in Modal shift from road to rail however will have potential benefits including about 15 percent reduction in fuel consumption per kilometre travelled.

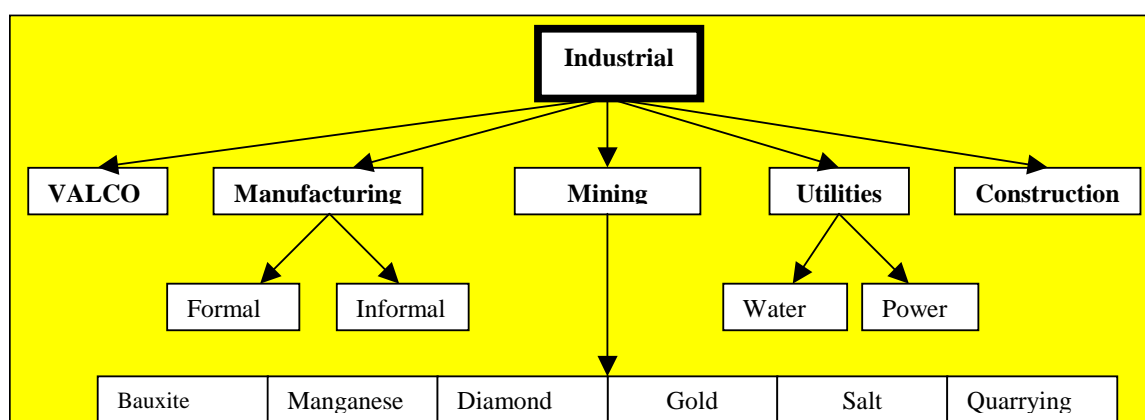
Air

- vi. Meeting the increasing demand of jet kerosene (ATK) due to the growing air traffic.

Maritime - freshwater

- vii. Relatively under-developed maritime transport leading to non-realisation of full commercial potential of the lake transport and the Ghana's coastal maritime traffic.

2.5 Industrial Sector



2.5.1 Description of the Sector³⁹

Structure

141. The Industrial sector, especially the Manufacturing sub-sector, is expected to lead in the rapid socio-economic transformation of the Ghanaian economy from a low-income to a middle-income country with US\$1,000 by 2015.
142. The industry's share in the GDP formation is projected to increase from about 25 percent in 2000, to 30 percent by 2015; and 32 percent by 2020 under the expected sectoral average growth rate of about 9 percent every year.

Sectoral shares of energy

143. The Industrial sector without VALCO had 21-22 percent of total national energy share every year since 2000. With VALCO, the industrial sector of the total energy share increased slightly to about 23 percent per annum.
144. Manufacturing had been the dominant subsector accounting for about 74 percent of industrial energy share since 2000, followed by Mining and quarrying (9-10 percent). Utilities had been taking just about one to one and half percent, whilst Construction has accounted for less than one percent of energy share per annum.
145. VALCO accounted for 16-17 percent of the industrial energy share until 2003 when its share fell to less than 2 percent due to suspended smelter operations.
146. In terms of electricity however, VALCO accounted for 50 – 60 percent, manufacturing subsector's share was about 14 percent, whilst the mining & quarrying subsector increased its shares to 22 – 23 percent per annum.

³⁹ Dis-aggregation adopted from the Ghana Statistical Services' classification.

147. The existing installed electricity generating capacity of 1,760 Megawatt would have to be at least doubled by 2020 should the nation be assured of secure electricity supply.
148. The total energy demand would grow from 6.2 million TOE in 2000 to about 22 million TOE by 2020 (figure 1.1).
149. Within the formal Manufacturing subsector, Sawmill & Wood products with 26 – 28 percent share accounted for the largest energy used, followed by Textiles with about 11-12 percent share. The remaining activities had shares less than 10 percent each from 2000 – 2004.
150. For the informal Manufacturing subsector⁴⁰, food processing accounted for around 99 percent of the energy used.
151. Gold mining activities takes the largest share of energy usage in the Mining and quarrying subsector. Percentage shares of energy consumed from 2000 – 2004 are as follows:

	2000	2001	2003	2004
	Percentage shares			
Gold	94.6	94.7	94.8	95.0
Diamond	0.8	0.8	0.8	0.6
Bauxite	0.7	0.7	0.7	0.7
Manganese	2.4	2.3	2.2	2.2
Salt	0	0	0	0
Quarrying	1.4	1.5	1.5	1.5

152. Energy for salt winning in Ghana is largely by solar (sun-drying), i.e. evaporation in sunlight, but the quantities had not been estimated for the country.

Fuel shares

153. The main fuels for industrial purposes are woodfuels, electricity and petroleum products (particularly, diesel and residual fuel oil). In the year 2000, industrial energy shares comprised about (table 2.2):
- i. 77 percent woodfuels but increased to 80 percent in 2004;
 - ii. 26 percent electricity, but dropped to 12 percent in 2004; and
 - iii. 10 percent petroleum products, but also reduced to 8 percent by 2004.
154. If VALCO's consumption was included in the industrial energy share, the electricity share of Industry increased to 26 percent for year 2000 whilst the woodfuel share

⁴⁰ Informal manufacturing subsector includes indigenous garages like 'Magazine' and 'Kokompe industrial estates in Kumasi and Accra respectively, local pottery (ceramic) industry, tie & die fabric industry, cane and craft industry, etc.

decreased to 65% in the same year. Petroleum product share was not significantly affected.

155. Woodfuel is used predominantly in the informal manufacturing subsector and as fuel for baking cooking and heating in the ceramics, commercial food processing and local textile industries.
156. On the other hand, if only the formal manufacturing subsector is considered, the major industrial energy was electricity (55 - 56 percent) followed by petroleum products (averaging 39 – 42 percent) and woodfuel (about 5.1 percent).

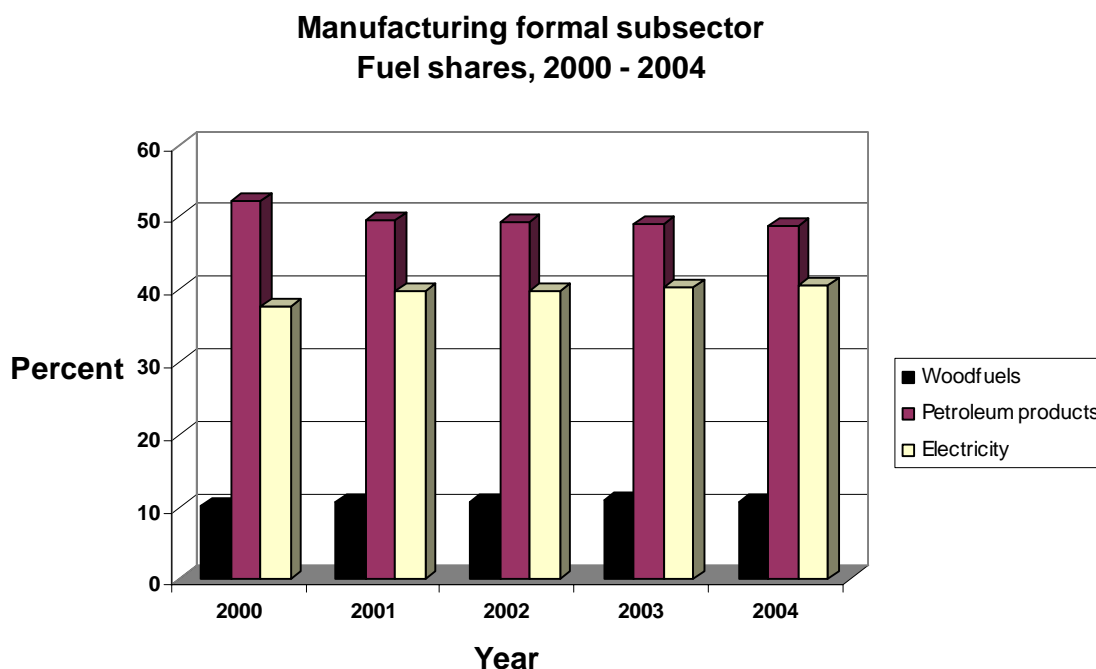
Table 2.2: Fuel share of the industrial sector for 2000 – 2004.

		2000	2001	2002	2003	2004 ⁴¹
		Year				
INDUSTRY	Thousand TOE ⁴²	1,406	1,461	1,474	1,367	1,420
including	<i>Percentage electricity</i>	26	25	22	13	12
VALCO and the	<i>Percentage woodfuels</i>	64	66	69	78	80
informal sector	<i>Percentage petroleum products</i>	10	9	9	8	8
INDUSTRY	Thousand TOE	278.2	275.6	279.7	284.0	300
excluding	<i>Percentage electricity</i>	55.6	55.0	55.5	56.1	56.0.
VALCO and the	<i>Percentage woodfuels</i>	5.1	5.1	5.1	5.0	5.0
informal sector	<i>Percentage petroleum products</i>	41.9	39.9	39.5	38.9	39.0
INDUSTRY	Thousand TOE	1,173	1,223	1,282	1,344	1,400
including the	<i>Percentage electricity</i>	12.6	12.4	12.1	11.9	11
informal sector	<i>Percentage woodfuels</i>	77.4	78.5	79.2	79.8	80
but excluding	<i>Percentage petroleum products</i>	10.0	9.1	8.7	8.3	9
VALCO						

⁴¹ Shares highly estimated

⁴² TOE is tonne of oil equivalent

Fig 2.2



157. The predominant petroleum products in industries are diesel and residual fuel oil (RFO), where the latter is used as a heating fuel. For the Manufacturing (both formal and informal) subsector, woodfuel is the predominant fuel (88-89 percent), followed by petroleum products (5 – 7 percent), then electricity (4 – 5 percent). However, if only the formal subsector of Manufacturing is considered, then petroleum products' share is the largest (figure 2.2). The predominant petroleum product in the formal Manufacturing subsector is RFO.
158. The percentage energy share of the utilities subsector had averaged 94 percent electricity and 6 percent petroleum fuels from 2000 – 2004. The latter had been used as fuel source for standby generators in times of grid outages and in off-grid remote areas.
159. Energy use in mining and quarrying activities is largely electricity (65 – 66 percent) and diesel (about 34 percent). Energy requirements of VALCO are mainly electricity needed for aluminium smelting and residual fuel oil for baking in the production of carbon anodes used in the smelting process. The VALCO plant used between 2000 - 2,500 Gigawatt-hour of electricity and about 120,000 litres of fuel oil on the average every year when in full operation.

Energy intensive industrial activities

160. In terms of energy intensities, i.e., energy required to produce one tonne of a product, underground gold mining required between 28-29 Gigawatt-hour per tonne of ore, followed by surface mining (8–9 Gigawatt-hour per tonne).
161. Aluminium smelting at VALCO's facility consumed about 16 Megawatt-hour per tonne of aluminium.

162. Secondary aluminium processing into finished products such as operations of Aluworks consumed about 800 – 900 kilowatt-hour of electricity for a tonne of molten aluminium.
163. Iron and steel scraps reprocessing in the country consumed between 600 – 900 units (kWh) of electricity per tonne of input materials.
164. Electricity consumption per tonne of bauxite, manganese and diamond were below 90 units (kWh) of electricity and is nearly the same value depending on the efficiencies of the production techniques. It is about the same for cement production.
165. In terms of consumption of petroleum products, surface mining of gold is the highest followed by manganese and bauxite.

2.5.2 Sectoral Challenges

166. After a downward trend in annual growth from a peak of 6.4 percent in 1997 to 2.9 percent in 2001, the industrial sector is recovering steadily to growth rates of 4.7 percent and above. The recovery is however unsatisfactorily when set against the government target of 12 percent annual growth by 2007.

Manufacturing – Iron and Steel industry

167. Output of local iron and steel industry has halved since 2000, as a result of the high cost and unreliable electricity. Total production was about 110,000 tonnes in 2000. The local steel industry depends on scraps and the high cost of energy has compelled the subsector to rely on imports of finished products to maintain its market share. The import-dependency of the local steel industry was estimated as 30 percent in 2000. Its operations are thus affected during periods of high depreciation of the cedi to the hard currencies leading to high production costs.
168. Even though, commercial quantities of low-sulphur iron ore (*Oppon-Manso reserves*) exist in the country, this key metal is imported. Manganese to alloy with the iron to produce tough, hard and abrasive resistance steel is also available, but currently exported.
169. Forecast for future operation however is optimistic, when the anticipated natural gas from Nigeria is brought into the picture. The use of natural gas, instead of electricity is expected to make the industry more cost effective. Natural gas could be used as a direct heat source as well as input into the chemical process.

Manufacturing - Cement

170. Cement production was about 1.5 million tonnes in 2000 and is projected to exceed 4 million tonnes by 2020. Clinker import for the production of Portland cement has been taken more than US\$100 million per annum of the country's scarce foreign exchange earnings since the 1990s, even though, the country has abundant limestone and clay for the production of clinker.

171. The high energy requirement for clinker production has been a major discouraging factor. The raw mix of limestone and clay has to be heated up to about 1,500 degrees Celsius, making it relatively expensive to use electricity. Natural gas as a direct heating source and chemical input would however offer a cheaper alternative.

Mining and Quarrying subsector

172. Ghana is Africa's number two producer of gold, third largest producer of manganese ore and aluminium and a major producer of bauxite and diamonds. The Mining subsector has attracted over 56 percent of foreign direct investment (FDI) to Ghana in the 1990s. The share of mining exports in GDP however has been at about 5 percent since 2000.
173. Manganese has shown an upward growth over the years reaching high growth of about 33 percent by 2004.
174. Bauxite output however has declined since 2002. The drop in shipments resulted from the inability of Ghana Railways Company (the only bulk mineral carrier) to achieve its haulage targets.
175. Diesel accounted for about 15 percent of operating costs of surface mining. The bulk minerals of manganese and bauxite are generally more susceptible to the price of diesel since they are transported over long distances to the Takoradi seaport for export.
176. The increasing diesel price since 2003 is contributing to the hike in rail freight rates for manganese and bauxite and consequently has affected the shipment rate by the Ghana Railways Company.

Gold Mining

177. Gold surpassed cocoa as the country's number one foreign exchange earner in the 1990s. Gold mining has attracted about 90 percent of foreign direct investment inflows to the mining sector. Yet, the industry saw a decline in 2000 until 2002 when it started to rise again due to the increasing world price of gold.
178. Four main factors influence gold production technology, particularly, as whether to opt for surface or underground mining. They are the richness or concentration of the ore; production costs, world market price of gold and energy price.
179. For most surface mines in Ghana, the concentration of gold is between 2–3 gramme per tonne of ore, reducing to 1–2 gramme per tonne for workable tailings.
180. For underground mining, concentration could go as high as 8–12 grammes per tonne of ore on the average in Obuasi underground but drops to a range of 3–5 gramme per tonne of ore for other areas of the country. In general for any given mining area, the ore is richer as one goes underground.

181. As a general rule, production cost is usually pegged between US\$ 190 – 200 per ounce of gold for a minimum average world market price of US\$300 per ounce. Below the US\$300 per ounce, most mines either fold up or move to surface mining, even so, depending on the richness of the surface ore. Production cost beyond US\$210 per ounce of gold is usually regarded as too high by the industry. Gold price hovered between US\$300 – 400 per ounce in the 1990s, falling below its S\$300 benchmark between 1998 and 2000⁴³.
182. Electricity consumption for underground operations is about thrice that for surface mining operations and as of 2004, the industry perceives the prevailing electricity price as relatively unattractive to encourage deep mining.
183. With the exception of Obuasi-underground where the ore concentration is exceptionally rich on the average, the other underground mines become economically unsustainable for bulk supply tariffs exceeding 4 US cents per unit of electricity, unless price of gold goes beyond US\$500 per ounce and above.
184. Electricity supply for surface mining is mainly for pumping and grinding of the ore. For underground mining, besides pumping and grinding, electricity is required for operating the transport-elevators, drilling, air-conditioning and ventilation underground.
185. The general observation is that the ambient temperature increases by 10 degrees Celsius for every kilometre below the surface of the earth.
186. Most operations thus shift from underground to surface mining, when cost of electricity per production of ounce of gold exceeds about 10 percent of the prevailing world market price of gold.
187. Surface mining is a relatively cheaper technology but has more serious environmental consequences for surrounding communities and the nation as a whole. Thus, while the mining sector contributed 36 percent of foreign revenue and about 14 percent of total government tax revenue in 2004, there has also been growing concern over environmental pollution and the social costs that accompany surface mining.
188. Gold is a rare but precious metal. Global gold output has averaged between 2,500 – 2,600 tonnes every year since the beginning of the decade⁴⁴. Total world resource is estimated at only 89,000 tonnes.
189. Ghana, ranking as the world's 10th – 12th producer, delivers between 60 – 80 tonnes per annum. At an average production of 100 tonnes per annum, Ghana's proven reserve is estimated to last about 20 years.
190. Long-term production of gold is expected to come largely from surface mining, if the status quo does not change.

⁴³ Sourced from Ghana Chamber of Mines

⁴⁴ Compare with VALCO producing between 150,000 – 160,000 tonnes of primary aluminium per year

VALCO – Aluminium smelting

191. The Volta Aluminium Company, VALCO is VRA's single largest non-utility customer when in operation. The smelter has an installed capacity of 200,000 tonnes of primary aluminium production at a maximum power demand of 320 Megawatt per annum via five potlines. The fifth pot however, has not been fully available and hence the plant has operated a maximum of four and a half potlines with maximum production of 180,000 tonnes per annum.
192. Primary aluminium production in general is energy-intensive, although, lower than gold mining. Old plants consume about 16 (thousand units of electricity) Megawatt-hours to produce one tonne of aluminium from alumina. Today's smelters use between 14 – 15 Megawatt-hours of electricity per tonne.
193. Electricity intensity of production at VALCO averaged 17 Megawatt-hour per tonne of aluminium in the early 1990s but has improved to the present average of 16.2 Megawatt-hour per tonne.
194. Absence of pollution charges in Ghana however, has eliminated the incentive for VALCO to improve its efficiencies further to the 15 Megawatt-hour per tonne level. On the average, aluminium smelting leads to significant generation of greenhouse gases⁴⁵. VALCO smelter, when in full operation 'pumps' about 300,000 tonnes of carbon dioxide per year into the atmosphere.
195. Aluminium smelting worldwide is very sensitive to electricity pricing. VRA bulk electricity tariff to VALCO was 1.65 – 1.80 US cents per unit of electricity whilst the approved bulk supply to other customers was about 4.5 US cents per unit of electricity. This invariably led to subsidizing VALCO to the tune of about US\$ 40-60 million in 2002 through importation of crude oil for thermal generation to supplement the nation's overall electricity requirements.
196. Aluminium production levels and electricity pricing are however, highly correlated. Typical European smelters of similar capacities as VALCO producing between 160,000 – 180,000 tonnes of aluminium per year operated at average power prices of 2.5 US cent per unit of electricity in 2002. Plants of over 200, 000 – 250,000 tonnes capacity operated at power prices ranging from 3 US cents to as high as 5 US cents per unit of electricity.
197. A 240,000 tonne smelting capacity will however require 3,888 Gigawatt-hour of electricity, which is 79 percent of generation from the Takoradi Thermal Power Plant in full operation.
198. Expanding VALCO to about 240,000 tonne smelting capacity will require 400,000 - 520,000 tonnes of alumina per annum and consequently 1 million – 1.5 million tonnes of bauxite every year.

⁴⁵ 1.6 – 2.2 tonnes of carbon dioxide per tonne of primary aluminium is produced depending upon the technology.

199. Processing of bauxite into alumina requires less electricity. Such a refinery will require just about 5 – 6 percent of VALCO’s power demand to produce the alumina needs of the VALCO smelter. The only refinery in Africa is in Guinea. Ghana’s relatively available power resource however, makes it an attractive option for any other future refinery in the West Africa sub-region.
200. Ghana’s proven bauxite reserves at an average mining rate of 3 million tonnes a year are estimated to last 30 years. At 1.5 million tonnes per year, such an alumina refinery can be assured of feedstock for 60 years, which is about twice the average economic lifetime of a typical VALCO type aluminium smelter.
201. Expanding the bauxite industry and building a refinery to produce alumina to feed the future VALCO will close the bauxite-aluminium industrial loop. More efficient mode of transport will be required to haul the bauxite from new fields yet to be developed.
- 202. The key energy related issues affecting the Industrial Sector are:**
- i. Ensuring adequate, reliable and good quality electricity supply to the industrial sector
 - a) A number of electric motors had failed due to unreliable power supply. The high cost of importing new motors has led many industries to rewind their motors, which has led to decrease in motor efficiency.
 - b) In order to cope with unreliable supply, some industries have invested in standby generators, which are not fully utilised. The sunk cost and the operation and maintenance cost of these standby generators increase costs of doing business.
 - ii. Upgrading industrial machinery and equipment to meet current state of the art energy efficient standards. Old machinery and under-capacity utilisation increase the specific energy use
 - Obsolete and energy inefficient machinery and equipment stock have led to frequent breakdowns, disruptions in production and higher specific energy use.
 - iii. Lowering the energy intensity of the industrial sector. Running motors on low load situations contribute to higher specific energy use.
 - v. Taking advantage of the natural gas from the West Africa Gas Pipeline to develop the industrial sector.
 - vi. Finding an efficient and alternative means for conveying mineral ore from the mining sites to the seaport.
 - vii. Providing a sustainable electricity tariff range to encourage underground mining at sites where deposits exist and consequently, boost the national gold output.

- viii. Providing a competitive bulk electricity tariff for sustainable operation of all primary industries including VALCO.

- x. Meeting the additional electricity demand and requirement of the country, should VALCO decide to expand its capacity to six potlines in order to be operative at higher power tariff ranges.

3 DEMAND SECTOR SUMMARY

3.1 Total Fuel Demand

203. In summary, the estimated energy and fuel needed to drive the Ghanaian economy to achieve the US\$1000 per capita by 2015 and thereafter, maintain a middle-income status up to 2020 are as follows:

	<u>Unit</u>	2008	2015	2020
Moderately high economic growth scenario				
Woodfuels	Tonnes	25-31 million	29-35 million	40–50 million
LPG	Tonnes	131,800	160,600	295,000
Kerosene	Tonnes	92,500	89,100	110,300
Jet kerosene	Tonnes	125,500	152,500	226,000
Gasoline	Tonnes	710,400	821,200	1.10 million
Premix Gasoline	Tonnes	69,000	73,000	81,500
Diesel	Tonnes	1.0 million	1.28-1.43 million	1.51-2.0 million
RFO	Tonnes	116,200–124,200	124,800–134,000	147,200 - 156,400
Electricity⁴⁶	Gigawatt-hour	11,300–13,500	13,800–16,300	20,100 – 22,300

3.2 Energy Cost

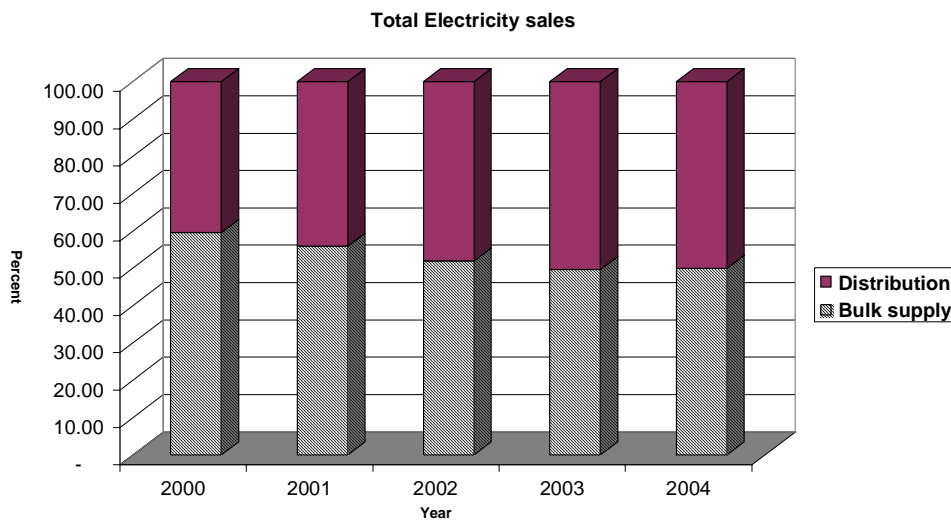
3.2.1 Energy expenditure between 2000 - 2004

204. Crude oil imports accounted for approximately 80 percent of the trade deficit in 2001⁴⁷. Cost of Crude oil imports rose from US\$ 280 million in 2000 to about US\$ 456 million by 2004.
205. The annual tax revenue on the petroleum product sales were equivalent to about 39% of the cost of crude oil import in 2000 and almost 60% in 2004. Revenue from grid electricity sales tripled from US\$ 214 million in 2000 to over US\$ 650 million in 2004.
206. The revenue share of final electricity (distribution) in the overall electricity trade grew from about 40 percent in 2000 to about 50 percent in 2004 (figure 3.1). Reduction and subsequent suspension of the VALCO smelter operations from 2002 – 2004 reduced the share of bulk electricity and consequently, made more electricity available for distribution.

⁴⁶ It excludes transmission and distribution losses. It is net electricity to the economy.

⁴⁷ Economic Analysis of Energy Sector by Prof. Bartholomew Armah, 2003, Energy Commission publication.

Fig. 3.1. Share of grid electricity sales



207. Woodfuel was the second most expensive fuel to the economy. The nation’s consumers as a whole spent between US\$400 – 600 million on woodfuels from 2000 – 2004. Woodfuel share of total national energy cost varied from 29 – 36% between 2000 – 2004.

3.2.2 Cost projections

208. For the high economic growth scenario, total energy cost is expected to reach:

- US \$3.1-3.4 billion, 16-17% of GDP in 2008;
- US\$ 4.3 - 4.6 billion, 13-14% of GDP by 2015; and
- US \$5.2 – 5.6 billion, 8-9% of GDP in 2020.

209. Expenditure on woodfuels will equally be as high as those for electricity and petroleum products.

210. The high economic growth energy expenditure share of the GDP is estimated at 16 – 17 percent in 2008 but it is expected to drop to about 8 percent by 2020, assuming that the average market price of crude oil per barrel drop from the US \$60 range to about US \$45 range by 2020. For the moderately high economic growth scenario, total energy cost drops to about (table 3.1):

- US \$2.6 - 2.9 billion in 2008;
- US \$3.0 – 3.3 billion in 2012;
- US\$3.5 - 3.8 billion by 2015; and

- US \$4.2 – 4.5 billion in 2020.
211. The share of energy expenditure of the GDP rises as the GDP drops. For instance, for the moderately high economic growth scenario, the energy share of GDP in 2008 goes up to 18 – 19 % from 16 – 17% in the High economic growth scenario. It increases further to 21-22% for the low growth or Business-as-usual growth scenario.
212. The expenditure on woodfuels is as important as on petroleum and electricity.

Table 3.1 Energy cost forecast for moderately high economic growth scenario, 2006-2020

	2006 – 2008	2009 - 2012	2013 - 2015	2016 - 2020
	US \$ million			
Woodfuels	1,830 – 2,600	3,770 – 4520	3,190 – 3,860	6,220 – 7,590
Petroleum products	1,870 – 2,700	2,850 – 4,090	2,470 – 3,530	4,920 – 7,070
Electricity	1,720 – 2,550	3,320 – 4,010	3,200 – 3,750	5,570 – 6,770
Total	3,920 – 7,850	9,940 – 12,620	8,860 – 11,140	16,890 – 21,430
			Grand Total	41,110 -53,040

3.3 Environmental Impact of Energy Use

213. The expanding economy demands growth in electricity; process heat; and transportation services. Increasing population will also drive growth in electrification; transportation and cooking fuels (figure 3.2).

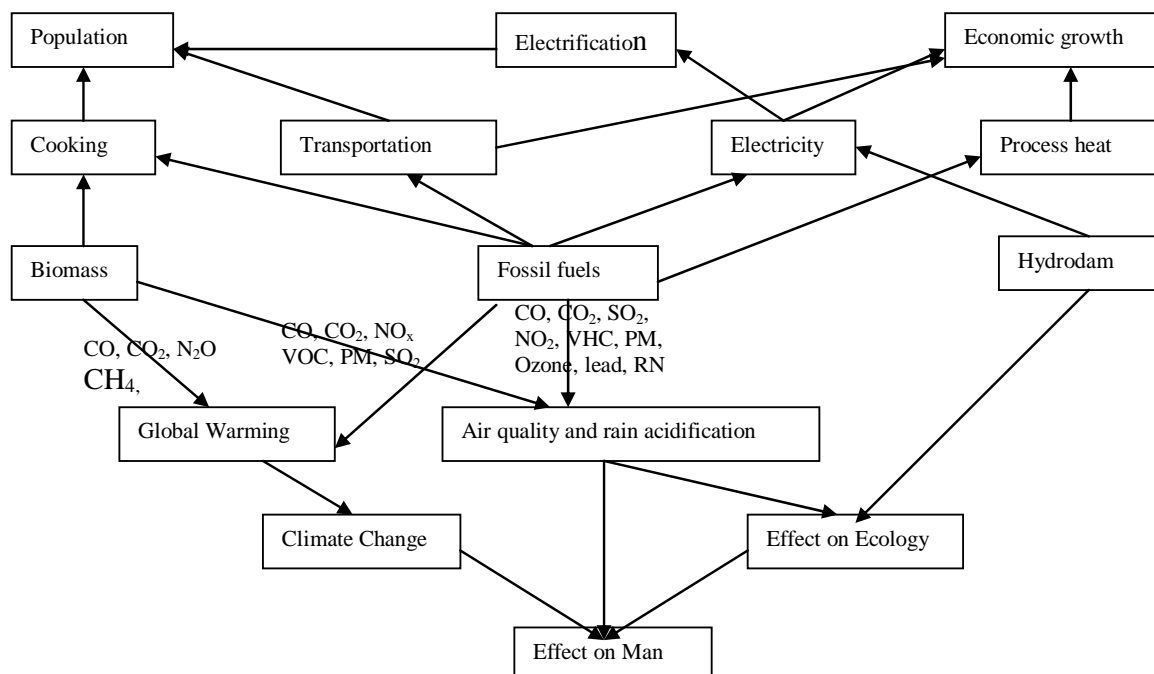


Figure 3.2 Conceptual Model of Environmental implications of energy usage

214. Processing and combustion of petroleum fuels to meet the transportation growth however give rise to more global warming gases, acid rain pollutants, particulates (including soot), also, ground-level ozone and toxic volatile hydrocarbons like benzene and toluene into the atmosphere. Woodfuel combustion to meet the largely cooking needs of the increasing population will also lead to increases in toxic volatile hydrocarbons as well as particulate matter mainly in the form of soot.

3.3.1 Emissions for 2000 - 2004

215. Energy utilisation by the Residential Sector 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, which are all global warming gases, from 2000 - 2004. Over 70 percent of sulphur oxides emissions were also from the Residential Sector (table 3.2).

216. Carbon dioxide originating from non-biomass sources in the Residential Sector amounted to an average of about 15 percent during the period.

217. The Transport Sector was responsible for over 60 percent of non-biomass carbon dioxide emissions, whilst energy use in the Industrial Sector accounted for just about 20 percent on the average during the period.

218. Effects on the atmosphere due to Commercial & Service Sector and the Agricultural & Fisheries sector operations were relatively not significant⁴⁸.

Table 3.2. Percentage share of gaseous emissions to the environment; 2000 - 2004⁴⁹

SECTOR	AVERAGE PERCENTAGE SHARE OF EMISSIONS 2000 - 2004							
	Greenhouse Gases				Pollutant Gases			
	CO ₂	CH ₄	N ₂ O	CO	*SO _x	*NO _x	*VOC	PM
Residential	14.5	53.0	68.6	68.5	72.2	11.6	19.6	22.4
Comm/Services	0.2	negli	negli	negli	0.1	0.3	negli	negli
Transport	61.6	0.4	19.1	8.0	12.4	51.8	6.4	0.7
Industry	21.5	7.0	9.3	9.0	12.5	5.6	3.0	3.4
Agric & Fisheries	1.4	2.4	2.4	2.5	2.5	2.4	1.0	1.2
<i>Production</i> ⁵⁰	0.8	37.2	0.6	12.0	0.3	28.3	70.0	72.3

Abbreviations CO₂ – Carbon dioxide; CH₄ – Methane; N₂O – Nitrous oxide;
CO – Carbon monoxide; SO_x – Sulphur oxides; NO_x – Nitrogen oxides;
VOC – Non-methane Volatile Organic compounds;
PM – Particulate matter (PM₁₀ and below); negli – negligible;
*- Total

⁴⁸ The modelling however could not capture emissions due to bushfires.

⁴⁹ The data for table generated using the LEAP model.

⁵⁰ Electricity production, charcoal production and transportation, oil production, refining and distribution.

219. Most nitrogen oxide emissions are emitted by the Transport Sector, largely due to combustion of petroleum fuels at high temperatures in vehicular engines (thermal oxidation of atmospheric nitrogen). Woodfuel combustion in the Residential Sector is also a major contributor of nitrogen oxides due to decomposition of chemically-bond nitrogen in the wood chemistry. Charcoal production also emits significant amounts of nitrogen oxides. Power production is likely to become the dominant emitter of nitrogen oxides when thermal surpasses hydro in the fuel power mix.
220. Ghana's carbon monoxide emissions originate mainly from the Residential Sector due to the massive use of woodfuels for cooking.

3.3.2 Emission projections

221. Emissions from combustion of fossil fuels are expected to overtake biomass-based emissions by 2020. The high economic growth is expected to increase the average GHG emissions of 16 million tonnes carbon dioxide equivalent in 2000 to about 48 million tonnes of carbon dioxide equivalent by 2020 (table 3.3).

Table 3.3: GHG emission forecast for 2015 and 2020 in carbon dioxide equivalent⁵¹

Greenhouse Gases	2000		2004		2015		2020	
	Million Tonnes	%	Million Tonnes	%	Million Tonnes	%	Million Tonnes	%
Non-biogenic CO ₂	7	39	9	39	16	58	33	70
Methane	9	59	10	59	11	41	14	29
Nitrous Oxide	0.2	2	0.2	2	0.4	1	0.5	1
Total	16.2	100	19.2	100	27.4	100	47.5	100

222. Prevailing sulphur oxide emissions are relatively very low and would remain so even in 2020; lower than 1998 emission levels of Malaysia's⁵², a model country for Ghana's middle income level ambition. Malaysia's transport sector alone recorded 38,000 tonnes of sulphur oxide emissions in 1998. Ghana's use of low-sulphur petroleum fuels explains the relatively low emissions from the transport (table 3.4).
223. Ghana's nitrogen oxides emissions by 2020 would be comparable with Malaysia's 1996 emission level (237,000 tonnes)

⁵¹ The data for table generated using the LEAP model.

⁵² Malaysia Environmental Quality Report, 1998, Department of Environment, Ministry of Science, Technology and Environment, Malaysia.

Table 3.4: Forecasts for emission of pollutants for 2015 and 2020⁵³

Gaseous pollutants	2000	2015	2020
		Thousand Tonnes	
Nitrogen oxides	50	193	310
Sulphur oxides	9	13	20
Non-methane VOC	295	440	640
Particulate matter	301	430	580

⁵³ The data for table generated using the LEAP model.

4 DEMAND SIDE MANAGEMENT

4.1 Background

224. Demand-side Management (DSM) is the process of managing the consumption of energy, generally to optimize available and planned generation resources. It comprises energy efficiency and conservation interventions, which seek to ensure the use of the minimum amount of energy at the consumer end, to produce the maximum amount of goods or services.
225. Energy Conservation is the practice of decreasing the quantity of energy used while achieving a similar outcome of end use. Individuals and organizations that are direct consumers of energy may want to conserve energy in order to reduce energy costs and promote economic, political and environmental sustainability. On a larger scale, Energy Conservation can reduce the energy consumption and energy demand per capita, and thus offset the growth in energy supply needed to keep up with population growth. This can reduce the need for new power plants and energy imports. The reduced energy demand can provide more flexibility in choosing the most preferred methods of energy production. In countries where thermal power is the marginal cost of generation, Energy Conservation measures can lead to decrease in thermal power production and consequently, result in GHG emission reduction; an important part of lessening Climate Change.
226. Energy Efficiency usually refers to programmes that are aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. It also refers to products or systems using less energy to do the same or better job than conventional products or systems. In national economic terms Energy Efficiency may refer to the amount of primary or final energy consumed per unit of gross domestic or national product.
227. Early noticeable attempts to draw the attention of the public to the need to use energy efficiently were initiated in 1975 after the first world oil price shock and in 1979 following supply disruptions that resulted from political events in Ghana. During these periods Ghana was spending over 20% of its foreign exchange earnings on the importation of crude oil alone. These early attempts at encouraging consumers to conserve energy were however abandoned as soon as the supply situation normalised.
228. The first planned energy efficiency programme was introduced and implemented by the erstwhile National Energy Board in the late 1980's. The initial programme consisted of studies, pilot demonstration projects, capacity building and the development of policy guidelines, which defined the main driving objectives for energy efficiency and conservation programmes for the country. The National Energy Board (NEB) was dissolved in 1991 and the energy efficiency activities were taken over and continued by the Ministry of Energy.

229. Although the results of the initial studies and pilot projects confirmed the potential for energy saving in Ghana, particularly in the industrial sector, the level of activities declined considerably and almost grinding to a halt when donor funds were exhausted. The relatively low energy prices in the 1990s did not encourage investments in energy efficiency technologies. Demand-side management was therefore not an issue in the early 1990s. However, when the Government of Ghana approached the donor agencies for funding to expand the nation's power generation capacity, it was proposed to Ghana as an option to consider rather than concentrating on the supply-side.
230. Other factors that contributed to the decline of the initial programme included the following:
- Although the erstwhile NEB was able to identify the areas and scope for energy efficiency, it could not enforce the measures some of which required regulations but the erstwhile NEB was not legally empowered to do so and the government too did not implement the NEB's recommendations.
 - Very few experts were available and besides, their high professional fees for energy audits scared off potential clients. The local personnel who were trained in the initial erstwhile NEB programme were drawn from industries, government ministries and the academia, which under normal circumstances had other job descriptions other than promotion of energy efficiency but were attracted to the programme because of the relatively high remuneration in the form of consultancy fees that were paid. In the absence of further donor support these personnel returned to their original vocations and abandoned the programme.
 - Energy saving technologies were not available on the local market and funds to purchase such equipment were not easily available from local financial institutions.
231. The Ministry of Energy in 1998 however transferred the role of promoting and executing Energy Efficiency Programmes to the Energy Foundation, which had been established in November 1997, as a Ministry of Energy – private sector partnership to promote energy efficiency and conservation programmes.
232. VRA and ECG also initiated energy efficiency programmes. Local energy service companies and consultants have received special training in energy auditing and energy service enterprise development to support the demand-side programmes in the country.

233. The Industrial Energy Assessment Centre (IEAC) based at the KNUST⁵⁴, was created by the Ministry of Energy with support from the USAID⁵⁵ to develop energy management capacity in the country and to offer energy-auditing services to industries.

4.2 Fuel efficiency challenges

4.2.1 Electricity

Residential

234. About 30 percent of electricity consumed within the economy is used in the Residential sector⁵⁶. Consumption in this sector however, is beset with inefficiency due to the flooding of the Ghanaian market with imported used or second-hand low-efficiency home appliances (e.g. refrigerators, pressing iron, air-conditioners, etc.), which are relatively less expensive, compared to new ones.
235. To tackle the low-efficiency of electricity utilisation in the residential sector, VRA and ECG first introduced compact fluorescent lamps (CFL) in the mid-to late 1990s. Energy Foundation adopted the CFL promotion exercise in the subsequent years. Penetration rate increased from 1.5% in 1998 through 3% in 1999 to almost 20% in 2001.

Commercial & Service Sector

236. Electricity consumption in this sector is mainly for air conditioning, lighting and office equipment. The Commercial & Service sector together with the Residential sector contribute significantly to the peak demand on the supply system. However, very inefficient technology end-use appliances characterize electricity consumption in this sector.
237. Public institutions including the public universities have all had some energy efficiency activities. The Ministry of Energy was one public institution where detailed energy audits were conducted in its buildings. Occupancy sensors were installed in the MOE building and monitored for reductions in electricity consumption. Initial results indicated that 7-25% savings on energy consumption are being attained through retrofits. The energy saving measures recommendations from the audits has already been implemented. Ghana Civil Aviation Authority (GCAA) is updating its energy management system as a result of the major expansion work since the first audit was undertaken. There is however no overview of the total potential for Energy

⁵⁴ Kwame Nkrumah University of Science and Technology, Kumasi.

⁵⁵ United States International Development Agency

⁵⁶ 55 - 60 percent if VALCO is excluded. A school of thought however suggests that significant small-scale or business activities are 'hiding' in homes and that explains the apparent high consumption by the Residential Sector.

Efficiency in the commercial sector but experience from other countries indicates that the potential could be substantial.

238. Largely non-productive use of electricity supplied to rural areas accounts for high inefficient use of energy in the rural commercial setup. Rural electrification is being undertaking largely with the aim of encouraging the establishment of cottage industries to create employment and consequently, reduce poverty as well as rural-urban drift. However, the desired impact has not been realized since very little attempt has been made to support rural electricity users to use the power for wealth creation.

Industrial

239. Industrial concerns, established in the 1960s dominate the Industrial sector in Ghana and the equipment in these industries are obsolete and inherently inefficient. Many of the industries were established at a time when electricity consumption was being encouraged through low tariffs, as there was surplus generation capacity that was available due to the commissioning of the Akosombo Hydroelectric dam at that time⁵⁷. Therefore the selections of equipment for most of the industry were not based on how efficient they were but on relative cost.
240. It was also observed that plant utilization factor was as low as 20-35% in most industries. With upward adjustment in tariff by about 100 percent in 1998, the Energy Foundation capitalised on the opportunity to successfully initiate a number of projects aimed at encouraging the local industries also to improve upon the power factors of their electrical equipment, which then averaged 0.6 in early 1990s.
241. According to Energy Foundation, average power factor in industries improved to 0.9 by end of 2000. In the process, the exercise freed about 20 MVA of reactive power to the national grid.
242. Studies conducted in 30 industrial enterprises in 1997-1999 did establish that by shifting loads from peak to off-peak periods, system peak demand could be reduced by over 75 Megawatt and the energy savings amounting to 1,800 Megawatt hours per annum.

4.2.2 Petroleum

243. Demand-side management (DSM) could help slow down the high growth in petroleum fuel consumption. Energy efficiency includes shifting from one mode of transport to a more efficient one. For instance, using haulage by rail instead of road reduces fuel consumption by 15 percent on the average. Resorting to mass transport

⁵⁷ Akosombo was of the largest hydroelectric power projects in the world when it was commissioned and it's reservoir is still the largest man-made lake in terms of surface area in the world.

for public transportation tends to be more fuel-efficient than individual private transportation.

244. There are also commercially available fuel-efficient devices for vehicles capable of 15-20% savings on fuel, but have been found to work well only with vehicles with high servicing and maintenance records.
245. Conservation means, relying on unmotorised ‘transport’ such as telecommunication as first line of contact before starting the engine saves fuel. For short distances, bicycle riding could be encouraged.
246. Improvement in the quality of the grid electricity will significantly reduce the industrial consumption of diesel.
247. Efficient urban planning will culminate in fewer traffic jams, less return trips from home to office, etc.

4.2.3 Woodfuels

Residential

248. In late 1980’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” .
249. The Ahibenso Improved charcoal 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.
250. In promoting the wider use of Ahibenso coalpot, the Ministry of Energy concentrated on providing the necessary framework for the uptake of the technology. This involved the training of local artisans and manufacturers who were encouraged to produce the stoves. A total of 40 artisans within Ashanti and the coastal regions were trained. As of 1992, a total of 45,000 stoves had been distributed through 53 retailers who were selected from the main markets in all the ten regional capitals. In 1993 alone, a total of 20,000 stoves were produced and distributed by the artisans.
251. However, the programme fizzled out by the mid 1995-6, because the programme could not be sustained after the Ministry’s funding ended⁵⁸. Artisans who were trained

⁵⁸ The Ministry’s initial funding for the Ahibenso programme was from the World Bank ESMAP project.

in the manufacture of the improved stoves could not sustain their production because it required much time and material to fabricate a unit of Ahibenso compared to that required for the fabrication of one traditional coalpot, thereby making the improved version more expensive.

252. In 2002, an NGO, EnterpriseWorks introduced another improved charcoal cookstove called 'Gyapa' which is equally as efficient as the Ahibenso⁵⁹. The NGO facilitated the sale of Gyapa in Accra & Kumasi, the two major urban cities in Ghana. Even though the improved stove is about 20% more expensive than the traditional stoves, the expected savings on fuel cost is said to be significant to pay off on the investment of the improved stoves. Over 54,000 Gyapa stoves were sold from November 2002 to December 2003. Sales increased to about 123,260 stoves from January 2004 to December 2006⁶⁰.
253. There had been other improved woodstove projects implemented by number of other NGOs, local government and community based organizations but largely targeted at reducing smoke emission into the immediate kitchen environment.

Industry

254. In the fish smoking industry, the Food Research Institute had introduced a new technology called the Chorkor Smoker with the intention of reducing the labour requirement of the industry. However, the technology was found to be very energy saving as well because the quantity of fish that could be smoked from a given quantity of firewood was higher than in the case of the traditional smokers, thereby decreasing the energy requirement of the industry.
- 255. The key barriers to the implementation of energy efficiency and conservation programmes in the country are:**
- i. Lack of clear-cut regulations to regulate the appliance market, which is contributing significantly to the high-energy demand growth.
 - ii. Absence of Energy Efficiency Codes and Standards.
 - iii. Lack of upfront financing of energy efficiency projects, including investment financing for retrofitting existing plants as well as installing new efficient plants;

⁵⁹ Ahibenso improved cookstove is cylindrical in shape and is all metal. The charcoal chamber is also made of metal. Gyapa improved cookstove is made up of two truncated cone shaped metals joined back-to-back at their short bases. The charcoal chamber however is made up of clayey material. Samples and pictures of the cookstoves are available at the Energy Commission's office.

⁶⁰ Major funding for the Gyapa stove programme were from USAID and Shell Foundation.

- iv. Lack of adequate incentives for efficiency initiatives.
- v. Lack of awareness among end-users of state of the art energy efficient technologies.
- vi. Inadequate expertise to provide DSM services.
- vii. High initial investment cost has been the major barrier regarding the improved woodstoves. Despite the modest efforts made with the improved woodstoves, their penetration rate has been very low due to their relatively high initial capital cost. Inefficient energy and smoky stoves are strongly linked to poverty as it is the poor who mostly rely on lower-grade fuels.

4.3 On going and future programmes

4.3.1 Energy Efficiency Standards and Labels

- 256. Standards and labelling programmes are essential elements in any government's portfolio of energy-efficiency policies and climate change mitigation programmes. Labels play the public education part and deliver the efficiency information to the consumers and standards transform the market by eliminating the most energy inefficient products. Separately, they each can stimulate the development of cost-effective, energy efficient technology and its diffusion into the marketplace.
- 257. A baseline study conducted in 1998/99, identified Room Air Conditioners, Refrigerators, Lighting Systems and industrial electric motors as the appliances, which would give the highest benefits to the economy. The analysis concluded that the implementation of the minimum performance level of an energy efficiency ratio (EER=2.8) would yield significantly higher benefits with only moderate additional costs. It was established that:
 - i. The Room Air Conditioner Standard will save Ghanaian consumers an average of \$64 million annually in energy bills.
 - ii. Payback on the initial incremental investment in efficiency by consumers is less than 9 months.
 - iii. Although the average price of the air-conditioner may go up by about 3% for the proposed standard, the new RACs will use about 9% less energy, paying off the investment very quickly.
- 258. Subsequently, the Energy Foundation in collaboration with the Energy Commission, the Ghana Standards Board and other stakeholders has developed the first Energy Efficiency Standard and Label for Room Air Conditioners.

259. A Legislative Instrument (LI) enforcing standards for Room Air Conditioners and CFLs was passed by Parliament in 2006. A Labelling Regime which made it mandatory for all appliance manufacturers importing to Ghana to provide labels on room air conditioners and CFLs expired in 2006. A Testing Facility to test and certify the energy efficiency of Room Air Conditioners and CFLs is being built. Testing and full enforcement of standards commence in 2007.
260. It is estimated that compliance with the standard could save about 950GWh per year by 2020, freeing up to nearly 250MW of generating capacity that can be used for other productive purposes.
261. The Energy Efficiency Standard and Labelling would be extended to cover other appliances like electric fans, televisions, refrigerators and deep freezers in the nearest future.
262. Penetration of fans in the residential sector is estimated at over 90 percent. Fans consuming between 20 – 30 percent less electricity than average fans are available.
263. Some television sets consume about 20 Watt power and some as low as 2 Watt at standby mode.

4.3.2 Monitoring and Targeting (M&T) Energy Management Scheme

264. The Energy Foundation has assisted some local industrial and commercial firms to strengthen their internal energy management capabilities by introducing Monitoring and Targeting (M&T)⁶¹ in their management practices. The concept of Monitoring & Targeting is based on the principle that, efficiency performance can be measured only when the amount of energy used per unit output is known.
265. Computer based M&T was introduced to 10 companies in 1997-98 while five Energy Service Companies were trained to provide this service to industry. Some of the pilot industries have reported malfunctioning of the meters that were purchased for the project. The software which was supplied in 1997 is no longer available since the license has expired. There is therefore the need to revisit the programme to replace the meters and software as well as consolidating the gains and eventually extend the service to other industries.

⁶¹ An effective energy management technique, developed in the United Kingdom.

4.3.3 Electrical Load Management

266. Detailed Electrical Load Management studies completed for 30 large industrial firms with maximum demand of 500kVA or more in late 1990s, identified opportunities for industries to reduce their peak electricity demand and shift loads to off-peak periods.
267. Energy Foundation estimates that 75MW could be shaved off the peak demand should the surveyed 30 industrial firms reduce their demand during the peak periods. The Energy Foundation has therefore recommended the introduction of a Time of Use (TOU) tariff for this category of consumers and has communicated the survey results to PURC.
268. The introduction of TOU tariffs would enable such industries as metal smelting, cement milling, electrical heating operations that operate 24hours a day to shift some of their energy intensive operations from the peak electricity demand period (6.00pm to 11.00pm) This would improve overall national load factor and system efficiency during the peak periods. There would however be the need to install load controllers and monitoring devices in industries once the TOU tariff is implemented.

4.3.4 Electric Motor Improvement Project

269. Feasibility study into the establishment of one-stop motor repair and sales centres to serve as outlets for energy efficient motors and drives in various parts of the country was completed in 1999. The study indicated that repeated motor refurbishments, a very common practice in Ghana, lead to efficiency losses and that it is feasible to establish private motor centres in the country that will sell energy efficient motors to industry and provide motor advisory and repair services as well⁶².
270. The study also recommended the development and implementation of motor testing procedures, minimum efficiency standards and labels as well as the establishment of a local motor manufacturing facility to produce small electric fan and pump motors which are in high demand in Ghana and the ECOWAS region.

4.3.5 Energy Management for Small & Medium Scale Enterprises

271. The Small and Medium Scale Enterprises (SME) which form over 80% of Ghanaian industries find it relatively difficult accessing funding for energy efficiency investments. The objective of the project is to introduce energy management in SME through direct audits and the creation of a mechanism for the procurement of equipment for the realisation of identified energy conservation opportunities.
272. In order to remove the barriers that hinder SME from fully participating in the energy efficient and conservation activities, Energy Foundation is putting together a

⁶² Energy Foundation source, 2005.

comprehensive technical assistance programme that would focus on the following key areas:

- i. Provision of technical support in the form of specialised diagnostic and design services for the installation/retrofits of energy efficient and cleaner production technologies in SME.
 - ii. The establishment of appropriate financing mechanisms and a Revolving Fund to enhance SME access to funding to finance the implementation of energy efficiency retrofits.
 - iii. Increasing the availability of energy efficient technologies such as efficient electric motors, lighting systems and boilers/furnaces.
273. Energy Foundation intends to purchase vehicles for use as “Energy Vans” (i.e. - vans equipped with a full complement of tools, computers and diagnostic instruments) to allow quick “on-the-spot” energy audits and analysis for SME throughout the country⁶³.

4.3.6 Energy Management in High-rise Buildings

274. The number of high-rise office buildings is gradually increasing in the cities of Ghana. Such buildings are high-energy demand centres with maximum demand of 1-3MW, especially since all of them have air conditioning.
275. Three buildings⁶⁴ have benefited from the initial Building Energy Management activities introduced in 1999. In 2004, a further 21 government buildings were retrofitted with efficient lighting and control systems⁶⁵.
276. A nationwide project to retrofit all government facilities, including about 500 secondary school buildings with energy efficient lamps and sensors where necessary is expected to cost about US\$10,000-US\$50,000 per building depending on the size and equipment installed in the building.

4.3.7 Industrial Co-generation and Fuel Substitution

277. The expected introduction of natural gas into Ghana’s energy mix in 2007, offers immense opportunities for Ghanaian companies to displace their more expensive industrial heating oils. Glass manufacture using silica deposits at Aboso, iron smelting using iron ore deposits at Opong Manso all in Western Region could

⁶³ The first Energy Van and associated equipment was acquired in 2003-2004. Two more vans were to be acquired in 2005-2006.

⁶⁴ The Ministry of Energy building, the Kotoka International Airport and the Golden Tulip Hotel all in Accra

⁶⁵ With financial support from Ghana Government and the Netherlands Government.

benefit from the extension of the natural gas pipeline from Takoradi to Tarkwa and beyond.

278. Enterprises that use both heat and electricity could also benefit from combined heat and power (CHP) production technologies, which can greatly enhance fuel use efficiency and reduce the environmental impact of energy production and consumption.
279. The oil palm and wood industries that generate combustible residues and wood wastes (renewables) could use the residues for both power production and process heat for operational purposes. Some of these oil palm and wood industries used to have their own distributed generation from their wastes but discontinued the practice when their operational sites were connected to the national grid, since there had not been any incentives to promote distributed and cogeneration or purchase the excess power produced by the industries.

4.3.8 Reactivating the IEAC and other energy centres

280. An Industrial Energy Assessment Centre (IEAC), has been established at the College of Engineering of KNUST⁶⁶. The centre trains students in energy auditing and energy management and is supposed to produce skilled manpower in energy management for industries. The Centre since 1997 has trained over 40 students and has conducted over 18 energy audits in industries in the Kumasi and Accra-Tema industrial zones.
281. Follow-up visits are undertaken in 2006 to assess state of the centre indicated that it has largely been inactive since the beginning of the decade due to attrition of personnel. The KNUST has therefore re-organised their energy-related centres by bringing all of them together to form one-stop energy centre.
282. The Energy Commission intends to rally support for the new KNUST energy centre to enable it reactivate its energy efficiency, conservation and renewable energy activities. The Commission also intends to support the centre to develop capabilities for verification of greenhouse gas emissions for national candidate projects under the CDM.

4.3.9 National Woodfuel Policy

283. The Energy Commission with the support of UNDP and the World Bank is disseminating more improved cookstoves.

⁶⁶ With the assistance of the US-Department of Energy under a Ghana - US technical cooperation agreement, signed in 1997.

284. The Energy Commission is also preparing a national Woodfuel Policy and is expected to be completed by end of 2007.
285. Besides, the Ministry of Energy is supporting the Forestry Department to set up fuelwood plantations. The Ministry is therefore collaborating with the Forestry Commission and the Forestry Department to conduct a review of the past and on-going Reforestation Schemes in the country in order to chart a Road Map for sustained development of woodfuel schemes. The review is expected to be completed in 2007.

4.4 Cost

286. Total cost for implementing the Demand-Side Management activities would cost at least US\$56 million comprising the following:
- About US\$16 million for the procurement of eight million CFLs to support the on-going energy efficiency campaign to a sustainable level.
 - US\$3 million for promotional activities.
 - Support for the KNUST Energy Centre and other energy training initiatives— a minimum of US\$500,000 for the first five years based on an average of US\$100,000 equivalent in cedis annually.
 - A Revolving Fund of US\$5 million to assist industries to install capacitors and pay for the savings. Also, to purchase and install load controllers for industries interested in the Time of Use tariff project.
 - A minimum of US\$25 million to retrofit government buildings⁶⁷ and public educational institutions in the regional and district capitals.
 - US\$2 million required for the construction of testing laboratory and associated facilities for the entire standards and labelling.
 - A minimum of US\$4.5 million to kick-start the promotion of grid-connected distributed and co-generation systems based on renewables (biomass wastes) and natural gas in existing and potential industries.

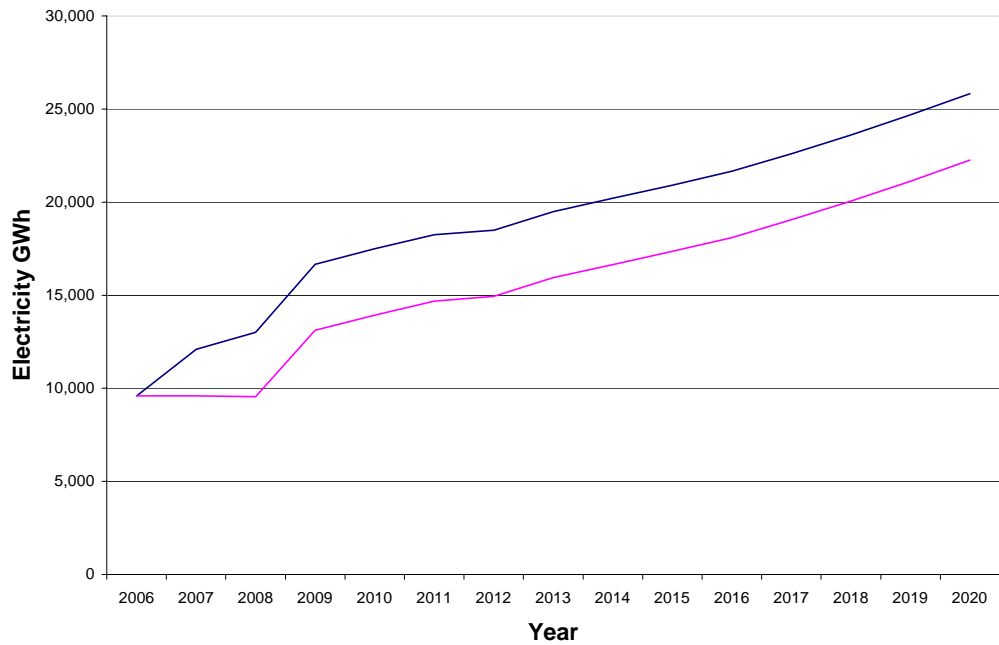
4.5 Impact of DSM on total electricity demand

287. Impact of DSM on energy demand is expected to be significant. For instance, should the DSM in the electricity subsector be implemented by 2007 and sustained up to 2020, an average of about 21% savings in electricity consumption per year by 2012

⁶⁷ Including the replacement of louver blades with panel or slide windows.

and about 16% per year by 2020. This translates to an average of about 3,500 GWh yearly savings by 2020 equivalent to a 500 MW thermal power plant (figure 3.3).

Impact of Demand Side Management on Electricity Demand
Moderately High Economic Growth Assumed



5 AVAILABLE ENERGY RESOURCE AND SOURCES

5.1 *Indigenous Resource*

5.1.1 Fossil fuels

Petroleum

288. Despite exploration activities since 1896, which have resulted in drilling less than 100 wells, no commercially sustainable deposit of oil and gas has been found. Proven reserves of natural gas have been established at Tano and Saltpond fields in the Western and Central Regions respectively. The Tano fields have 193 billion cubic feet (BCF) and the Saltpond fields for now have only 20 billion cubic feet (BCF) as proven.
289. The proven gas reserves at the Tano fields can feed the 125 Megawatt ‘Osagyefo’ power barge for between 20 – 25 years, delivering around 930 Gigawatt-hours every year when the power barge is at full operational capacity. The Tano fields will not last beyond five years if directed to feed the Aboadze thermal power plant.
290. Proven crude oil reserves are about 2 and 36 million barrels at the Saltpond and Tano fields respectively. Commercial extraction of between 300-1000 barrels of oil a day is on-going at the Saltpond fields.
291. The corresponding gas flared per day at the Saltpond field since operations resumed in 2002 averages 2 million cubic feet day. Even though, relatively small it is capable of running at least, a 45 Megawatt capacity gas turbine power barge delivering about 335 Gigawatt-hour per annum over its economic lifetime; about a third of energy delivery from the proposed Bui Dam. The natural gas itself can provide direct energy source for mineral processing to develop the potential ceramic industry in the area⁶⁸.
292. The existence of large commercially producing fields in neighbouring Cote d’Ivoire, Nigeria and the Gulf of Guinea⁶⁹ in general, however and the rather low historical drilling rate continue to sustain the dream that substantial oil and gas deposits could soon be found and exploited, if the exploration activities in Ghana’s waters are intensified and sustained.

⁶⁸ The ceramic company in Salpond had been in distress due to high cost involved in using electrical furnaces.

⁶⁹ Gulf of Guinea includes Mauritania, Gabon, Equatorial Guinea and Angola.

In Ghana, drilling has been on average one to two wells per annum, but worldwide, the success ratio of oil and gas has been 10% per annum. The current strategy is to focus exploration activities off shore in deep waters, 200-3000m.

5.1.2 Renewables

Hydro

293. Electricity generation efficiencies of hydro power plants are usually very high, ranging from 86 – 97 percent depending on the type and characteristics of the plant.
294. Large hydropower of the size as Akosombo however, is no more available in the country. The remaining gross potential hydro resource including medium, small to mini hydro⁷⁰ sites does not exceed 1,400 Megawatt or 2,000 Gigawatt hours a year when tapped using the available hydro generation technologies.
295. The notable large-to-medium hydro sites of major interest to utility developers include Bui on Black Volta at 200 Megawatt or 400 Megawatt capacity, Hemang on River Pra at 93 Megawatt, Juale on Oti River at 87 Megawatt, Pwalugu on White Volta at 48 Megawatt and Tanoso on Tano River at 56 Megawatt.
296. Small to mini-hydro sites total around 25 MW but dispersed over 70 sites with Dayi River cascades (2,000 – 5,300 kWp) in the Volta Region as the most attractive. However the power exploitable potential of the mini-hydro sites in general, has been found to be lower than anticipated in earlier studies. 50 percent of the sites now dry out during the dry season⁷¹.

Biomass – wood and wood wastes⁷²

297. Biomass resources can be converted into electricity, heat, transport fuels, etc. Biomass for electricity generation could come from logging and wood processing residues, agrofuels and municipal by-products, as well as plantations. Almost two million tonnes of wood residues are available in the country annually for energy and other purposes.
298. For electricity, most reliable data suggests that at least 95 Megawatt capacity providing about 600 Gigawatt-hours could be tapped from farm-wastes, sawmill and logging residues between now and 2008. Increasing to at least, 220 Megawatt (and 1,300 Gigawatt-hours) by 2015 and reaching about 350 Megawatt (and 2,000 Gigawatt-hours) by 2020 as the economy expands. There would however be competitive alternative uses of the residues.

⁷⁰ Assume a medium to be more than 10 MW but less than 400 MW in installed capacity. Small hydro is 10 MW and below but more than 1 MW in installed capacity. Minihydro is less than 1 MW and less.

⁷¹ Energy Foundation feasibility study report on minihydro project sites in Ghana, 2002/2003.

⁷² Essandoh-Yeddu et al., Sustainable energy scenarios for Ghana's long term development plan, M.Sc Thesis – Chalmers University of Technology/Gothenburg University, Sweden, 2001.

299. Another major source will be by cultivating energy crops such as eucalyptus. For power generation, a plantation or a close conglomerate of 150,000 hectares of eucalyptus, which is just about 1 percent of the total land area of Ghana, can fuel a 300 Megawatt-Steam electric power plant of 25% efficiency and 80% availability to produce 2,100 Gigawatt-hours per year; about one-third of the total firm electricity produced from Akosombo and Kpong combined, in every good rainy year. The power generation is enhanced for plants with higher efficiencies.
300. However, estimated cost of cultivating such a plantation with an average wood yield of 14.2 tonnes of dry wood per hectare per year with energy density of 14.9 Gigajoules (4.14 MWh) per tonne of wood can cost US\$18 million⁷³.
301. Due to high cost of transporting wood, the power plants can be located near the plantations. This provides economic boosts to rural communities hosting such plants.

Biomass – animal wastes

302. Livestock waste and residues are potential sources of energy. The dung produced by different species of livestock can be collected and either dried and burned directly, or anaerobically digested to produce biogas, which can then be burned as a fuel in a much more efficient manner than solid fuels. Total energy from animal wastes in 1996 was estimated as over 300 Terajoules or 87 Terawatt-hours. There would however be competitive alternative uses of the residues.
303. Energy use in the poultry industry is mostly electricity. Poultry population is expected to increase to about 120 million by 2020 from around 19 million in 2000, under business-as-usual growth and will require final electricity estimated at 61 GWh. In theory, poultry droppings and wastes of the estimated population are enough to meet the electricity requirement of the industry⁷⁴, but this will depend on how efficient chemicals are applied in the poultry management.
304. For instance, large traces of antibiotics in the droppings will drastically reduce the methane production. Secondly, the droppings from subsistence farming will be difficult to aggregate at central points.

Biomass – municipal wastes

305. Municipal waste is a bioenergy resource, which is generated, in fairly large quantities in the metropolitan centres. It includes solid wastes from the domestic and commercial sectors as well as sewerage sludge. Of the two, municipal solid waste (MSW) holds the prospects for significant power generation in the country.

⁷³ 14.2 dry tonne/ha x 150,000 ha x US\$8.58 / dry tonne.

⁷⁴ Assume internal combustion engine of 10% efficiency. 611 GWh of biogas will be needed. Energy content of biogas is 6.25 kWh/m³. Meaning 98 million m³ of biogas needed. 1 kg of fresh animal manure produces 0.03 m³ of biogas on the average. Assume a bird produces 36.5 kg manure per year. Meaning just 90 million birds needed to generate 61.0 GWh via a 14 MW plant of 50% availability.

306. Average MSW generation in the country would be between 150 – 200 kg per capita. Collection efficiencies of the MSW for the three metropolitan cities of Accra, Kumasi and Sekondi-Takoradi are about 80 – 85 percent, 65 – 70 percent and 60 – 65 percent respectively.
307. Total generation of municipal solid waste (MSW) in the three metropolis averaged one million tonnes in 2000 and this is expected to double by 2020 as the population grows and the economy expands.
308. A typical Waste-to-energy incineration plant of 20 Megawatt installed capacity, 25 percent efficiency and availability of 85 percent, consumes around 670,000 tonnes of hard (dry) waste to produce about 150 Gigawatt-hour of electricity⁷⁵. 20 MW plant in Accra could be feasible at present expanding to about 40 MW by 2020.
309. Degradable organic materials making about 65 percent of the MSW generated in the country is responsible for the low capacity availability. High composition of wet or organic material in the MSW means it would be more suitable for disposal in landfills where the landfill gas could be tapped for power generation or heating. Power generation from landfills are however relatively very low.
310. The observation is that as the GDP per capita increases, the dry material content of the MSW also increases.
311. Finally, even with the best available pollution controls, MSW combustion can still release dioxin and heavy metal pollutants into the atmosphere, making MSW waste-to-energy projects less favourable to landfill power projects. Again, power generation levels of MSW waste-to-energy plants are however far higher than those of landfill plants.
312. However, it is unlikely to see serious commercial MSW waste-to-energy plants until the right business climate emerges (See Box).

BOX: Economics of Municipal Solid Waste for power

MSW power business however has three components:

- Earnings from the waste tipping
- Earnings from the heat generated as process heat
- Earnings from the power sales.

It becomes cost competitive when all the three arms of cash flow are working. Else, it is considered more of a disposal facility than a power plant, since burning of MSW is very inefficient from an energy standpoint. Moreover, the technology competes with re-cycling, which is at times regarded as a higher value use of the waste stream, as the composition of the dry material component of the MSW improves.

Liquid biofuels - biodiesel

313. Tests conducted by the Tema Oil Refinery and Ghana Standards Board (GSB) indicate that the biodiesel oil from physic nut (*Jatropha curcas*) plant is suitable for

⁷⁵ Calorific value of Ghanaian waste is assumed to be 4 GJ (1.1 MWh) per tonne due to the high proportion of moisture and inert materials.

use as industrial diesel oil directly, while a blend of up to 20 percent by volume of the oil with regular diesel could be used for automobiles without significant adjustment to the engine.

314. The biodiesel obtainable from *Jatropha curcas* plant is of interest to Ghana, since the plant can also thrive on marginal lands and can live up to 50 years, yielding fruits within six months of germination and reaching its peak from the fifth to the sixth year, thereafter, bearing fruits every year throughout its lifespan.
315. As a rule-of-thumb, 3 – 4 tonnes of dry *Jatropha* seeds yield 1 tonne of crude *jatropha* oil of which about 98 percent is transformed into refined bio-diesel.
316. Biodiesel has the potential to serve as an alternative fuel in running diesel powered grain mills in rural and remote areas.

Liquid biofuels - alcohols

317. Gasohol, a mixture of alcohol and gasoline is a well-known fuel for the transport sector and can supplement gasoline use in the country. Main alcohols used are methanol and ethanol.
318. Methanol can be produced from biomass but also natural gas. Initial production cost of bio-methanol had ranged from US \$30 – 45 per Megawatt-hour (about 0.30 US cents per litre in the average) in 2004
319. Ethanol is produced mainly from corn and sugar but also from cassava wastes with introduction of an enzyme. On the average worldwide, initial production cost averaged about US \$36 per Megawatt-hour (0.23 US cents per litre) in 2000 – 2004.
320. Alcohol production from sugar plantations is an energy sustainable industry where the waste is used to meet the energy needs of the factory. Such a programme offers the opportunity to meet not only the alcohol needs of the transport sector, but the sugar needs of the country and for export as well. Species of sugar that take less water are now available.
321. Being agro-fuels, biodiesel and alcohol have the potential to provide direct employment in rural communities having such plantations by way of cultivation, harvesting and processing of the produce.

Solar Energy

322. The average duration of sunshine varies from a minimum of 5.3 hours per day in the cloudy semi-deciduous forest region to 7.7 hours per day in the dry savannah region. The average solar energy incident in different parts of the country ranges from 4 to 6 units of electricity (4.4 and 5.6 sun hours)⁷⁶ for every square metre per day. The

⁷⁶ 1 sun hour = 1 kWh/m²-day. 4.4 – 5.6 kWh/m² = 16-20 MJ/m²-day

theoretical energy available yearly in the country is about 400,000 Gigawatt-hour (about one and half billion Gigajoules).

323. High diffuse radiation constituting more than 30 percent of the total solar radiation in the country however, does not augur well for concentrating collectors used in solar thermal power plants. Flat plate solar collectors and photovoltaic (PV) modules are hardly affected by the diffuse fraction and hence these perform satisfactorily in most parts of the country.
324. On the other hand, it makes flat-plate solar collectors for water heating, drying and electricity generation via solar photovoltaic (PV) ideal for Ghana.
325. The key issue with solar for electricity generation is the high cost of pure-grade silicon-the heart of the solar-to-electricity conversion, which has very competitive uses in the lucrative semi-conductor industry such as the Information and Communications Technology (ICT)⁷⁷. Whereas it is true that silicon is abundant in the sand⁷⁸, making the silicon pure enough to be useful for solar cells is more difficult and energy-intensive raising the price of the required silicon to US \$65-80 per kg compared to regular industrial silicon grade costing about US \$2 per kg.
326. The silicon feedstock average price increased from US \$65 per kg by the end of 2004 to close to US \$90 per kg by the end of 2005. Demand continued on abated, but with silicon supply severely constrained the industry was just not capable of meeting the demand. It is projected that the world market spot price for silicon feedstock could skyrocket into US \$200-400 per kg range. Supply is however expected to improve by 2011 bringing back the feedstock price range to pre-2004 levels⁷⁹.
327. The alternative semi-conductor materials for solar applications are not as abundant as silicon and consequently, equally expensive to obtain.
328. Solar water heaters however are fairly non-high-tech industry. Materials for their local fabrication are readily available such that two or three local companies and institutions are already fabricating domestic brands.

Wind

329. Ghana has some wind resources that could be tapped to supplement her energy requirements. For now, the 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). The corresponding wind power density range from 185 - 210 Watt per square metre at 1.225 kg per cubic metre (kg/m³) air density.

⁷⁷ The global chip sales hit almost US \$250 billion compared to solar PV sales that was about US \$10 billion or below in 2006. Both subsectors are equally registering significant annual demand growth.

⁷⁸ Makes up about 60% of earth's crust.

⁷⁹ REFOCUS, November/December 2006, edition. Published by the International Solar Energy Society (ISES), article - PV: The Story so far, written by Paul Mint, p 32.

- 330. Aerial survey by an international team⁸⁰ has also identified some spots within inland Ghana and suggesting about 2,000 Megawatt wind potential for the country but those potential sites are yet to be corroborated by ground measurements.
- 331. The maximum energy that can theoretically be tapped from the available wind for electricity using today's technology is about 500 – 600 Gigawatt-hours every year⁸¹.
- 332. On the other hand, wind available for water pumping and other mechanical applications is immense since it requires lower wind speeds.

5.2 Sources of Energy and Fuel imports⁸²

5.2.1 Electricity imports

- 333. Ghana has been importing bulk electricity from la Cote d'Ivoire since 1995 to supplement the nation's power generation requirements. Future long-term supply from la Cote d'Ivoire and other countries in the sub-region however, cannot be assured.
- 334. In the context of NEPAD⁸³ however, River Congo has about 40,000 Megawatt hydropower potential capable of producing 770-1,400 TWh per year and it is one of the highest in the world. The proposed hydropower project is estimated to cost US\$50 billion. A plan to construct the first-stage plant of around 8,000 Megawatt to export power largely to South Africa is envisaged by 2010. Ghana can buy into the Congo River project through the impending West Africa Power Pool (WAPP) he closest neighbour with the highest oil reserves, in fact the second largest in Africa. The country has about 34 billion barrels (4.6 billion tonnes) as at 2004 and is projected to last for about 43 years Ghana can buy into the Congo River project through the impending West Africa Power Pool (WAPP).

5.2.2 Oil Imports

- 335. Diesel and Residual Fuel Oil (RFO) are the most popular petroleum products for heating and bulk power generation worldwide.
- 336. Ghana imports light crude oil (LCO) mainly from Nigeria and it is likely to be so for the foreseeable future, except if significant commercial fields are discovered locally. Within the sub-region, Nigeria is the closest neighbour with the highest oil reserves, in fact the second largest in Africa. The country has about 34 billion barrels (4.6 billion tonnes) as at 2004 and is projected to last for about 43 years based on current average production of around 2.2 million barrels a day (107 million tonnes per

⁸⁰ A Solar and Wind Energy Resource Assessment (SWERA) project being run jointly by UNEP, Global Environment Facility, and US National Renewable Energy Laboratory (NREL), 2004.

⁸¹ A theoretical maximum installation is expected to be in the order of 100 – 200 units with a spacing of at least 500 m in one line, corresponding to about 300 – 400 MW

⁸² See Appendix 1

⁸³ NEPAD: New Partnership for African Development

annum). Nigeria's oil is noted for its low sulphur content and the country's close proximity to Ghana means lower transportation cost. Moreover, Nigeria has been providing the Ghana Government with some credit facilities.

337. Even though, more distant away Ghana had some supplies from Libya in the past through government bilateral arrangements. Libya produces about 1.5 million barrels of oil a day (70 million tonnes per annum) and has a proven reserves estimated at 36 billion barrels (4.7 billion tonnes) with about 66 year lifetime. Libyan crudes are also generally light and have very low sulphur.
338. A second neighbouring country with oil export potential to Ghana is Equatorial Guinea. Ghana signed a bilateral cooperation with Equatorial Guinea on oil business between the two countries in 2004. The latter produced 12.3 million tonnes (249,000 barrels a day) in 2003 and has proven reserves of about 563.5 million barrels (73.6 million tonnes) estimated to last for only six years.
339. Price of crude oil however, is the most erratic of all commercial fuels. Diesel is usually more expensive than the light crude oil. RFO on the other hand is about two-thirds the price of the crude and is the cheapest petroleum product for energy production. On the average, RFO enjoys the most stable price but it emits more gaseous pollution than light crude oil during combustion.

5.2.3 Natural gas imports

340. Natural gas imports at the rate of about 100 million cubic feet per day (mmcf/d) will be delivered to Ghana by end of 2007. The West African Gas Pipeline (WAGP) will be the transport vehicle for the natural gas, which will be tapped from the eastern coast of Nigeria, from a proven reserve estimated at about 176 trillion cubic feet (5 trillion cubic metres) as at 2004 and its recovery years is expected to last about 260 years based on Nigeria's current average production of about 677 billion cubic feet (19.2 billion cubic metres per annum). Significant amount of the gross gas production is flared but this is expected to be eliminated by end of 2008 due to significant growth in local usage and for export as liquefied natural gas (LNG) to largely Europe.
341. The other immediate external source of natural gas is la Cote d'Ivoire but her proven reserve available for export is relatively small (169 – 336 billion cubic feet) compared to the Nigerian reserves. Supply to Takoradi Thermal Power Station from la Cote d'Ivoire is estimated to last between 7 – 8 years, or 10 years on the average if new discoveries are confirmed.
342. The Ivorian-Ghanaian gas pipeline will however be about 290 kilometres offshore, i.e. about half the distance of the WAGP from Nigeria. Construction cost will therefore be cheaper given its shorter length⁸⁴. Final cost of gas delivered will however depend on the cost of gas fixed in la Cote d'Ivoire.

⁸⁴ US \$154 – 205 million for the first 25 year operations within a typical life 40 years, taking Vridi Gas Station in Cote d'Ivoire as the commencement point and the Takoradi Thermal Power Station in Ghana as the finish point.

343. It is envisaged that in the event of la Cote d'Ivoire's own demand outstripping supply, natural gas would then be supplied to Cote d'Ivoire from Nigeria or Ghana in reverse flow through the same pipeline but linking up with the West Africa Gas Pipeline (WAGP).

5.2.4 Coal imports

344. Coal is the most popular fuel for electricity generation worldwide but Ghana has no known coal deposits. Coal is usually dirtier than the oil-based fuels but less expensive and enjoys long-term price stability. The most probable source of coal supply to Ghana is Nigeria and could be transported to the country using marine barges. Total proven reserves in Nigeria were estimated at 190 million tonnes in 1999 and it comprised almost 89 percent sub-bituminous coal. Production is about 20,000 tonnes per annum and is largely for domestic use other than electricity generation
345. Niger being within the sub-region could be an obvious source, but transportation could be a hindrance since there is no direct rail-link between the countries. Road transport is not effective for mass transportation of coal for operation of power plants. Niger's proven reserves totalled 70 million tonnes in 1990. Prevailing production of about 168,000 tonnes is used mainly for domestic operation of its uranium mines.
346. South Africa is apparently the most cost competitive alternative country for coal imports. Its proven reserves are about 49.5 billion tonnes and are projected to last for about 200 years. Average production is around 223 million tonnes of which about 70 percent is used locally. Cost-competitive transportation is usually by marine super-barges.

5.2.5 Nuclear imports

347. Nuclear fuels could be enriched uranium, enriched thorium and of late MOX⁸⁵. Enriched uranium is apparently the most common nuclear fuel. Enriched thorium is for thermal (low speed neutron) nuclear plants.
348. Within the sub-region, Republic of Niger is the exporter of uranium and is the world third largest producer. Proven resource recoverable at US\$40-180 per kilogramme is up to 71,000 tonnes of uranium oxide. Uranium oxide (popularly called the yellow cake) however, contains just about 0.7 percent of the active material, Uranium-235 and so has to be processed and enriched to levels of higher U-235 before it can be used as nuclear fuel. There is no known commercial enrichment facility in Africa and so all enrichment are done elsewhere.
349. The main sources of commercial nuclear fuels are therefore likely to be United Kingdom and the United States. Transportation of nuclear fuel as well as the wastes however, requires a larger and relatively expensive engineering and regulatory infrastructure to safeguard against accidents and theft.

⁸⁵ MOX fuel consists of 4-9% plutonium mixed with natural uranium or with depleted uranium

6 STRATEGIC PLAN FOR THE DEMAND SECTORS

Residential Sector

Electricity

350. National goal is to achieve 100% universal electrification by 2020. Sixty (60) percent access is estimated for now. Connection however has largely been by grid.
351. Strategic Targets:
- i. To achieve 15% penetration of rural electrification by decentralised renewable energy complementation by 2015 expanding to 30% by 2020.
 - ii. To reduce the average electricity intensity per urban household by 50% by 2020.
352. Decentralised renewable energy penetration is less than 1% at present. The energy efficiency measure can free about 5,000 GWh nationwide by 2015 expanding to about 8,000 GWh by 2020.

Energy for Cooking

353. Strategic Targets:
- i. To reduce the average woodfuel energy intensity per urban household by 30% by 2015 and by 50% by 2020.
 - ii. To reduce firewood intensity per rural household by 10% by 2020.
354. The strategic targets can reduce the annual wood requirements for the production of charcoal by 50% by 2020. Woodfuel share of cooking fuels for urban household averaged about 90% since 2000. Share of LPG, a potential substitute for woodfuel for cooking in urban households, was just about 6% in 2000.

Commercial and Service Sector

355. Objective: To reduce the energy consumption in general and woodfuel consumption in particular, by introducing energy efficiency programmes and cleaner energy alternatives.

Electricity

356. *Strategic Targets:*

i. To reduce electricity consumption of military and police barracks, residential halls and hostels of public tertiary institutions by 50% by 2015.

ii. To achieve 1% penetration of solar energy in hotels, restaurants and institutional kitchens using solar water heaters by 2015 and 5% penetration by 2020.

357. Defence and security together is the third highest consumer of electricity in the this sector, though the share has fallen from about 15 percent in 2000 to a little less than 10 percent per annum in recent times. The Education subsector comprising the tertiary and secondary institutions, etc had its share of electricity drop from 10 percent in 2000 to around 5 percent on the average in recent times. Even though the impact on the nation is not expected to be significant, the strategy will benefit the institutions by reducing their annual energy bills by 50%.

358. Solar energy for now is completely absent.

Cooking

359. *Strategic Targets:*

i. To increase LPG penetration by 20% by 2015 and 30% by 2020.

ii. To reduce woodfuel share of energy to 50% by 2015 with subsequent reduction to 40% by 2020

iii. To achieve improved efficiency cookstove penetration of 5% by 2015 and 10% by 2020.

iv. To achieve 1% penetration of biogas for cooking in hotels, restaurants and institutional kitchens by 2015 and 2% by 2020.

360. LPG is just about 6-9% share of energy for cooking. Restaurants are responsible for over 75% of LPG consumed by the sector. “Chop-bars”, which are small local kitchens serving traditional dishes, take on the average about 13% share every year. Most of the energy used in these “chop-bars” had come from woodfuels (over 65%). Cleaner energy alternatives, using biogas produced from liquid wastes, as heating source in restaurants, institutional laboratories and kitchens will be encouraged. For now biogas use is almost negligible.

Agricultural and Fisheries Sector

361. **Objective:** To increase the penetration of modern energy into agriculture for increased agricultural production, to help achieve the nation's food supply security objectives.

362. **Strategic Targets:**

i. To achieve 2% penetration of biodiesel by 2015 and 10% by 2020.

ii. To achieve 20% penetration of solar energy by 2020.

iii. To increase electricity penetration to 2% by 2015 and 5% by 2020.

363. The objectives are to:

- Encourage the substitution of diesel with biodiesel in agricultural mechanization.
- Encourage more drying of exportable farm produce such as pepper with solar dryers.
- Displace the use of diesel for irrigation with grid electricity and mechanical wind pumps.
- Encourage large-scale commercial poultry farmers to meet at least 10 percent of their electricity needs from biogas, using the droppings from the birds.

364. For now, biodiesel use in this sector is non-existent. Solar energy use is about 13% on the average. Electricity consumption is less than 1% on the average.

Transport Sector

365. **Objective:** To reduce the dependence on imported fossil fuels for transport.

366. **Strategic Targets:**

Achieving fuel consumption per GDP growth of 1:1 by 2015 and sustaining it up to 2020⁸⁶.

367. The immediate objective is to encourage fuel efficiency measures in the transport sector.

⁸⁶ from about 2:1 at present.

368. The transport sector accounted for about 85% and 99.7% of diesel and gasoline consumption in the economy respectively. With the increasing world crude oil prices, such an efficiency strategy will have the positive impact of slowing down the growth of future demand.
369. To help promote energy efficiency in the transport sector, there would also be the need to deregulate the railway system to permit private sector participation in urban passenger and long distance freight railways systems. Also, provide incentives for the promotion of nationwide mass transit systems.

Industrial Sector

- 370. Objective:** To ensure sufficient, cost effective but affordable high quality energy supply to meet the increasing demand of an efficient and expanding industrial sector. Light or non-energy intensive industrialization will be encouraged.
371. Average power factor in the industrial sector is still less than 90%. At present, no pollution charges exist so there are no incentives for primary industries to further improve their energy use efficiencies. Bulk tariff varies across large industrial users, even though some of the rates are unsustainable⁸⁷. In the end the tax payer is compelled to absorb the deficits. The nation expects to see a natural gas market for the first time in 2007. Natural gas is relatively clean compared to RFO currently being used in industry for heating. Natural gas is also expected to be less expensive per unit of energy value.
372. Strategic Targets:
- i. Achieving high quality and reliable (95% uninterrupted) electricity supply to the industrial sector per annum by 2015 and improving reliability to 98% by 2020.*
 - ii. Achieving an average of 95% power factor per annum in the industrial sector by 2015, increasing to 98% by 2020.*
 - iii. Introducing pollution charges in high-energy intensity industries to encourage efficiency by 2015.*
 - iv. Providing a competitive bulk electricity price to all primary industries (including VALCO) by 2012 to maximise wealth creation.*

⁸⁷ VRA power tariff to VALCO is a typical example.

- v. *Developing a local market for the industrial use of natural gas when the WAGP project is complete, including displacing residual fuel oil use for heating in most coastal industries by 2015.*

Energy Efficiency and Conservation

373. *Strategic Targets:*

To reduce the average electricity intensity in the Residential and Commercial sectors from an average of 2-2.4:1 to 1.5:1 by 2015 and maintaining the ratio up to 2020.

374. Energy efficiency and conservation besides saving energy will also be encouraged as a means towards cleaner production and pollution control measures in industries. Energy audits in the industrial and Commercial/Service Sectors will continue to be supported. Co-generation in industries to ensure that energy is used at the highest level of efficiency will also be encouraged.
375. The regulatory institutions would be encouraged to implement performance benchmarks for energy producers.
376. To ensure that energy is used efficiently in industry, commerce and in residential facilities, a law – the Energy Efficiency and Conservation Act – that would spell out mandatory energy management practices, building codes, requirements on energy efficiency levels of energy consuming equipment, energy audit regimes for formal industries and commercial entities such as hotels should be instituted to give legal support to energy efficiency initiatives.
377. Support provided by Government in the introduction of Standards, Legislation and labels is highly commended. This would help ensure that inefficient energy consuming devices and appliances are not dumped on the Ghanaian market. The labels would help inform consumers about the choice of energy consuming appliances.
378. However, to reduce government recurrent expenditure, lessen pollution and set precedence for good practice, it would be prudent for Government to make it mandatory for all equipment bought for government facilities and educational institutions to meet minimum energy efficiency standards/specifications, set by the Ghana Standard Board.
379. For the same purpose, Energy Management in government buildings and educational facilities as well as vehicular fleets should be instituted.

Increase Energy Fund levy or set up a special purpose fund for promotion of energy efficiency and conservation

380. The Government may have to set up a special purpose fund to enhance the capacity to provide credits for the financing of energy efficiency and conservation projects. Such a special purpose fund can be established through collaboration with donors and the private sector.
381. Local sources to the fund could include special levies on inefficient equipment imported into the country, power factor surcharge already in operation, donations and grants.
382. Such a special purpose fund can also be farmed out of Energy Fund if the prevailing levy is increased significantly.
383. Further financial resources for the development of energy efficiency projects could be sought through the development of projects that would reduce greenhouse gas (GHG) emissions and therefore qualify for funding under the Clean Development Mechanism (CDM) and other Climate Change mitigation initiatives.

7 POLICY RECOMMENDATIONS FOR THE DEMAND SECTORS

Residential Sector

Electricity

Policy

384. It is recommended that

- i. Government continues to improve access to modern energy services to all income groups of the country.*
- ii. Schemes that support the provision of electricity services to communal facilities in rural areas will be encouraged.*
- iii. The Government supports the setting up of a 'one-stop shop', which will serve as a resource centre to coordinate activities of utility agencies and the physical planning agencies regarding power extension for real estate development.*
- iv. Government supports the promotion of pre-paid meters in urban centres.*
- v. Government supports the sustaining of on-going energy efficiency programmes.*

385. Implementation measures

- a) Continue the extension of the national grid to all communities where appropriate.
- b) Provide solar electric systems in small⁸⁸ populated off-grid communities as a kind of pre-grid quality electrification facility.
- c) Provide minigrid systems in off-grid but remote large populated areas using biomass-to-power plants and wind, whichever is applicable.
- d) Provide communal facilities like schools, health centres in off-grid locations with sustainable and environmentally friendly distributed power systems.

⁸⁸ Population of 1,000 or less. Number of homes/customers 100 or less.

- e) Use NGOs, community based organisations (CBOs), independent commercial service providers and District Assemblies as key facilitators⁸⁹.
- f) Support the energy efficiency activities of Energy Foundation.

386. A key concern of poorer income households is the issue of communal sharing of metering facilities. Even though, lifeline subsidy is targeted to help the poor, poorer families hardly enjoy this subsidy owing to the sharing of communal metering in compound houses.
387. Sharing of communal metering in compound houses causes the units of electricity consumed by these poorer households to fall into the high unit cost bands of the current progressive tariff structure. This could ultimately place them in the maximum tariff bracket of 1,018 cedis /unit (kilowatt-hour) compared with a charge of between 300–400 cedis /unit being the lifeline tariff for consumption up to a maximum of 50 units⁹⁰. Thus, communal use of meters increase electricity bills particular for the poor.

Policy

388. **It is recommended that**

The distribution utilities and PURC provide guidelines on equitable bill-sharing systems for use in compound houses.

389. **Implementation measures**

- a) The utilities make available and accessible more meters.
- b) Since compound house dwellers are generally familiar with the ‘point’ system, the utilities and PURC should share with the consumers, information on advantages of own meter.
- c) Utilities should experiment with voltage or current limiters in compound houses since they are less expensive than meters.

Kerosene

390. Kerosene is used mainly for lighting in rural and non-electrified communities. However, the quality of kerosene lighting is inferior compared with lighting by electricity or solar lamp.
391. Moreover, 65 – 70 percent⁹¹ of rural households spend as much as US \$10 or more equivalent per month on kerosene and dry cells for lighting.

⁸⁹ NGO is Non-governmental organisation. CBO is Community-based organisation.

⁹⁰ Power tariff as at 2006

⁹¹ Study conducted between 1999 – 2001.

392. It will however cost US \$8 – 13 per month to provide better quality lighting including opportunity to also operate a radio/cassette player using just a 50 Watt peak solar PV home system; the low-side being DC (battery-type) power and the high-side being AC (mains-type) power⁹².
393. As the off-grid community is provided with electricity or better lighting source such as solar energy, the kerosene consumption is expected to reduce.
394. Poor electricity services in urban areas give rise to kerosene being used as back-up lighting source. Kerosene consumption as back-up energy source in grid connected areas averaged 5,000 tonnes per annum from 2000 – 2004. Increasing interest in solar lamps as back up lighting systems could displace the kerosene, which could be diverted for production of more valued added jet kerosene to support aviation traffic in the country.

Policy

395. It is recommended that

- i. Government in the short term continues to improve access to kerosene in rural areas.*
- ii. Government in the medium-to-long term accelerates the rate of rural electrification to improve the quality of lighting in rural communities and consequently, reduce the kerosene consumption per home in the communities.*

Cooking

396. Start-up cost of LPG usage is high due to relatively high cost of appliances. Subsidy on LPG on the other hand tends to benefit largely urban dwellers.

Policy

397. It is recommended that

- i. Government supports the promotion of woodstove efficiency programmes.*
- ii. Government improves access to LPG in the country by supporting measures aim at widening LPG distribution network to increase access for rural dwellers.*
- iii. Government reduces subsidy on LPG and redirect it to subsidize LPG-related appliances for the poor.*

⁹² DC – Direct current and AC – Alternating current

398. Implementation measures

- a) Energy Commission jointly with Energy Foundation will manage efficiency woodstove promotional programmes.
- b) Intensify support for demand-side management activities of Energy Foundation for the residential sector.
- c) Energy Commission grants licences for more LPG filling plants to be opened in-country.
- d) Increase LPG production at the refinery.
- e) Expand production of domestic LPG cylinders.
- f) Government through the sector ministry, Energy Commission and the National Petroleum Authority encourage and design financial packages to support fabrication of single and double LPG burners.
- g) Use NGOs, community-based organisations and District Assemblies as key facilitators and implementing agencies.

Commercial and Services Sector

Electricity

Policy

399. **It is recommended that**

- i. Government supports energy efficiency and conservation measures in the service sector.*
- ii. Government supports the promotion of pre-paid meters in government buildings and offices.*
- iii. Government sets an electricity consumption ceiling for ministries, government departments and agencies, military barracks, police and other security services, as part of efficient usage measures.*

400. Implementation measures

- a) Activities of Energy Foundation in this regard are acknowledged but would be intensified.
- b) Promote the use of solar water heaters in hospitals, hotels and restaurants to satisfy part of their hot water needs.

- c) Government makes it mandatory for all ministries, government departments and agencies to use pre-paid meters instead of credit meters.
- d) A committee comprising the PURC, Energy Foundation, the Energy Commission and chaired by the Ministry of Energy works out ceilings for the ministries, government departments and agencies and the barracks. Beyond a ceiling, the defaulting ministry, government department or agency ministry pays from its own coffers.
- e) Extend CFL promotional projects to the campus of the four public universities and the 10 public polytechnics as first phase. Subsequent phases will cover the rest of the tertiary institutions.
- f) Distribution utilities introduce pre-payment meters to the residential halls.
- g) Target Residential halls of the country's tertiary institutions for demonstration and later replicated nationwide.

Cooking

Policy

401. It is recommended that

- i. Government regulates the use of firewood and charcoal for cooking in restaurants, chop bars, canteens located in regional capitals.*
- ii. Government ensures that LPG is fairly accessible throughout the country.*

402. Implementation measures

- a) Energy Commission and Energy Foundation will promote woodfuel efficiency stoves for commercial cooking facilities such as canteens, chop bars, restaurants, pito/beers located outside towns, regional and district capitals.
- b) Energy Foundation implements the programme targeting commercial cooking facilities located in regional capitals.
- c) Use NGOs, CBOs and District Assemblies as key facilitators and implementing agencies targeting district capitals and rural areas.
- d) Energy Commission encourages more LPG filling stations to be opened in the regional and district capitals.
- e) Encourage more OMCs to operate LPG mobile tankers.

Policy

403. **It is recommended that**

- i. *Government promotes biogas-for-heating in institutional kitchens, laboratories, hospitals, boarding schools, barracks, etc.*
- ii. *Government supports the development of biodiesel as a substitute for diesel for running grain mills and other cottage industries in rural areas.*

404. Implementation measures

- a) Examples of such facilities exist in Agogo Hospital, Ashanti Region and the Catholic hospital, Akwatia in the Eastern Region. Biogas generated from the liquid wastes of the hospital is fed back to the kitchen as a cooking fuel.
- b) Energy Foundation may implement similar biogas-for-heating in institutional kitchens nationwide supported by the Energy Commission.
- c) Energy Commission may act as the execution agency.
- d) Identify government institutions, schools, and barracks for demonstrational and promotional projects.
- e) Contract expertise from the Department of Mechanical & Agricultural Engineering, which has been building previous biogas facilities in the past for nationwide promotion.
- f) Draw similar demonstration programme for biodiesel development.
- g) Seek counterpart and funding support from the GEF, the CDM and other the donor agencies

Agriculture and Fisheries Sector

Policy

405. **It is recommended that**

- i. *Government through the PURC devises a separate cost-effective tariff for the agricultural sector to induce electricity consumption and growth.*
- ii. *Government ensures that adequate premix gasoline is available to farmers and fishermen.*
- iii. *Government encourages commercial agricultural projects to meet at least 10 percent of own energy by providing incentives to develop appropriate*

alternatives with emphasis on electricity in order to promote decentralised and minigrid countrywide to complement the national electrification programme.

- iv. *Government promotes the utilisation of solar energy for large scale drying of cash crops and cereals.*

406. **Implementation measures**

- a) Mandate PURC to develop feed-in tariff for decentralized power generation
- b) Mandate PURC to set up a special attractive tariff for the use of electricity for irrigation and poultry production.
- c) Encourage energy efficiency measures in irrigation and other agricultural activities using agricultural inputs as incentives.
- d) Undertake capacity building, information and awareness campaigns.
- e) Put in mechanism to ensure that large agricultural and agro-processing ventures based in remote areas get adequate supplies of energy.
- f) De-monopolise the supply of premix gasoline. Allow competitive bidding from other oil marketing companies.
- g) Demonstrate the use of solar for commercial drying of pepper, maize, paddy rice, etc.

Energy for fish preservation

407. Between 70 – 80 percent of all fish landing comes from canoe and boat fishing. Only about 10 – 20 percent however is handled by cold storage, the rest is smoked.
408. Commercial cold-storage is available in grid connected urban centres and some grid-connected rural communities. It is less labour-intensive but becomes unreliable if power supply is intermittent.
409. Commercial cold storage is also relatively very expensive to construct or install in rural areas. Constructing a 30 cubic-metre cold store could cost around US \$8,300 equivalent. Installing a used(second-hand) freezer-container costs about US \$6,600 for a “20ft container” and US \$8,000 for a “40ft container”, labour and haulage costs excluded. New freezer-containers will of course cost more⁹³.

⁹³ Nyberg J., and K. Nilsson, (2004) *Options for Rural Electrification in Ghana – A study for Edumafa Settlements in Ghana*, Energy and Environment Systems Degree Project, Division of Engineering Science, Physics and Mathematics, Karlstads universitet, Sweden.

410. Traditional fish smoking is a must for non-grid rural fishing communities, if healthy preservation is desired.
411. Commercial or large-scale fish smoking is labour-intensive but labour is seemingly becoming harder and expensive to come by in rural fishing communities.
412. Chorkor smoker so far happens to be the largest traditional fish smoker but it is still labour intensive. It is however the most efficient traditional fish smoker; consuming between 0.26 – 0.51 kilogramme of fuelwood to smoke one kilogramme of fish⁹⁴.
413. Large-scale solar drying of most of the preferred fish has so far not been commercially proven. A larger more efficient fish smoker with reduced labour is likely to be welcomed by the indigenous fish-smoking industry.

Policy

414. **It is recommended that**
Government supports the development of larger and more efficient commercial fish smokers.
415. *Implementation measures*
- a) Develop large-scale smokers, at least double the size of a typical ‘chorkor smoker’⁹⁵.
 - b) Energy Commission provides seed funds to develop such larger commercial fish smokers.
 - c) Energy Commission partners with Food Research Institute, Ministry of Agriculture, research institutions and NGOs to undertake field trials of larger fish smokers.

⁹⁴ Fish in question are tuna and sardinella (‘Amane’). Initial and final moisture contents are about 70 percent and 40 percent respectively.

⁹⁵ A tandem traditional commercial fish smoking pot. It is either constructed from mud or metal drum. (For more information, see Energy Sector Technology Catalogue, Ghana, a publication by the Energy Commission and the Royal Danish Ministry of Foreign Affairs, September 2004).

Transport Sector

Road

Policy

416. It is recommended that

- i. Government supports promotion of fuel efficiency and conservation programmes for the road transport sector.*
- ii. Government supports evaluation of the potential of alternative fuels to supplement petroleum products.*

417. Implementation measures

Continue to provide incentives to promote the use of mass transport systems (commercial cars and buses).

Fuel efficient devices

418. There are some fuel-saving devices on the market, some claiming to have between 15-20 percent savings in fuel consumption. Whilst some have proven to be true in the short term in some respect, the use of the devices would require regular monitoring and strict maintenance schedule by the motoring public.

419. The state of the average vehicle on the Ghanaian road however, is difficult to project. The low salaries of most workers in the country mean that they can hardly support regular procurement of brand new vehicles. So a significant number of the vehicles on the market are used vehicles with refurbished engines. The state and age of the engines suggest they are operating at low efficiencies. Also, many motorists do not follow regular maintenance schedules. These circumstances do not allow the efficacy of these fuel efficiency devices to be realised over their life span.

Policy

420. It is recommended that

Government supports the promotion of fuel-efficient devices.

421. Implementation measures

- a) Regulatory institutions provide support in the form of public education and demonstrations to the motoring public.
- b) Support energy efficiency activities of the Energy Foundation.

The newer a vehicle, the more efficient it is

422. Technological advancement means that new or young vehicles tend to be more fuel-efficient than older and aged versions.

Policy

423. **It is recommended that**

- i. *Government supports reduction of import payments on new vehicles*
- ii. *Port clearance fee, where import costs increase with the age of the vehicle is encouraged.*

424. **Implementation measures**

- a) Limit importation of vehicles and engines older than 10 years.
- b) Re-look at the way import taxes and duties are imposed on vehicles.

Pollution control

425. With the withdrawal of leaded gasoline from circulation, adoption of other pollution control measures such as the use of catalytic converters for reduction of nitrogen oxides in engines in the country should be encouraged. Nitrogen oxides are precursors to ground-level ozone and are also acidic pollutants with the potential for acid rain.

426. Bicycle is a popular means of transport in northern Ghana, where the sun is relatively scorching compared to southern Ghana. Bicycle use is however relatively low in the south.

427. Elsewhere in the developed world, bicycle is the most popular means of transport on university campuses. This is however not common on the campuses of Ghana's tertiary institutions.

Policy

428. **It is recommended that**

- i. *Government through the regulatory institutions encourages the use of catalytic converters in vehicles by 2015 and adopt it legally by 2020.*
- ii. *Government supports the introduction of non-motorised vehicles on the campuses of the country's tertiary institutions.*

429. **Implementation measures**

- a) Encourage the use of bicycles on the campuses of the country's tertiary institutions.
- b) Support the university authorities to erect bicycle stands on the campuses.
- c) Set up credit schemes to allow students to purchase bicycles at affordable rates.

Rail

430. The sector ministry in the late 1990s sought to re-introduce the idea of bulk transportation of petroleum products inland, mainly by rail transport instead of road transport.
431. Rail transport in Ghana, even though it relies on diesel, is more fuel-efficient than road transport in medium to long distance freight haulage. Diesel consumption for rail transportation is on the average 15 percent lower than for road transport. Secondly, rail transport has a greater carrying capacity for both passenger and freight than road transport. Furthermore, the transportation of petroleum products by rail is much safer.
432. Thus, rehabilitating the rail sector and expanding the national coverage, particularly into remote and rural communities to make it more accessible to the rural poor could invariably reduce the nation's consumption of diesel fuel. The Government plans to modernise, improve and expand the country's railway system and make it safer and more attractive to both passengers and freight is highly commended.

Policy

433. **It is recommended that**
- i. *Government promotes the modal shift of bulk haulage from road back to rail transport.*
 - ii. *Government deregulates the railway subsector to permit private sector investment and participation in rail transport system.*

Maritime

Policy

434. **It is recommended that**
- i. *Government improves inland water transport from the south to north over the Volta Lake by removing physical obstacles posing risks to safe and smooth navigation.*
 - ii. *Government builds a pipeline from Debre to Buipe in the north to offset the interruption in fuel supply on the Volta Lake to the north which occurs during certain periods of the year.*
435. **Implementation measures**
- a) Government, public and the private sector support the VRA to continue to remove tree stumps in the Volta Lake in order to reduce risks to boat users and to improve movement on the lake.
 - b) Promote south-north transport over the lake for both commercial and recreational (tourist) purposes.

- c) Provide more ferries and build more landing points in major towns along the lake.
- d) Remove the Debre shoals that interrupt water transport during certain periods of the year.

Policy

436. **It is recommended that**

Government promotes the use of more efficient transportation modes by developing others such as boat transportation to coastal areas.

437. **Implementation measures**

- a. For instance, introducing ferry transport between Tema port to James Town of Accra for speedy connection to central Accra could be a novel pilot project. Other potential pilot projects could be Tema port or Accra James Town to Bortiano to link motorists from Tema or Accra central to Accra-Winneba Road bypassing vehicular downtown traffic. Or, Tema/Accra James Town port to Winneba port to allow bulk haulage road vehicles to bypass traffic jams in the city centre of Accra to join the Accra – Takoradi Road through Winneba, etc.
- b. It will however require building belting ports in the selected coastal towns.

Industrial Sector

Policy

438. It is recommended that

- i. Government through the regulatory bodies ensures that energy supply to the industrial sector is adequate, reliable and of acceptable quality to the industries.*
- ii. Government through the regulatory bodies ensure that energy audits are made mandatory for all formal industries.*
- iii. Energy efficiency and conservation measures in industries will continue to be supported.*
- iv. Government supports attractive feed-in tariffs to encourage industries capable of generating own or part of their energy especially from renewable sources such as biomass and wastes to do so.*

439. Implementation measures

- a) Energy Commission and the PURC ensure the utilities strictly comply with code of performance.
- b) Develop incentives for energy efficiency, e.g. the introduction of “time-use” electricity tariffs for industries.
- c) Develop protocol for energy auditing for the industries.
- d) Energy Commission and the Energy Foundation will jointly promote energy efficiency and conservation awareness programmes in industries.
- e) Set up revolving fund to provide training for Energy Managers for industries.
- f) PURC develops feed-in tariffs to encourage industries capable of generating own or part of their energy especially from renewable sources such as biomass or wastes to do so.

Policy

440. It is recommended that

Government supports environmental management practices and cleaner production methods in industries.

441. Implementation measures

Energy Commission, Energy Foundation and the Environmental Protection Agency coordinate on energy and environmental issues in industries.

Policy

442. **It is recommended that**

The Government ensures that primary industries are provided high quality but cost-effective energy services to induce high industrial growth for wealth creation in the country.

443. Implementation measures

- a) PURC and the utilities work out an electricity price range for sustainable operation of primary metal industries in the country.
- b) Offer price incentives only for underground gold mining and aluminium smelting. Utilities and the PURC provide price incentives to surface miners on condition that they will use it for deep mining only where the latter exists.
- c) For industrial power tariff:
 - i. An option is to dedicate all hydropower for industrial customers, whilst the thermal and other sources of power go to commercial and residential customers.
 - ii. Another option is to fix the proportion of energy mix for all the consumer classes (sectors). 'x' hydro + 'y' thermal is kept same for Residential, Commercial and Industrial customers. Where 'x+y=1'.

Energy Efficiency and Conservation

Policy

444. **It is recommended that**

- i. *Government continues to encourage the use of efficient end-use appliances such as compact fluorescent lamps as well as good energy savings practices in the home, at work places and industries.*
- ii. *Energy Commission makes available the necessary regulations for the safety of household energy appliances.*
- iii. *Government supports promotion of solar water heating and drying for demand-side management.*

445. Implementation measures

- a) Adopt energy demand management in middle and high-income households.
- b) Government supports Energy Commission to extend the Energy Efficiency labelling to cover other home and commercial appliances notably; refrigerators, freezers, electric fans and television sets.

- c) Government continues to support Energy Foundation in its energy efficiency and conservation measures in institutional buildings, ministries, government departments and agencies, barracks, etc.
- d) Set up a special purpose fund; an Energy Efficiency Revolving Fund. The objective is to offer low interest credit facility for energy efficiency improvements (retrofits), targeting industries and service entities such as hotels and restaurants.
- e) Sustain the Public Education and Information Programme campaign activities of Energy Foundation.
- f) Encourage training of industrial energy managers for local industries and for countries within the sub-region, particularly, under the ECOWAS protocol.

Policy

446. It is recommended that

- i. *Government enacts an Energy Efficiency and Conservation Act to make it mandatory for industries in the formal sector, all grades of hotels and commercial guesthouses to adopt energy management practices and building codes and carry out routine energy audits in their facilities.*
- ii. *Government makes it mandatory for all equipment bought for government facilities and public educational institutions to meet minimum energy efficiency standards/specifications, set by the Ghana Standard Board.*
- iii. *Government supports instituting Energy Management practices in government buildings and facilities including public educational institutions and vehicular fleets.*

447. Implementation measures

- a) The Ghana Standards Board, in collaboration with the Energy Commission and all other appropriate agencies develop and establish minimum energy efficiency standards and labels for energy consuming appliances imported or manufactured for use in Ghana. These include lighting, air conditioners, refrigerators and deep freezers, industrial electric motors.
- b) Encourage private sector Energy Service Companies (ESCOs) to invest in upgrading energy consuming facilities and share in the cost savings accruing from lower energy bills. This would help enhance the adoption of energy efficiency practices and technologies by the entire public.
- c) Government helps by providing tax incentives to financiers of energy efficiency projects and dealers in energy efficiency devices and appliances.
- d) PURC introduces tie-in tariffs to help promote Combined Heat and Power Production (co-generation).

- e) Energy Commission helps to intensify capacity building of Energy Service professionals both at the formal and informal levels to produce the required expertise needed for building an energy efficient economy.
- f) Energy Foundation and the Energy Commission intensify public education on Energy Efficiency strategies and practices. Include the existing formal and informal educational structures of the education sector ministry and the local government.
- g) Government supports Energy Foundation and the Energy Commission to set up a network of local energy advisory units in the district assemblies to advise consumers on energy efficient technologies and practices.

APPENDICES

APPENDIX 1 THE INSTITUTIONAL SET-UP OF THE ENERGY SECTOR

The energy sector comprises the following agencies⁹⁶:

- i. The Ministry of Energy is responsible for energy administration and supervision of all the sector entities.
- ii. The Volta River Authority (VRA) is a state-owned power generation utility. It used to own the national transmission network as well but that has been separated from its functions by act of parliament since 2006⁹⁷.
- iii. The Electricity Company of Ghana (ECG) is the power distribution company responsible for southern Ghana, namely Ashanti, Central, Greater Accra, Eastern and Volta Regions of Ghana. As of now, it is a public limited liability company fully owned by the government.
- iv. Northern Electrification Department (NED) is a department of VRA and is responsible for power distribution in northern Ghana namely, Brong-Ahafo, Northern, Upper East and Upper West Regions. Under the Power Sector Reform programme, NED and ECG are proposed to be merged into a single entity for power distribution.
- v. Ghana National Petroleum Company (GNPC) is responsible for oil and gas exploration. It is also the regulator for the petroleum upstream activities.
- vi. Tema Oil Refinery (TOR) is the only refinery in the country. It is also responsible for primary distribution of petroleum fuels.
- vii. Oil Marketing Companies (OMCs) are responsible for secondary distribution and retailing of petroleum products. The companies are licensed by the national regulator – National Petroleum Authority (NPA).
- viii. GOIL is the only government owned oil-marketing company.
- ix. There is an Industrial coordinator who acts as the spokesperson for the OMCs and as well liaises between the OMCs, the regulatory agencies and the Ministry of Energy.
- x. Bulk Oil Storage and Transportation Company (BOST) is responsible for planning and management of strategic stocks of petroleum products.
- xi. The Energy Foundation, a Ministry of Energy – Private Enterprises Foundation initiative, was set up in 1997 to promote energy efficiency and conservation programmes. Besides the Ministry and the PEF, funding for their initial activities was provided by the World Bank and the USAID⁹⁸ The Energy Foundation currently finances its activities by providing commercial services as well as soliciting for support from both the Government of Ghana and the donor community.
- xii. The three regulatory agencies in the energy sector are the Public Utility Regulatory Commission (PURC), Energy Commission and the National Petroleum Authority (NPA)

⁹⁶ as at the time of publication of this document

⁹⁷ VRA is still operating the transmission network as new rules of operation are being worked out by the Energy Commission, the technical regulator.

⁹⁸ United States Agency for International Development

APPENDIX 2: THE ENERGY SECTOR REGULATORY AGENCIES

PURC	The Public Utility and Regulatory Commission (PURC) was established by the PURC Act which came into effect in 1997. It is as an independent body to regulate and oversee the provision of utility services by the public utilities to consumers. Its present jurisdiction covers settings of tariffs for the supply, transmission and distribution of electricity and water ⁹⁹ Natural gas regulation is the latest to be included.
Energy Commission	The Energy Commission Act came into effect in 1997. The Energy Commission (EC) has the mandate to regulate the technical operations of all energy service companies through licensing and monitoring with the exception of those in the Petroleum subsector, ¹⁰⁰ Akosombo hydroelectric dam is also excluded under the EC Act. The Energy Commission also provide advisory role in the area of planning and policy to the sector ministry.
National Petroleum Authority	Formed under Act 691, 2005, the National Petroleum Authority (NPA) regulates all the downstream operations of the Petroleum subsector. Its activities include coordinating the procurement of crude oil, products as well as monitoring the daily changes in parameters making up the petroleum pricing formula.

⁹⁹ PURC website is www.purc.com.gh

¹⁰⁰ Energy Commission regulated all energy service companies in the country till July, 2005 when the petroleum subsector activities were legally farmed out to NPA.

APPENDIX 3: COMPARATIVE ADVANTAGES OF THE IMPORTED FUELS

Parameter	Natural gas	RFO	Coal	Nuclear fuel
Most possible Market sources	Nigeria via the WAGP La Cote d'Ivoire	Open market	Nigeria South Africa	United Kingdom, US
Size of the source by 2020	176 trillion cubic feet in Nigeria	Relatively infinite	Relatively infinite	Relatively infinite
Reliability of source	Moderate to High. It is Moderate due to seemingly chronic communal unrest in the Niger delta. It is High is unrest ends.	High	Very high But not a much fancied fuel for environmental reasons	Restricted. Can be halted should there be some suspicion of diversion for weapon development or shipment to a third party.
Nature of fuel supply contracts	Long term	Usually short – medium term	Usually medium to long term. Short term also exist.	Short term and subject to regular review.
Price volatility	Stable	Stable	Very stable	Very stable
Transportation of fuel	Via pipeline, limited amount as LNG ¹⁰¹ . by ship	Ocean tankers	Ocean barges	Highly specialised ships
Storage of fuel	Not possible in large amounts. Limited amounts stored as LNG.	Easy; - liquid in tanks; some security required.	The easiest – solids; requires less security; Not easily inflamed	Easy to store but requires maximum security
Multiple or single supplier	Multiple supplier if the WAGP and future potential supply from la Cote d'Ivoire is considered.	Varied from single to multiple.	Varied from single to multiple.	Usually single supplier but highly regulated.

¹⁰¹ Liquefied Natural Gas

APPENDIX 4: LIST OF PARTICIPANTS

LIST OF INSTITUTIONS REPRESENTED AT THE STAKEHOLDER MEETINGS ¹⁰²			
	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 Cmmtee. 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
	•		
	0		
	<i>Attended</i>		
	<i>Absent</i>		

¹⁰² 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	•	•	•
	•			
	0	<i>Attended</i>		
		<i>Absent</i>		
Note	Names of experts attending in their individual capacities are not included here but available at the Energy Commission			

APPENDIX 5. MAJOR COMMITTEES DURING THE SNEP PROCESS ¹⁰³

	<u>Steering Committee</u>
1.	Ministry of Finance
2.	Ministry of Energy
3.	Energy Commission
4.	Royal Danish Embassy (<i>sponsor of SNEP as of 2003</i>)
5.	RAMBOLL Consultancy (<i>Secretary</i>)
	<u>Technical Committee</u>
1.	Ministry of Energy
2.	Ministry of Land and Forestry
3.	Ministry of Trade and Industry
4.	Ministry of Food and Agriculture
5.	Ministry of Roads and Transport
6.	National Development Planning Commission
7.	Public Utilities Regulatory Authority
8.	Minerals Commission
9.	Environmental Protection Agency
10.	Ghana Statistical Services
11.	Energy Foundation
12.	Volta River Authority
13.	Electricity Company of Ghana
14.	Ghana National Petroleum Corporation
15.	Tema Oil Refinery
16.	Ghana Chamber of Mines
17.	Association of Ghana Industries
18.	Dept. of Geography & Resource Development, University of Ghana
19.	Institute of Statistical, Social & Economic Research (ISSER)
20.	Energy Research Group
21.	Private Enterprise Foundation

¹⁰³ As of April 2003, when Danish Support ended and the contract with Ramboll was not renewed. Names of persons representing the institutions are 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 Atta 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 Laboratory¹⁰⁴, Denmark, 1997)

A teaching material on energy efficiency, end-use analysis, demand-side management and integrated resource planning (IRP).

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 www.npa.gov.gh.

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