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(*) This paper is part of an on-going research on this subject. Please send any comments you may have to *john.turkson@risoe.dk*

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Preface

The African continent has not been spared by the electric utility industry reform sweeping across the globe. The electric utility industries in most countries in the region are confronted by the twin-problem of deficient capacity and lack of adequate financial resources to undertake capacity expansion of their respective systems. The critical aspects of the reform are the shift away from state-owned monopoly model towards private sector participation and some competition in the industry.

Hydropower plants dominate power systems in most countries in the region. Ghana, which is the focus of this study, has such characteristics. The hydrology of the river on which the two dams (Akosombo and Kpong hydropower plants) are built is increasingly becoming uncertain, and besides, the power output from the two plants is insufficient to meet the increasing electricity demand of the country. The alternative is to build thermal power plants to complement the two hydropower plants.

The purpose of the study is to assess the environmental (more specifically air pollution) implications of changing fuel mix in power generation in Ghana within the context of the ongoing reform of the power sector.

The study describes the structure of the power sector and the state of electricity production. It discusses the different factors that affect demand for electricity in the country and the spatial dimension of electricity demand. It also presents a general description of environmental issues of the sector. The study then presents a more quantitative analysis of the potential levels of certain air pollutants – CO_2, SO_2 and NO_X – that would result from changes in fuel mix for electricity generation. Using different capacity expansion options proposed for the Volta River Authority (VRA) between 1997-2013, the levels of these air pollutants are estimated for this period under four scenarios referred to as: High (demand) growth, Base (demand) growth, Low (demand) growth and hydropower-electricity imports. The first three scenarios are made up of combinations of hydropower, natural gas and distillate oil fuelled plants and the last with more emphasis on hydro and import of electricity at different points in time. As expected, the levels of these three gases under all the four scenarios.

The study then examines the different environmental policies for dealing with air, water and land pollution under command-and-control regime and market-based or economic instruments, and the requirements for successful implementation of any or combinations of these measures. Finally, institutional assessment is made to determine the strengths and weaknesses of the existing institutions mandated by law to deal with various environmental issues, and how equipped they are to regulate the environmental pollution associated with the emerging power generation mix in the country.

The study concludes that the emerging power generation mix would increase the CO_2, SO_2 and NO_X emission levels and other environmental effects in the country, and strategies for reduction in air and other environmental pollution associated with power generation must be integral part of the design of power plants. When considered late, air quality improvement programmes may not be accorded the priority they deserve since they would be competing with other priority programmes such as housing, medical care and general economic development programmes.

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Abbreviations

AGI	Association of Ghanaian Industries
CEB	Communauté Eléctrique du Benin
CIE	Compagnie Ivoirienne d'Electricité
CO_2	Carbon Dioxide
CSIR	Council for Scientific and Industrial Research
DA	District Assembly
ECG	Electricity Corporation of Ghana
EECI	Energie Eléctrique de la Côte d'Ivoire
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EP	Environmental Permit
EPA	Environmental Protection Agency
EPC	Environmental Protection Council
ERP	Economic Recovery Programme
GDP	Gross Domestic Product
GEPC	Ghana Export Promotion Council
GHG	Greenhouse gas
GNP	Gross National Product
GNPC	Ghana National Petroleum Corporation
GOG	Government of Ghana
GWh	Gigawatt hour
IPP	Independent Power Producers
kV	Kilovolt
kVA	Kilovolt Ampere
KW	Kilowatt
kWh	Kilowatt hour
MEST	Ministry of Environment, Science and Technology
MOME	Ministry of Mines and Energy
MW	Megawatt
NDPC	National Development Planning Commission
NDPF	National Development Policy Framework
NED	Northern Electricity Department
NEP	National Electricity Plan
NES	National Electrification Scheme
NLCD	National Liberation Council Decree
NOx	Nitrogen Oxide
NRCD	National Redemption Council Decree
PER	Preliminary Environmental Report
PURC	Public Utility Regulatory Commission
PWD	Public Works Department
RCC	Regional Co-ordinating Council
ROW	Right of Way
SHEP	Self Help Electrification Programme
SO_2	Sulphur Dioxide
TOE	Tons of Oil Equivalent
USA	United States of America
VALCO	Volta Aluminium Company
VRA	Volta River Authority
NEC	National Energy Commission

Part 1

Background: Economy, Energy and the Environment

1 Introduction

1.1 Background and Context

Over the past several years, pressure has been increasing throughout the world for fundamental changes to the structure of the electric power sector. Once regarded as a natural monopoly and a critical “national security” sector best suited for state ownership, the power sector has been undergoing a transformation. There is a consensus that power sectors in most African countries have been performing badly (Gutierrez, 1995). The causes include poor management, government interference in daily operations and investment and pricing decisions, and opaque regulatory systems. These and other factors such as the economic crises facing many countries in Africa and lack of capital to invest in rehabilitation and expansion of the power systems are putting pressure on governments in the region to reform their power sectors.

Restructuring of the electric power sector can take different forms, varying both in terms of degree of private sector participation and in terms of degree of unbundling (splitting vertically integrated monopolies into separate generation, transmission and distribution entities) and extent of market forces operating in the electricity market. In some countries, the government-owned monopoly structure has been fundamentally maintained, but utilities’ ownership has been transferred to the private sector and/or independent power producers (IPPs) have been invited to construct new power plants and sell their power to the state monopoly.

Regardless of the model used, the fundamental objective of electric power sector restructuring has been the same in all countries: to improve the efficiency performance of the industry. Thus far, the process of the reform has focused on institutional aspects, including restructuring, ownership changes, regulatory changes and competition. However, power sector reform can also have other unintended consequences not always envisioned by the promoters of reform. Environmental considerations and social issues are two areas in which the effects of power sector reform may be particularly significant.

The power sector in Ghana is partially vertically integrated. Power is generated and transmitted by one state-owned company and distributed by two state-owned companies. The Government of Ghana has decided to reform the power supply industry; and the framework for reform and the proposed industry structure has been approved. The reform in the power sector envisages the separation of the generation and transmission functions, and a competitive generation segment of the industry. The transmission system will be a limited liability company and the country will be divided into power distribution concession areas, which will allow private sector participation. This industry structure will encourage competition at the generation level and open access to the transmission network. With the setting up of the Public Utility Regulatory Commission (PURC), the reform of the power sector has been set in motion. Where electricity systems have been operating as closed monopolies, the effect of the Electricity Act (1997) will be to allow gradually increasing access, both for electricity users (mainly big consumers) and independent electricity generators. Considering the fact that the identified hydro potential of the country is insufficient to satisfy projected future needs there is a movement from an essentially hydro-based power generation system to a mix of hydro- and thermal- based systems.

The introduction of fossil fuel-based generation has its environmental ramifications with which the country has no experience in dealing.

1.2 Study objectives and scope

The reform of the power sector in Ghana seeks, among others, to reform the way electricity services are provided, and to provide an environment that would attract the private sector to participate in the sector. Decisions made in the sector that affect the environment include the choice of generation technologies and fuel; operations and maintenance practices, investments in transmission and distribution systems, tariff structure, and investment in end-use efficiency. The main objectives of the study are:

(i) to analyse the likely implications for the environment of changes in fuel mix for power generation, and

(ii) to evaluate strategies (including identification of alternative environmental regulatory tools/instruments for the industry) to minimise negative environmental impacts of power sector restructuring.

While there are different environmental ramifications associated with changes in the fuel mix of power generation such as air, water, soil pollution and emissions of other pollutants, this study focuses on some air pollutants. It can be argued that with the increasing trend in electricity demand in the country, thermal additions to the two hydro plants and the resultant environmental impact are inevitable whether the power sector is reformed or not. This is a valid argument and the environmental consequences of such thermal additions would merit study irrespective of power sector reform. The issue of reform of the power sector and its environmental protection implications is worthy of investigation to the extent that electricity prices will be rationalised to reflect the cost of supply. This, it is contended in this study, will affect demand for electricity, and consequently will affect which type, how much and when capacity will have to be added to the system. The environmental consequences will thus increasingly be determined by such considerations.

1.3 Analytical Approach to Study

In pursuing these objectives, the study adopts both qualitative and quantitative approaches to studying the issues raised. The qualitative approach is used to describe the background to the study - macroeconomic situation and the power sector structure and performance. An assessment of public policies on electricity generation, transmission and distribution; regulatory instruments on environmental protection is made. The strengths and weaknesses of current environmental protection laws/regulatory instruments with respect to the power sector; and their adequacy in dealing with the environmental consequences of the envisaged electric utility industry structure are then examined.

The impacts on the environment that could result from the reform of the power sector are uncertain. Accordingly, a quantitative approach based on different scenarios has been used. In this approach, alternative views of the future are postulated and analysed. The potential environmental impacts of air pollutants such as carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxides (NO_X) are estimated under different scenarios. A spreadsheet model is used to estimate the levels of these air pollutants over the period used for the study (1997-2011). As base case in the scenario analysis the future of the electric utility industry and environmental conditions without the price reform are examined. This presupposes a generation plan of thermal plant complementation to the existing hydro plants. The second step is to examine the future impact assuming (i) an high growth rate for electricity demand with fossil-fired plants with no new hydro plants; (ii) low growth rate for electricity demand with fossil fuel-fired plants with no new hydro plants; (iii) new hydro plants, import of electricity and fewer fossil-fired plants; (iv) base case with only oil-fired plants. These will be followed by a description and analysis of other types of pollution associated with changes in the power generation landscape.

1.4 Organisation of Study

The study is organised in three parts. Part 1 deals with the background while Part 2 takes up the issue of the power sector and the environment. In the final part, Part 3, issues essential for mitigating the environmental impacts of the power sector reform are considered.

The current chapter, Chapter 1, lays out the background to and objectives of the study. Chapter 2 gives an overview of the economy of Ghana – past and present performance.

In Chapter 3 the authors examine in some detail the evolution of the electric power industry in Ghana. Chapter 4, examines the general environmental and other effects of the power sector in relation to further hydro-power plant development, thermal plants, transmission lines and distribution networks and Chapter 5 presents the core of the study where the authors estimate the CO_2, SO_2 and NO_X level under different scenarios.

Chapter 6 assesses the capacity of the existing environmental regulatory framework and Chapter 7 draws together the main findings, conclusions and recommendations and identifies areas for further action and research.

2 Overview of Economic and Energy Situation in Ghana

2.1 Macro-economic context

Ghana is predominantly an agricultural country. Agriculture accounts for over 41% of gross domestic product (GDP), 50% of export earnings and 70% of employment. The most important product is cocoa, which occupies 25% of cultivated land and accounts for 20% of employment. Until recently, it also was the largest single source of export earnings, after gold. From 1992, the mineral sector overtook cocoa as the number one foreign exchange earner.

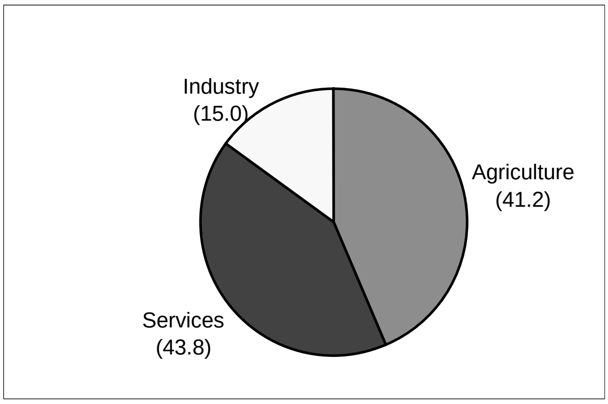
In the early 1980s the Ghanaian economy almost totally collapsed. Economic growth stagnated throughout the 1970s. This has largely been attributed to economic mismanagement and low commodity prices of the main exports of the country. The GDP fell by 20% from 1980 to 1983. Inflation rose to 123% per annum, having averaged 70% between 1976 and 1982. Merchandise exports fell consistently from 1970, including a 60% decline in the early 1980s, largely due to the collapse of the cocoa sector. Export earnings fell from 20% of GDP in 1975 to 6% in 1983. Similarly, imports had fallen by 20% since 1971.

Consumption declined but the proportion of consumption as a percentage of GDP rose from 74% in 1975 to 94% in 1983. This reflected the contraction of savings and investment in the economy. By 1983, foreign exchange was nearly depleted and investment had fallen to a mere 4% of GDP, barely sufficient to replace the depreciated capital stock. Communication and transport systems had almost broken down completely. Due to the lack of imported inputs, capacity utilisation in industry fell to less than 20%. Social facilities and services including schools, hospitals and clinics were in a very bad state of repair.

Improved Economic Management

In 1983, a broad based sequence of reforms known as the Economic Recovery Program (ERP), was undertaken, in order to overcome the fundamental problems in the Ghanaian economy. These reforms were overall able to stop the decline in the economy. The ERP enabled Ghana to reverse significantly the adverse economic and social conditions in the country and to put the country back on a path of moderate economic growth averaging about 5% per annum over the last 14 years (GOG, 1997).

Growth was recorded in almost all the economic sectors and sub-sectors especially over the period beginning from the early- to mid-nineties. The service sector is the largest and also the fastest growing sector (See Figure 2.1 and Table 2.1)



Source GOG: From Economic Recovery To Accelerated Growth, 1995

Figure 2.1. Sector Contribution to GDP (%)

Table 2.1. Growth of Sectors (% per annum)

Service Sector	**1991**	**1992**	**1993**	**1994**	**1995**
Transport, Storage & Communication	6.4	8.5	7.3	6.1	4.2
Trade, Restaurants & Hotels	8.5	10.1	8.2	5.5	6.5
Finance, Insurance & Real Estate	5.5	6.5	6.0	4.0	3.0
Government Services	1.3	8.0	7.4	5.1	5.0
Other Services	1.8	2.7	2.9	2.8	2.8
Total Service	**5.2**	**8.2**	**7.2**	**5.0**	**4.9**
Industry Sector					
Mining and Quarrying	6.7	104	9.1	5.1	5.5
Manufacturing	1.1	3.5	4.0	1.5	1.8
Electricity and Water	7.9	12.0	8.2	5.3	6.0
Construction	9.1	10.1	6.3	4.2	5.2
Total Industry	**3.7**	**6.2**	**5.4**	**2.8**	**3.3**
Agricultural Sector					
Crops and Livestock	4.8	-0.7	3.0	0.9	3.1
Cocoa Production & Marketing	13.9	-7.2	0.1	12.2	11.1
Forestry & Logging	2.1	3.3	1.2	1.8	2.0
Fishing	1.4	2.0	2.4	1.2	1.6
Total Agriculture	**5.8**	**-1.2**	**2.3**	**2.7**	**4.2**

Source: GOG Vision 2020, The First Medium-Term Development Plan (1997-2000)

The industrial sector was able to make a turnaround and achieve some growth as indicated in Table 2.1. Manufacturing growth, however, has been the slowest in the sector. Improvements in agricultural production were achieved but the sector continued to be troubled by weather conditions. For instance after impressive growth in 1991, the sector went into a decline due to crop and livestock failure, and a greater failure in cocoa production as depicted in Table 2.1.

2.2 Prospects for Future Economic Growth

The National Development Planning Commission (NDPC), was established to co-ordinate new national development planning efforts to achieve growth and prosperity in Ghana. As a first step, the NDPC prepared a long-term perspective: the National Development Policy Framework (NDPF). The framework, renamed Ghana Vision-2020 shows the strategic direction of national policy over a 25-year period from 1996. The main aim of implementing such a framework is to transform Ghana from a poor, underdeveloped, low -income country into a vibrant, prosperous middle-income country within a generation. The NDPF has been the basis for the preparation of national, sectoral, and district five-year medium-term rolling plans. Realisation of this vision will strongly depend on how credible implementation strategies are drawn up and how committed the government will be to them. In the next sub-sections we examine the general implications of the national perspective.

Savings and Investment

An aggregate domestic saving in 1995 was12.7% of GNP. Table 2.2 shows an overall upward trend in private domestic savings. The government's target is to achieve a level of 17.9% of gross national product (GNP) as gross investment in the year 2000. The largest part of foreign direct investment is in the mining and mineral sector. It is the government's fiscal and monetary policy to attract foreign direct investment especially into manufacturing and agriculture. It has been projected that by the year 2000 gross domestic investment must be over 22% of GNP (GOG, 1997).

Table 2.2. Savings and Investment as a Proportion of GNP

	1991	1992	1993	1994	1995
Gross Domestic Investment	14.2	14.8	17.1	17.5	17.1
of which: Private	10.3	9.8	11.5	11.1	10.8
Gross Domestic Savings	9.9	8.2	8.8	10.3	12.7
of which: Private	9.4	7.9	8.5	9.7	11.8
Foreign Savings	4.2	6.6	8.3	7.2	4.5
Foreign Savings as % Gross Investment	29.9	40.5	48.7	41.1	26.0

Source: Ghana Statistical Service, Quoted in GOG, 1997

Private investment is held to be the engine of growth. In 1991, private investment was only 8% of GDP. Investment rates of 25-30% of GDP are necessary to achieve a growth rate of 8-10% per annum that has become the target for the country. Private investment must increase to 10-20% of GDP. Public investment, also around 8% in 1991, may increase slightly to 10% GDP.

Agriculture and Industry

Export growth was the key feature of the fast growing economies of Southeast Asia (until the recent recession). Much evidence elsewhere supports the view that exports are vital for rapid growth. Non-traditional exports comprise a large range of agricultural products such as pepper, pineapple and banana, but most of these are still in very small quantities.

Growth in agricultural production generally has been very slow at an average rate of 2% or less. The sector continues to be at the mercy of the weather. In 1995, the sector grew at 4.2% and it is expected that higher growth will be achieved in response to government programmes outlined in the medium term plan. Some of these include the development of small scale community based valley bottom irrigation facilities to raise land under irrigation from 10,000 hectares to 17,000 hectares, reduction of cocoa export taxes, improving the availability of input supplies by government to increase farmers' access to smallholder credit, inputs supplies and marketing facilities.

A number of programme activities have also been lined up for ensuring manufacturing growth. The re-organised and strengthened investment promotion agency, the establishment of an industrial processing zone, expansion of the rural electrification programme in support of agro-processing, the review of national laws, regulations and tax policies to minimise costs to manufacturers have been some of the measures the government has initiated to promote industrial development, particularly in the manufacturing sector.

Other sector activities

Many other policies and programmes have been defined by the government under it medium and long term programmes. All these are meant to enable Ghana fulfil her development themes of human development, economic growth, rural development urban development and the creation of an enabling environment for sustained economic development.

2.3 Energy Sector

The upturn in Ghana's economic performance since the late 1980s, the potential for sustained economic growth and the government's National Electrification Programme has major implications for energy supply, particularly electricity supply. In order to meet the growing demand for electricity the building of new generation plants - hydro or thermal or both is required. The construction of a thermal plant with a potential installed capacity of 330MW is nearing completion with 220MW already in place. This plant is the first of a few thermal plants planned to be built in the country. This option to meet the growing electricity demand has environmental implications - the extent of pollutants to be emitted depends on the fuel choice (oil, natural gas or coal) in the thermal plants.

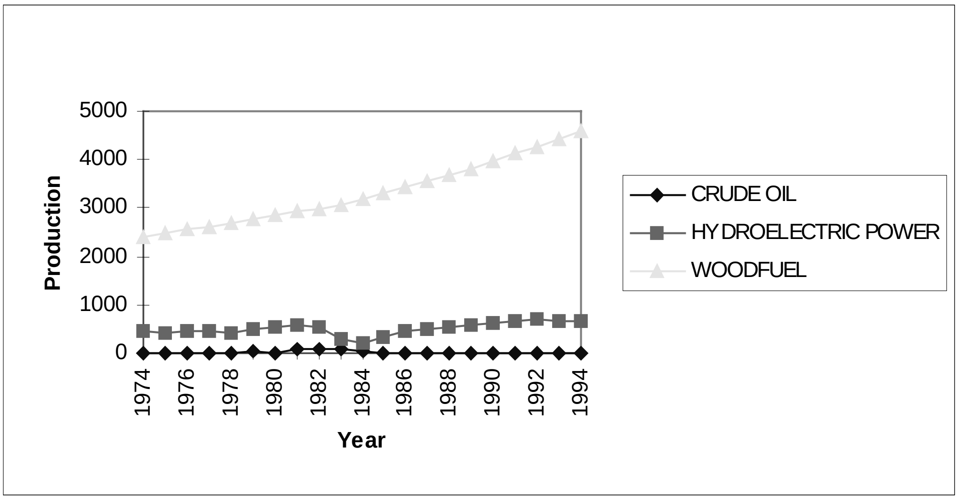
Energy Production

Ghana obtains energy for her needs from three main sources: electricity, petroleum products and woodfuels. Figure 2.2 shows the production levels of these forms of energy from 1974 to 1994. In absolute terms, energy production has grown from a total of 2848.08 tons of oil equivalent (toe) in 1974 to 5259.35 toe in 1994.

Electricity is the second most important source of commercial energy in Ghana. Production has been fairly constant from the early 1970s to almost the end of that decade. Production picked up in the late 1970s till 1981. Growth in production slowed considerably in 1982 and declined sharply in 1983 due to drought conditions, which hit the West African Region affecting the water levels of the hydroelectric power dams. The curtailment of the country's electricity generation and supply sharply focused attention on the fragility of the electric energy production in Ghana. The almost total dependence on hydroelectric power is, to say the least, highly unstable and unsatisfactory.

Petroleum production from national sources is negligible. In the 20-year period, production occurred only in seven years in varying quantities from 12.04 toe to 68.06 toe. The bulk of petroleum products in Ghana are imported. However, petroleum remains the most important source of commercial energy in Ghana.

Woodfuel is by far the largest source of energy in Ghana. Production levels are between five to seven times that of hydroelectric power. Woodfuel is made up of firewood and charcoal. Though potentially a renewable resource, future supply will be constrained by environmental degradation. Already, there is a worsening of the deforestation and desertification.

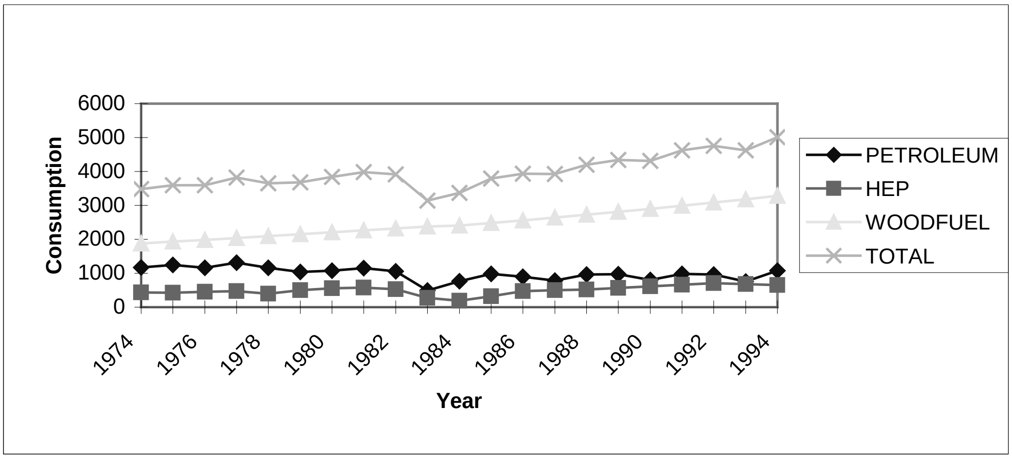


Source: Ministry of Mines and Energy, National Energy Statistics, 1995

Figure 2.2. Production of Energy by Source (in 1000 toe)

Energy Consumption

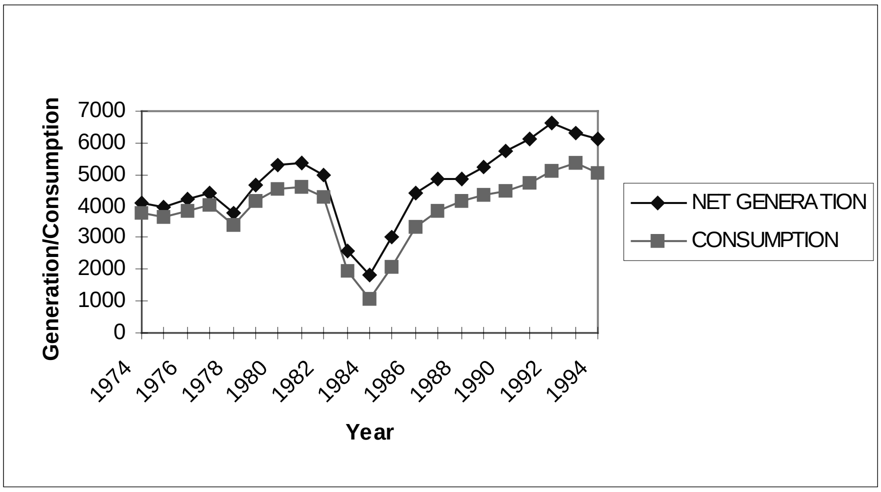
Energy consumption does not follow the pattern of production as shown in Figure 2.3. While electric power production is greater than that of petroleum in Ghana, its consumption is much less. Ghana's petroleum needs are met by imports. Woodfuel consumption is 69% of total energy consumed. Electricity and petroleum products account for 10 and 21% respectively (VRA, 1992). Electricity consumption has been growing at 13% per annum since 1991.



Source: Ministry of Mines and Energy, National Energy Statistics, 1995

Figure 2.3. Consumption of Energy by Source (in 1000 toe)

Figure 2.4 shows the generation and consumption of electric power in Ghana. Most part electricity consumed in Ghana is generated internally. Between 1974 and 1983, exports had been more steady than imports of power into Ghana. The turning point was 1992, when the first imports occurred due to severe drought conditions that affected the level of water in the dams of the Volta Basin.

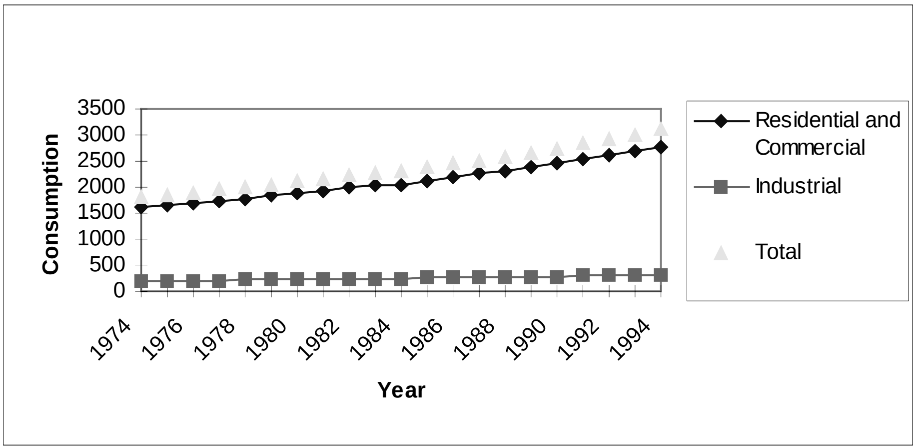


Source: Ministry of Mines and Energy, National Energy Statistics, 1995

Figure 2.4. Historical development of Electricity Generation & Consumption (GWh)

There is a predominance of hydroelectric power generation in the country. The drought situation referred to above has raised serious concern over this over reliance on such a source. The strategic internal solution has been the focus on diversifying power sources to include thermal, using gas and oil, and renewables such as solar, biomass and biogas. Thermal electricity production began in November 1997 in Takoradi with an initial output of 220MW.

Woodfuels are Ghana’s primary source of energy (see Figure 2.5). Most of it is used for residential and commercial purposes. With economic growth, both residential and commercial uses of woodfuels are expected to decline as more people and industries substitute woodfuel with cleaner fuels such as liquefied petroleum gas (LPG) and electricity. This will, however, not come too soon.



Source: Ministry of Mines and Energy, National Energy Statistics, 1995

Figure 2.5. Consumption of Woodfuels by Sector (1000 toe)

2.4 Environmental Issues

Meeting energy requirements for economic development has its environmental consequences. Until recently various attempts of looking at the environmental effects of Ghana's economic development have focused primarily on the environmental impacts of hydro plants and to a limited extent of mining, agriculture and the timber industry. The environmental impact of the two hydro plants have been studied extensively (GOG, 1989; Diaw and Schmidt-Kallert, 1990; Tamakloe, 1994). The major problems relate to the displacement of 80,000 people from 700 settlements, and the spreading of schistosomiasis. Similarly, studies have been done to assess the rate of deforestation resulting from agricultural practices and logging of timber (Nsiah-Gyabaah,1994; Vincent and Binkely 1992). There are other equally significant environmental concerns, which have not been studied in detail such as urban waste management and local and regional air pollution.

Regarding air quality in Ghana, no systematic assessment of ambient air quality has been carried out besides those undertaken for Tema and Obuasi. As such, relatively little is known about air quality in various settlements. The major industrial and commercial cities of Accra, Sekondi/Takoradi and Kumasi may already have problems in the quality of their air. A similar situation may exist for mining towns such as Tarkwa, Konongo, Bibiani and others. Fossil fuel-based electric power plants will add to air pollution. Furthermore, acid rain, which is another environmental problem associated with fossil fuel combustion, is not known to be a serious environmental issue in the West Africa region.

In 1994, the Environmental Protection Agency (EPA) undertook a study to assess greenhouse gas (GHG) emissions from major sectors of the Ghanaian economy including agriculture, energy, mining, industry and waste.

The figures for 1990 and estimates for 2000 in the study shows that GHG emissions in Ghana will grow at 3.5% 4% and 9.7% for CO_2, CO and N_2O respectively (SEI, 1994). Table 2.3 shows the absolute levels of these GHG emissions(giga grams)

Table 2.3. GHG Emissions by Sector in Ghana (Giga grams)

Sector	1990			1995			2000		
	CO_2	CO	CH_4	CO_2	CO	CH_4	CO_2	CO	CH_4
Energy	13,489	418.1	61.4	14650	489.8	73.8	16,823	549.7	88
Industry	1,920	50		1920	50		1,920	50	
Agriculture	14,290	585	962,9	18,160	747	1,526.6	23,195	955	2,554.9
Waste	84		54.4	97		62.3	112.4		71.5
Total	**29,783**	**1,054**	**1,029**	**34,827**	**1,294**	**1,597**	**42,054**	**1,554.7**	**26,34.5**

Source: Climate Change in Africa: Country Report, Ghana, SEI, 1994

The figures presented above indicate a rising trend in carbon dioxide (CO_2), carbon monoxide (CO) and methane (CH_4) emissions. The energy sub-sector does not include thermal power complementation that has been planned by the VRA. This issue will be taken up in more detail in Chapter 5 when a model is developed to determine some air pollutants and other pollutants from thermal complementation of electric power generation in the country.

Part 2

The Power Sector and the Environment

3 Electric Power Supply Industry in Ghana

3.1 Institutions in the Power Supply Industry

Electric power supply development has largely been in the public sector since the pre-independence times when the Public Works Department (PWD) was in charge of electricity generation in few urban centres and mining towns.

The power sector is made up of a number of institutions. At the apex is the Ministry of Mines and Energy (MOME). The others include: Volta River Authority (VRA), Electricity Company of Ghana (ECG), the Northern Electricity Department, (NED), which is a subsidiary of VRA, Ghana National Petroleum Corporation (GNPC), the Public Utilities Regulatory Commission (PURC) and the National Energy Commission (NEC)

The Ministry of Mines and Energy

Currently, the Ministry of Mines and Energy is the lead institution with responsibility for the totality of the energy sector, including electric power. Its key role is the formulation of policy, co-ordination and monitoring of policy implementation. Prior to its new designation, the ministry had been known as the Ministry of Fuel and Power (MFP). Under MFP was a board, the National Energy Board that performed the functions that have now been largely transferred to the MOME. The board was established in recognition of the weakness of the MFP as a civil service bureaucracy and in response of the need to strengthen the energy sector institutional framework.

The Volta River Authority

The Volta River Authority was established in 1961 under the Volta Development Act, (Act 46 of 1961). It is a state owned corporation required to operate on sound commercial lines. The main purpose of the VRA was to develop, generate, transmit and sell hydroelectric power from a dam constructed on the Volta River at Akosombo to meet industrial, commercial and domestic needs. Power generation was to rely on the potential of the Volta River. It was empowered to generate electricity afterward by any means deemed appropriate.

The first VRA power project was completed in February 1966. Two power generating units with installed capacity of 294 MW were commissioned. Akosombo began commercial operation in September 1966. By the end of 1966, the capacity had risen to 588 MW, increasing to 912 in 1972. In 1975, the VRA completed and commissioned a 160 MW hydroelectric plant at Kpong. The total available capacity rose to 1072 MW by 1975.

In November 1997, the VRA completed part of a combined-cycle-generating turbine power plant at Takoradi. This brought on-line 220 MW of electric power. Another 110 MW of power will be available by the end of 1998. The balance of power supply is expected to be available in phases, which will be completed by 1999. In addition to the thermal plant development, VRA is advancing plans to construct another hydroelectric plant on the Bui River. Capacity generation from this plant will be about 400 MW.

Ghana's total installed public generating capacity is 1,322 MW of which 1072 MW (95%) is hydroelectric, based on two dams on the Volta River at Akosombo, 912 MW and Kpong, 160 MW. Total diesel generating capacity is 30 MW. These are all operated by the VRA. The combined-cycle gas turbine (CCGT) plant at Takoradi has added the last 220 MW.

The VRA is the sole agent in the country that has developed high-voltage transmission lines for electric power supply. The transmission system comprises over 2100 km of 161 kV lines. Eight circuits of 67 km each connect the Akosombo and Kpong hydroplants to the Volta Aluminium Company (VALCO) smelter at Tema and to other industrial loads, while a 650 km transmission loop supplies ECG and mines in the southern sector of the country (VRA, 1993). The northern sector of the country is provided for by a subsidiary of the VRA as shown below.

VRA pioneered electricity supply across national boundaries in the West Africa region, and established links with Communauté Electrique du Benin (CEB) in Togo and Benin in 1972 and with Energie Eléctrique de la Côte d'Ivoire (EECI) in 1984. These interconnections are done through a 161 kV double circuit line connecting Akosombo to Lome, Togo (CEB), and a 225 kV transmission line capable of supplying a demand of 100 MW to the Côte d'Ivoire.

The VRA’s major domestic consumers are the Electricity Corporation of Ghana, ECG, the Northern Electrification Department (NED) and the mines. It also supplies electricity to the some of the mines, Akosombo township and two industrial plants, the Akosombo Textiles in Akosombo and Aluworks at Tema.

The VRA operates as a quasi-economic enclave within the country. It has been allowed by the government to retain and exclusively use its foreign currency from sales to Volta Aluminium Company (VALCO) and exports to Togo, Benin and La Côte d'Ivoire. As at 1985 VRA had 130 km of 225 kV lines, 1248 km of 161 kV lines and 102 km of 69 kV lines.

The Northern Electricity Department

In 1987, VRA created a distribution subsidiary, the Northern Electricity Department, NED. Together with the ECG, these institutions are responsible for the implementation of almost all the country's power projects. The current and perhaps the most important of these projects is the long term National Electrification Scheme, NES. Electricity supplied by the NED, as in the case of the ECG, is purchased from the VRA.

The VRA is therefore, indirectly through the subsidiary, responsible for the generation, transmission and distribution of power in what is known as the northern sector of Ghana. Spatially this comprises Brong Ahafo, Northern, Upper East, and Upper West regions and is much more extensive than the south, but less in population. Supply of power to this sector is part of the implementation of a national electrification scheme initiated in 1987 as indicated above.

Unlike the ECG, NED’s customers are generally rural based. Spread over the four regions the total number of customers is about 66,000. Comparatively, NED's capital-output ratio is higher due to the very large geographical spread. The capital output ratio is bound to be very high for the rest of the power needs as populations become more and more dispersed unless the preferred technologies are cost-effective and small scale.

The Electricity Company of Ghana

In 1967, the Electricity Company of Ghana (ECG), known as the Electricity Corporation of Ghana until 1997, was established to take over from the old Electricity Department to supply electric energy to the people of Ghana. The decree which established it, National Liberation Council Decree (NLCD) 125, charged the ECG with the bulk purchase of electricity from the VRA for distribution throughout the country. Like the VRA, this state enterprise was also required to run on sound commercial lines.

Even though the mandate of the ECG includes the construction, maintenance and operation of electrical generating, transmission and delivery facilities, its investments and activities have been limited largely to that of distribution. The ECG took over about 20 diesel stations from the Electricity Department of the Ministry of Works and Housing. At present, apart from a small diesel plant in Kete Krachi in the Volta Region, the ECG runs no generating plants. It has been estimated that the total power generation outside that of the VRA, including even the effects of the rush in 1998 to provide electricity from petrol/diesel generators, constitute less than 10% of total supply in the country.

In March 1997, the ECG was converted to a limited liability company as provided under Act 461 of 1993 and will operate under the companies code act, Act 179 of 1963. This change in status was to correct the unsatisfactory performance. The new company is expected to ensure a greater degree of accountability for field managers, revenue collection and customer services.

According to its mission statement, the ECG is committed at all times to give its customers an adequate and reliable service at an economic price (ECG, 1994). This is becoming exceedingly difficult to achieve due to price and profitability as will be made clear later in the Chapter.

Currently the corporation has responsibility for electricity transmission and distribution to domestic, commercial and industrial consumers and some mining companies in six regions in Ghana. These regions which are in the southern sector of the country include Ashanti, Central, Western, Eastern, Greater Accra, and Volta. Prior to 1987 when the Northern Electricity Department was established, the ECG was also responsible for the northern sector which is made up of Northern, Upper East, Upper West and Bong Ahafo regions.

In order to operate, the ECG purchases bulk electricity at 33 kV from the VRA, the main electricity generation and transmission company in Ghana, for distribution. The ECG receives 27% of the total electricity generated by the VRA and allocates this for residential, industrial and commercial users totalling 400,000 customers.

Ghana National Petroleum Corporation

The Ghana National Petroleum Corporation (GNPC) has yet to make any significant contribution to electric power supply. Primarily responsible for the management of petroleum imports and exploration, it has taken steps to contribute to electricity production and supplies. The GNPC has established a subsidiary, the Western Power Limited, to generate power from natural gas from the Tano River Basin.

Regulatory Institutions

Two very important institutions are being established that will have major influence in the electric power industry. A Bill for the establishment of the Public Utilities' Regulatory Commission (PURC) has been passed by parliament and members of the Commission appointed for oversight of water and electricity industries. The law establishing the Energy Commission has also been gazetted. The Energy Commission will be responsible for the entire energy sector including electricity. The main issues in the regulation of power will be institutional arrangements for service provision and coverage, pricing and the availability and reliability of supply.

3.2 Electricity Demand

Structure and Growth

Electricity demand in the country has grown from 3651.6 GWh in 1978 to 5540.6 GWh in 1992. There was a drastic fall in the generation of electricity in 1984. This was due to the severe drought the country experienced between 1983 and 1984 and this consequently affected the level of electricity supply. Electricity generation fell from 3700 GWh in 1978 to 1,798.7 GWh in 1984, about a 50% fall. VALCO alone consumed over 50% of electricity generated by VRA from its two hydropower plants. VRA's supply of electricity to VALCO is also considered as export. In 1990, exports constituted approximately 64% of total electricity supply by VRA to its customers. This was about 10% lower than the 1980 level. During the period under discussion, export of electricity exceeded domestic consumption except between 1983 and 1985 when the drought forced VRA to cut down its export. In 1980, for instance, electricity export was 3,758.5 GWh compared to domestic consumption of 1,371.1 GWh. During the drought, electricity export fell to 560.8 GWh compared to domestic consumption of 1,029.4 GWh.

In 1992 the number of customer connections had grown gradually to 324,000 in the southern sector supplied by ECG, while NED supplied 30,000 in the northern sector, in 478 population centres, representing 3.6 million people with electricity in their homes. The number of people that had access to electricity[1] was 4.5 million representing 33% of the entire population, and 46% of the urban population[2] (MOME, 1991). ECG was also to continue generation of electricity by diesel plants in areas not served by the national grid system. In the area

[1]Electricity supply in the population centres (not necessarily to all homes).

[2]An Urban centre is defined here as centre with over 5000 residents.

served by ECG, 67% of its customers are concentrated in three cities, Accra, Tema and Kumasi. ECG is also charged with the operation of the government sponsored rural electrification program. ECG currently purchases almost all of its power requirements in bulk from VRA.

Figure 3.1 shows that exports to Côte d'Ivoire, Togo and Benin reached their peak in 1991/1992 and began to fall, especially to Côte d'Ivoire. Sales to ECG and NED have been rising steadily over the period. There is every indication that this upward trend on the domestic front is going to continue due to the National Electrification Scheme. Sales to the mines started rising in 1990 after a period of sluggish growth in electricity demand in the mining sector. This growth in electricity demand after 1990 is due primarily to an increase in mining activities in recent times.

Discussing the issue of electricity demand, one aspect of it is transmission and distribution losses. These losses reflect a generally poor performance. The losses can be classified as technical and non-technical (i.e. the difference between energy generated and energy billed). The average transmission loss for VRA was about 3-4% while ECG's distribution loss was about 16% in 1990. These losses have a direct impact on the finances of the utility company affected.

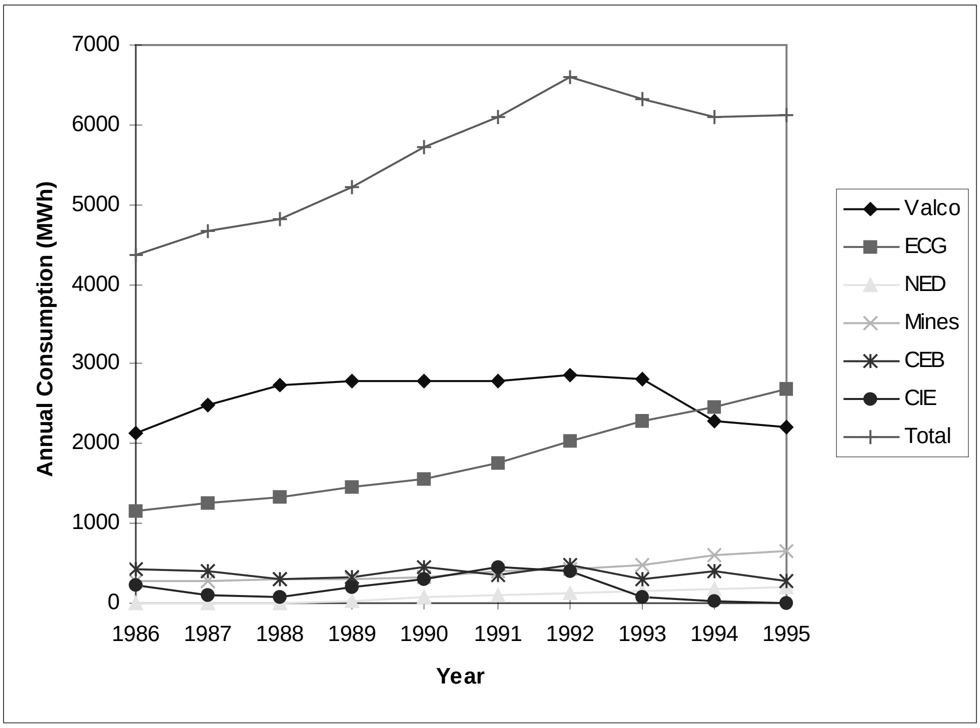


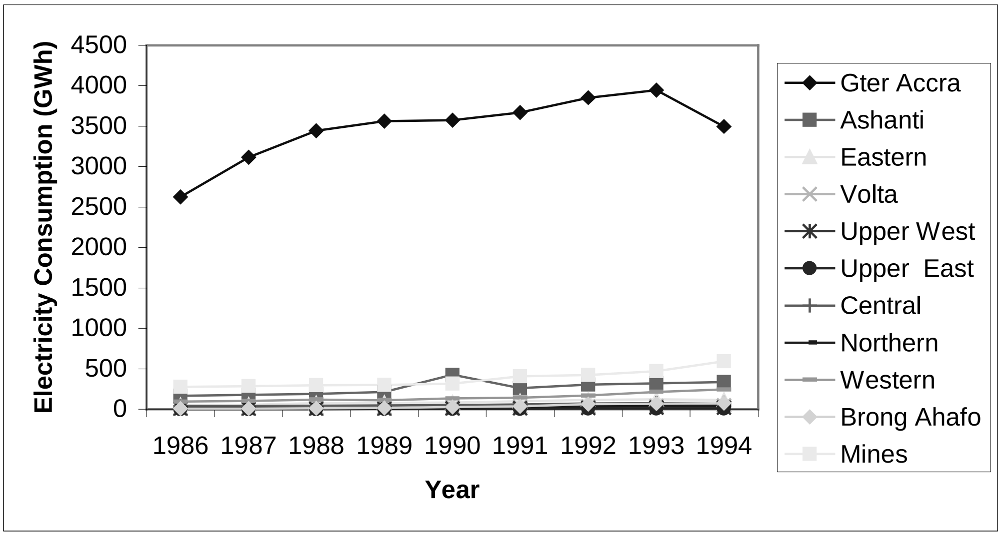
Figure 3.1. Annual Energy Consumed per Customer Class (MWh)

Before 1987, retail sales of electricity to all classes of customers were the sole responsibility of ECG. About 78% of ECG's customers are classified as residential and 22% as non-residential (commercial), with less than one percent classified as industrial. Its sales measured in GWh were about 36% to residential, 18% to commercial 33% to industrial customers and 13% as distribution losses in 1980. In contrast, ECG's sales in 1990 were about 42% to residential, 29% to industrial and 13% to commercial customers, with distribution losses up by 3% to 16%. The residential customers generate about 38% of ECG's sales revenue, while non-residential and industrial customers account for 28% and 34% respectively.

Spatial Variations

There is a large spatial variation in electricity consumption in the country. The size of variation in electricity consumption is a reflection of the spatial variation in the distribution of economic activities, which use electricity as one of their major inputs. Out of the ten regions in Ghana, Greater Accra, the region which includes the capital city Accra and the industrial town of Tema, consumes about 80% of the total domestic electricity consumption, followed by the Ashanti Region, then the Western Region.

Regions with very low electricity consumption are Upper East, Upper West, Central and Volta. Figures 3.2 and 3.3 below give a graphic representation of the spatial variations in electricity consumption in the Ghana. Figure 3.2 shows the regional pattern with the Greater Accra region and Figure 3.3[3] shows the regional electricity consumption pattern without the Greater Accra region. Even within regions, there is a huge disparity between urban and rural electricity consumption patterns. With approximately 33% of the population having access to electricity, most of them are in the urban centres and mining towns.



Source of data for figure: National Energy Statistics, Ministry of Mines & Energy, Ghana, 1994

Figure 3.2. Regional and Mines Electricity Consumption (GWh) (With Greater Accra Region)

[3] Figures 3.2 and 3.3 shows that in 1990, the Ashanti Region experienced a marked increase in electricity consumption which goes against the general trends in all regions including the mining sector. The cause or causes of this increase are not quite clear to the authors.

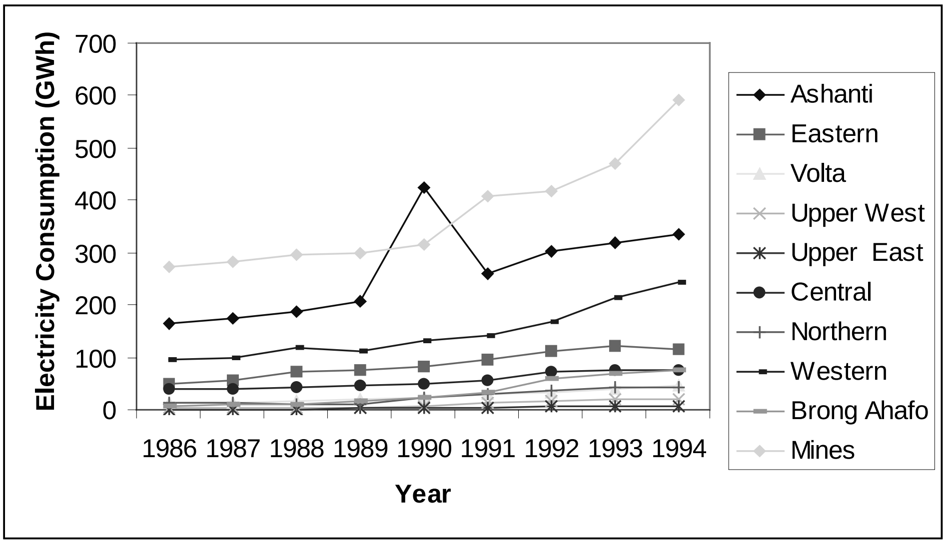


Figure 3.3. Regional and Mines Electricity Consumption (GWh) (Without Greater Accra Region)

ECG's share of the total supply of electricity available for distribution within the country in 1989 was 80.6% and NED's was 0.7%. In 1991 ECG's share fell to 75.9% whilst NED's rose to 4%. Table 3.1 shows the allocation of electric power to each distribution company and the growth pattern.

Table 3.1. Supply and Rate of Increase of Electricity to ECG and NED

Year	1989	1990	1991
ECG (GWh)	1460	1561	1753
% change		6.9	20.1
NED (GWh)	13	66	99
% change		407.7	615.4

Source : Compiled from ECG and VRA annual Reports (1989 - 1991)

In the same period electricity demand in the NED service area increased by 615%. The phenomenal increase in consumption of electricity in the NED service area is attributed to increase in residential connections. In other words a lot more urban centres were connected to the national electricity grid system. This part of the country, which is now under NED, was served by isolated diesel generators supplying electricity to the urban centres where they are installed.

In 1987, the government announced a policy of electrifying the entire country by the year 2020. As a result of this government policy, the national transmission network has been extended to the northern half of the country, making access to electricity from the national electricity grid system to the regional and district capitals much easier.

3.3 Factors Influencing Electricity Demand

The Price of Electric Power

The demand for electric power is not simply the identification of areas that have not been supplied with electricity. Demand at any level is based on a particular price. In Ghana electricity tariffs have been controlled by the government for a long time. Generally speaking, electricity prices have been below cost of supply, and this to a large extent has influenced how electricity is used by the different customer classes. Attempts in 1997 at economic pricing of electricity ended in a stalemate due to stiff opposition by consumers.

ECG's tariffs, especially for residential customers were relatively stable in nominal terms (between 1980 - 1983) over the years but have been declining in real terms in the face of inflationary pressures. In 1990 for instance, average revenues were 16% below 1989 levels in real terms and 46% below 1986 levels (MOME, 1991).

Such a weak financial situation has been accompanied by constant outages and voltage- fluctuations since maintenance levels fall below standard. Expansion to meet the national requirement is severely constrained. This is the state in which the ECG finds itself. De Oliviera and Mackerron (1992) have made a similar conclusion, generally, and assert that the challenge facing utilities in developing countries in the 1990s is to recover their financial soundness, in order to be able to invest to meet a still rapidly-growing demand and simultaneously improve their technological performance to levels close to those of the industrial countries.

To get a better perspective on how controlled electricity tariffs are in Ghana, we set out to compare electricity tariffs in some selected developing countries with that of Ghana. The average ECG retail price of electricity was 1.66 US cents/kWh in 1987. This was very low by comparison to other developing countries. Table 3.2 compares the average electricity tariff in Ghana with some selected developing countries. Ghana, Zambia and Nigeria had the lowest tariffs. All the countries bordering Ghana had higher tariffs than Ghana. Côte d'Ivoire's tariff was over 8 times higher than that of Ghana.

Table 3.2. Average Electricity Tariffs for Selected Utilities
(in US cents/kWh, Official Exchange Rates)

Country	Average Tariff	Country	Average Tariff
Gabon	17	Uganda	9.2
Guinea	16	Mali	12.5
Malawi	2.4	Nigeria	4
Cameroon	3	Sierra Leone	16
Côte d'Ivoire	30	Zambia	2
Ghana	3.6	Zimbabwe	3.1

Source: Symposium on Power Sector Reform & Efficiency Improvement in SSA. Johannesburg Dec. 5-8 1995. ESMAP Report No. 182/1966 June 1996. World Bank, Washington DC

The higher tariffs set in these countries do not imply that governments of these countries do not control electricity rates. They do, but they set a more realistic rate. The on-going rehabilitation and refurbishing of the distribution network of ECG are being made at a great cost to the country. The government and the tax-payer, for that matter have had to pay off ECG's past debts in excess of 18,000 million cedis to put the corporation on a sound financial and commercial footing to deliver better quality and reliable services to its customers (MOME, 1991). Within the period 1983 - 1992, ECG has had access to foreign loans and grants totalling US $144.96 million, and VRA has had US $173.28 million also in loans and grants (Brew-Hammond, 1994).

The World Bank (1992), in a separate study of the power sector in developing countries reiterates this point that in many developing countries, including Ghana, the problem of low tariffs, resulting from non-periodic adjustments of the tariff to reflect higher costs of electricity supply, encourages wasteful energy end-use practices and makes it financially unattractive for the electric utilities to undertake energy efficiency programs and technology initiatives.

The distribution companies like ECG and NED are not the only ones affected by inappropriate pricing of electricity. For the generating company, profitability, growth, and the ability to innovate are also undermined. Profitability from export sales of electricity to the VRA were able to offset losses from domestic sales till November 1997. Two or three months prior to that date, the VRA had been forced to import power from Côte d'Ivoire at 168 cedis per kWh which it resold at 23 cedis per kWh or in dollar terms about 8 cents to 1 cent respectively.

Incomes

The income levels of residential customers influence their electricity consumption. The extent of such influence is determined by the quantity and quality (efficiency) of the electrical appliances used by the consumers. High-income households tend to have high electricity consuming appliances such as air-conditioners, electric cookers, freezers, refrigerators and electric water heaters. These are in addition to other electronic gadgets such as radio, television, tape recorder/player and VCR. Characteristics such as age and efficiency of these appliances and gadgets affect the amount of electricity consumed. Table 3.3 below shows percentage of electricity usage by different electrical appliances by income groups.

Table 3.3. Electricity Consumption by Income Groups

Electrical Appliances	Low Income Household % electricity used	Middle Income Household % electricity used	High Income Household % electricity used
Air-condition	0.0	16.5	20.0
Refrigeration	28.6	29.8	26.3
Water heating	27.9	12.4	14.7
Fans	8.3	4.7	4.9
Lighting	9.9	17.7	14.8
Cooking	7.6	9.1	10.2
Ironing	6.2	3.3	0.1
Television/VCR	5.7	3.9	7.0
Radio	5.8	2.6	2.0

Source: MOME, 1994.

These figures are complied from a study done by the MOME in 1991 using a sample size of 1000 households in Accra (capital of Ghana), 350 high income households, 350 middle income households and 300 low income households. Table 3.3 shows the type of electrical appliances used in households, and their electricity consumption. In low-income households, if there is a 20% a reduction in efficiency of refrigerators and water heaters (which account for 66.5% of electricity usage), for example, it can have a significant impact on electricity consumption in households with such inefficient appliances.

Population and Urbanisation

Residential demand for electric power is based on size and the total number of households in each settlement and the country as a whole. Penetration rates have been measured as 50% in the north and 65% in the south and residential consumption rate of 1310 kW/year per connection, by the VRA.

Analysis shows that the urbanisation process has been dominated by the four major settlements of Accra-Tema, Sekondi-Takoradi, Kumasi and Tamale. These settlements have a disproportionate share of total urban population. They also have the largest proportion of public utility services such as electricity. The rate at which urban growth occurs will be important in determining electric power supply. Scattered rural settlements with low populations raise the cost of provision. unless appropriately scaled efficient technologies are used. The GOG has identified as one of the major constraints to economic growth, the large number of scattered settlements that lack threshold populations for effective, economical provision of services and facilities (GOG, 1997).

Orderly urban growth is being encouraged in Ghana with investments in public utilities and infrastructure including water, sanitation, roads and electricity, through World Bank support (GOG, 1993). A seven-tier hierarchy of settlements is expected to develop. In the current spatial structure, Accra alone is at the apex of the hierarchy, see Table 3.4 below. The proposals expect that Accra will be joined by Kumasi, Tamale and Takoradi in size and importance to change the current hierarchy.

Table 3.4. Ghana: Hierarchy of Settlements

Settlement Hierarchy	Existing Number	Proposed Number
I	1 (Accra)	(Accra, Kumasi, Tamale, Takoradi)
II	3	12
III	6	50
IV	27	200
V	42	550
VI	267	All Rural Service Centres
VII	All Rural Settlements	All Rural Settlements

Source: Task Force, National Spatial Strategy, 1993, Accra

The hierarchy is as follows:

I) Accra
II) Kumasi, Tamale and Takoradi
III) The six remaining regional capitals of Ghana
IV) Medium sized towns of which the majority are the large district capitals
V) Small towns, which are predominantly, market centres.
VI) Rural growth centres (typically below 5000 population)
VII) Rural settlements

Such spatial re-organisation could also lead to an increase in urban type activities that require greater levels of utility provision including electricity.

Price of Substitute Fuels

Charcoal, kerosene and LPG are substituted for electricity for cooking, if the relative price of electricity is higher than the prices of these competing fuels. Such fuel substitutions are likely to take place in the high and middle-income households where cooking with electricity is found. Unfortunately, it is the low electricity price that makes these other fuels relatively more expensive.

Demand Side Management (DSM)

This strategy has the potential of affecting the levels of electricity demand of consumers. Demand side management can have significant effects on the total demand of electricity through reductions in consumption without loss in productivity or satisfaction. Some DSM programmes have been initiated in the country and may have some impact on electricity demand. A public awareness programme was initiated jointly by VRA and ECG. The main components of the programme include promoting the following:

i) the introduction of energy efficient appliances
ii) regular checks of door seals of fridges, freezers and so on to prevent leakages
iii) the use of efficiency lighting fixtures

iv) quality control of imported electrical equipment and appliances
v) regular switch offs of lighting fixtures and electrical appliances that are not immediately needed

While these are important, proper electricity pricing is the most effective means of demand side management.

Special Characteristics of Electricity

Electricity is a high quality energy form with versatility, flexibility, adaptability and amenability to control that is unmatched (Y. H. Kim and K. R. Smith 1986). There are certain applications that require electricity, for example communication, lighting and computation. In addition, the cleanliness, convenience, familiarity and reliability, of electricity make it the choice energy in many applications. According to Kim and Smith (1986) in industrial usage, electricity can replace many flame-based technologies with a consequent improvement in quality.

Many industries, businesses and households use machines, equipment and appliances that depend on electricity's distinctive versatility. It is therefore usually the most rapidly growing energy sector. With even the modest economic growth recorded in Ghana the growth rate of electricity demand has been very significant at around 13% per annum.

3.4 National Electrification Scheme (NES)

Demand for electricity by the large majority of the population has been suppressed, and continue to be so because they do not have access to electricity. In 1989, the government initiated a National Electrification Scheme to specifically address this problem. There are 47,800 settlements in Ghana. The NES has targeted 69 electrification projects that will cater for 3,743 urban and rural population centres with population above 500. The main objective is to extend the national electricity grid to all parts of the country and improve access to electricity by the majority of the population by the year 2020.

The distribution of shortfalls in electricity supply to be satisfied through the NES is a close proxy to the distribution of potential demand in the country. The Northern Region, the most extensive region in Ghana, has as many as 54 towns that must be supplied with electricity. Apart from Tamale and Savelugu, all the other nine district capitals are yet to be connected. By April 1996, the distribution of power needs to be satisfied in the north of Ghana was as shown in Table 3.5.

Table 3.5. NES Packages for the Northern Electricity Department

Region	Number of Towns	District capitals	Cost (¢ billion)
Brong Ahafo	31	3	12
Northern Region	54	89	43.0
Upper East	38	3	12.1
Upper West	16	3	9.4

Source: Ministry of Mines and Energy, 1996

The Upper East Region is next in-line. Even though relatively the southern sector of Ghana is more provided with electricity, it still has an absolutely larger number of towns and population to satisfy. Table 3.6 shows the distribution of electricity needs as revealed by the NES study results.

Table 3.6. Electricity needs of the Southern Regions of Ghana

Region	Number of Towns	District capitals	Cost (¢ billion)
Volta	30	2	10.7
Ashanti	33	0	5.1
Western	84	3	48.8
Central	70	2	28.7
Eastern	51	0	11.7

Source: Ministry of Mines and Energy 1996

About 84 towns in the Western Region need to be connected to electricity supplies, including three district capitals, which so far have no electricity. The Central Region follows with 70 towns that need electrification, including two district capitals. The Eastern Region has 51 towns waiting to be connected, but all its district capitals have electricity. Both Ashanti and Volta Regions are much better supplied. Ashanti Region has no district capital that is not on the electricity grid but Volta Region has two.

The Greater Accra Region was not part of the NES perhaps because of less pressing need for electricity. Some suburbs of Greater Accra would be connected as part of another funding scheme.

Supplying electricity to all parts of the country will involve extensions to the existing transmission lines and construction of new power plants. The NES is based on an elaborate electrification plan called the National Electrification Plan (NEP). The NEP consists of six 5-year phases. Universal access to electricity by all Ghanaians and residents is the main objective of NES. The main components of the phases are outlined below.

Phase 1, [1991-1995]

Phase 1, which is almost completed, was for the period 1991-1995. This phase involved the supply of electricity to 41 of the 110 district capitals. The second component of Phase 1 is the extension of electric power to150 communities through the Self-Help Electrification Programme(SHEP). The total cost for this phase was estimated at about US $100 million (in constant 1990 USD)

Phase 2, [1996-2000]

This phase involves the supply of electricity to areas with the lowest unit costs of service and is estimated to cost a total of about US $72 million (in constant 1990 USD).

Phases 3 to 6 [2001-2020]

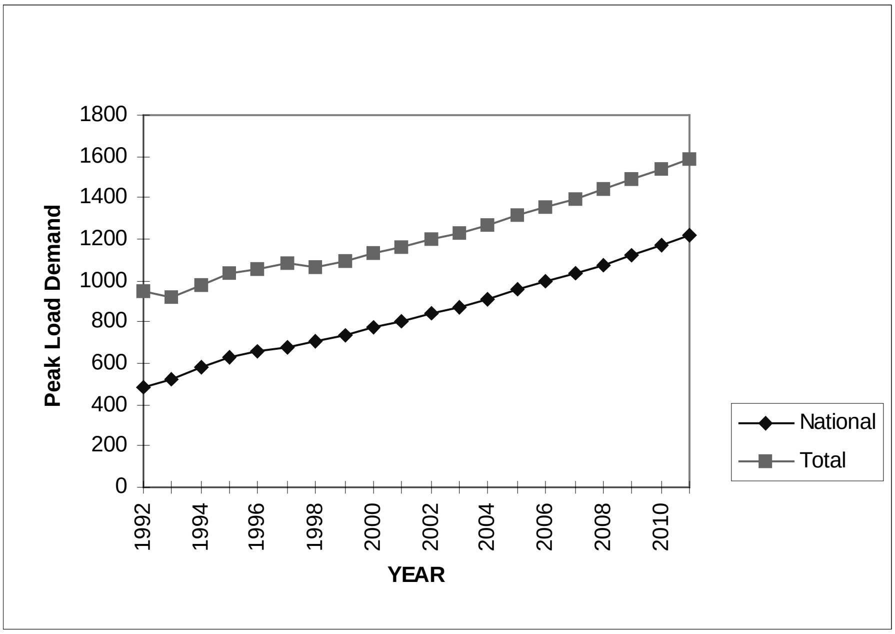
These phases will undertake the remaining projects in the order of the unit costs of services, beginning with those with the lowest. These phases will cost in terms of 1990 constant prices, about US $120 million, US $138 million, US $156 million and US $144 million, respectively.

Implementation of the NES will lead to the retirement of several diesel plants, which have been supplying electricity to many of these towns. Retirement of diesel plants is an important change in the fuel mix in electric power supply. The NES appears to be an appropriate scheme for extending electricity to the population. However, grid supplies are usually cheapest in areas with high load densities, as well as in areas near the grid, but connecting small isolated villages to the grid can be expensive, (Barnes et al, 1997). Renewable energy sources from solar and micro-hydropower schemes may be attractive options. Electricity for local distribution can also be generated from fuels such as biogas and biomass. These and many more are being investigated into and developed as alternative sources as discussed in the next section.

3.5 Projected Electricity Needs

Economic policies and national planning are important for determining the future growth of the economy. A growing economy needs an increasing amount of energy including electric power supply. Electricity consumption has grown steadily in the past decade and has followed closely, the growth of GDP (Brew-Hammond, 1994). According to Brew-Hammond growth in electric power consumption continued, despite a slowing of the economy in the early 1990s, with high annual growth rates of 14.5% for all sectors and 19.2% for the mining sector from 1990 to 1993. This was probably caused by the effects of government policy of electrification, which is being implemented through the National Electrification Scheme (NES).

Domestic demand growth has been estimated at 10% between 1985 and 1993 (MOME, 1996). The report indicates that the System Expansion Programme 1997-2013 foresees the commissioning of 900 MW of new thermal power plants. Electric power supply and consumption as a proportion of total energy is therefore set to increase from the current level of 10%. Supply cannot continue to come from an almost entirely hydroelectric power sources. VRA has made projections of peak load power demand with and without exports (See Figure 3.4).



Source: VRA (Thermal Plant Feasibility Study Report , 1992)

Figure 3.4. Peak Load Domestic Demand and Exports

The resulting power production mix to satisfy these forecasts will have different implications for energy imports, power tariffs, spatial distribution of supply, demand management and environmental protection.

3.6 Future Power Supply Options

To augment the current supply and meet the potential growth in electricity demand resulting from improved economic performance of the country and the National Electrification Scheme (NES) initiated by the government in 1989 to increase access to electricity, would require major investments in power generation and extension of transmission and distribution networks. Expansion in generation capacity may require the electric power industry to diversify its sources of power generation. Diversification of sources has come ahead of complete exhaustion of hydroelectric potentials because of the need to ensure stability and security in supply.

Hydropower Potentials

The most part of current power supply comes from the Volta basin. There are other potentially stable hydro basins, which have been identified in the western parts of Ghana such as Pra, Tano and Ankobra rivers. These rivers have a combined potential of 225 MW. In general a number of river basins have been identified as having hydropower potentials. Table 3.7 shows a ranked order of these potential projects.

Table 3.7. Ranked Hydroelectric Projects

Rank	Project	Unit Cost of Energy Index ($/kWh)	Average Annual Energy (GWh)	Installed Capacity (MW)
1	Awisan	0.029	270	50
2	Hemang	0.030	308	75
3	Bui 2	0.030	527	100
4	Tanoso	0.034	258	56
5	Juale 1	0.036	627	100
6	Abatemasa	0.050	233	50
7	Kojokrom	0.050	136	30
8	Asuaso	0.054	129	25
9	Ntereso	0.056	257	64
10	Daboya	0.057	230	80
11	Koulbi	0.058	392	68
12	Pwalugu	0.060	280	50
13	Jambito	0.067	180	55
14	Jomuro	0.075	85	20
15	Lanka	0.082	319	95
16	Kulpawn	0.089	280	70
17	Juale 2	0.112	128	50
18	Sedukrom	0.114	67	17

Source: VRA/GOG, 1985, Ghana Generation Planning Studies, Appendix D.

Ranking of the hydroelectric alternatives by the VRA was based primarily on the unit cost of annual average energy supply expressed in dollar per kilowatt hour ($ / kWh).

Other parameters which the VRA considered but which did not affect ranking were unit cost capacity, socio-economic impact and the ability to function independently such as in the north or west of Ghana without the need to tie into the main grid. Environmental issues were not considered.

This least cost of energy ranking may be superseded by other considerations like location, installed capacity, or the average annual energy depending on the specific requirements. It may also change due to environmental considerations.

Thermal Power Development

Thermal power plants will be an important source of electricity generation diversification Already, one is under construction in Takoradi and is expected to increase electric power supply by 600 MW in total. An initial production of 220 MW of electricity from this source started in November 1997 using distillate oil.

Natural gas will be an important source of power generation. The GNPC, a state owned enterprise with primary responsibility for petroleum exploration, has plans to finalise arrangements for the installation of a 130 MW power facility to utilise natural gas from the Tano gas fields. A West African Pipeline Project is being developed to transport imported gas from Nigeria.

Renewable Sources

Renewable resources are potentially important sources of power supply in Ghana. The Ministry of Mines and Energy has taken their development seriously. In 1996 for instance a total of ¢339 million was spent on renewable energy projects for that year. The proposed expenditure over the period 1996 - 2000 is ¢1.2 billion. The Ministry has defined a number of criteria for the promotion of and commercialisation of renewable energy technologies. The criteria include sustainability, cost recovery, environmental protection and basic community needs.

In the first instance the technology pursued must be proven to be efficient and reliable. This means that the technology must be capable of being used by a large number of people and that there are resources to ensure that its use is continuous. Beneficiaries of renewable energy must be both willing and able to pay for the cost of its services. Thus there must be effective demand though some subsidies may be permitted from the government in order to encourage potential investors (MOME, 1996) Subsidies are meant to accelerate the penetration of the renewable technologies into the existing market and are necessarily short term. In the long run it is expected that only technologies for which economic prices are paid can be sustained.

There are two main types of non-hydro renewable energy sources in Ghana. One source is from biomass and the other is solar. Investments in renewable energy potentials will have the long-term effects of reducing the number of thermal power plants that will have to be built, including hydroelectric power plants. The Ministry of Mines and Energy has outlined a number of activities that are being carried out in its Medium Term Plan (1996-2000).

External Electric Power Sources

Power supply can also come from other West African countries through regional inter-connection of electrical systems. Transmission links have already been established with Côte d'Ivoire, Togo and Benin. Power sharing arrangements with these countries, particularly with Côte d’Ivoire, are an effective strategy to augment internal power generation. For each of the countries involved, domestic production may not have to be pushed to greater levels merely to serve as standby capacity.

3.7 Reform Issues

In 1994, the government set up the Power Sector Reform Committee to submit proposals to reform and restructure the power sector in Ghana. The main purpose of reforming the power sector is to improve the performance of the companies in the industry and also to create an enabling environment to attract private capital into the sector. In 1997 the committee submitted its recommendations to government and subsequently, the Public Utility Regulatory Commission (PURC) Bill was enacted, paving the way to the setting up of the PURC and to implement the reforms in the sector. The industry structure recommended and also accepted by government is an unbundled industry structure with wholesale competition envisaged, where large industrial users will be able to purchase at least some of their electricity from generators other than existing local systems; and independent generators will be able to sell electricity in competition with former monopoly suppliers such as the VRA, ECG and NED. It is anticipated in this structure that the private sector would be involved in the development of the sector. The reform of the power sector, which is underway, will have major implication for the longer term - for the evolution of the power systems, for investments in electricity technologies and for the environmental effects of electricity.

3.8 Generating Technologies

One of the emerging results of reforming the power sector is the different mixture of technologies for electricity generation. Electricity systems all over the world were originally established to take advantage of economies of scale for electricity generation by water power and steam power. Since the deregulation of the gas and telecommunication industries in the US, the purported economies of scale present in the conventional power stations started to be questioned. Two developments, however, have made the question far from being theoretical. The availability of abundant and cheap natural gas in Europe and North America; and development of gas turbines which have emerged as clean, reliable and efficient technology for electricity generation, especially when coupled with steam turbine in the Combined Cycles. Table 3.8 below shows some of the power generating technologies commercially available. These technologies are fossil-fuel based. There are also renewable energy and nuclear technologies (UNEP/WMO, 1995). Some of these technologies, such as combined cycle, combustion turbine, diesel co-generation and some renewable energy technologies are very likely to feature in the emerging competitive electricity market in Ghana. A CCGT plant, for example, can operate at base load, like coal or hydro plant, but it is much flexible, has a lower unit cost, and has been found to be easier to site than a coal or hydro- plant.

Table 3.8. Some Power Generating Technologies

Generating Technologies	Design Fuels	Efficiency Rating%	Design Lifetime (yrs)
Atmospheric Fluidised Bed Combustion	Coal, Anthracite Biomass etc.	25-35	30-40
Coal Benefaction	Coal		20
Combined Cycle	Natural gas, Refinery gas, Distillate Oil	45-53	30
Combustion Turbine	Natural gas, Refinery Gas, Distillate Oil	30-35	30
Diesel Co-generation	Natural Gas, Propane, Diesel Oil No. 2	35-45	Depends on speed, fuel type etc.

Source: UNEP/WMO, 1995

Until very recently, the electricity system in Ghana has been based mainly on two hydro-plants with a total capacity of 1072 MW. Ghana now has a combined cycle gas turbine (CCGT) plant. It is expected that this will be the first of many such plants to be built in the country as the reform progresses. Those advantages mentioned earlier and others make CCGT technology a potential dominant player in the power sector reform in Ghana. In a competitive market-based electricity system which is envisaged in the country, the traditional large-scale power plants, with long construction period, its costly capital structure and low flexibility in operations may be the thing of the past. With the difficulties involved in financing huge power projects from traditional funding sources such as the World Bank, private sector investors such as the IPPs may find it difficult to finance such projects without the guaranteed revenue stream of a monopoly system. Any arrangement less than that makes such investment very risky, and those who venture require high rates of return. In the face of such risks, difficulties in securing project financing and the emerging competitive environment, IPPs prefer smaller scale modular generating units with short construction time.

The existing hydro plants face serious problems of changing rainfall patterns in Ghana. The 1983/84 drought as well as the current drought are a stark reminder of this problem. Ghana still has a couple of hydro sites with potential generating capacity of 300-400 MW, and a few sites ranging from 20-75 MW. The uncertainty surrounding rainfall patterns makes reliance on hydroplants to meet the growing demand for electricity an unsustainable strategy. Two major options are available: importing power from Côte d'Ivoire and generating power from fossil fuel-based plants. A start has been made with the commissioning of CCGT plant in Takoradi in the western region of Ghana. This plant is to start using distillate oil as fuel feedstock for the plant pending the finalisation of arrangements to get natural gas from either Nigeria or Côte d'Ivoire. If the discussion to build an offshore gas pipeline from Nigeria to Ghana and from Côte d'Ivoire to Ghana becomes a reality, this will encourage the choice of gas fired CCGTs for new generating capacity. In the reformed electricity market context, gas suppliers are likely to be eager to sign long term contracts for stable supply to electricity generating plants in the country.

3.9 Concluding Remark

Meeting the present and future electricity needs may require use of fossil fuel and renewable energy sources to generate and supply power. The resulting fuel mix and expansion in electric power generation and expansion in transmission lines will have impact on the environment. The various environmental protection consequences of these likely changes in power generation landscape will be taken up in chapters 4 and 5.

4 General Environmental Effects of the Electric Utility Industry

4.1 Introduction

Virtually all energy production, conversion and consumption processes entail some sort of environmental impact. The combustion of fossil fuels leads inevitably to emissions of pollutants. The use of renewable energy sources such as solar, geothermal, hydropower although "emission-free", also have some direct and indirect environmental effects, and may also be associated with other types of environmental impacts such as the disturbance of the ecosystem. The environmental issues related to thermal power generation concern air pollution and impacts on land, pollution of both fresh and seawater.

4.2 Local and Regional Environmental Impact

Energy activities may have impacts at local, regional and global levels, and the boundary between local and regional impact is clearly one of definition (WEC, 1995). The principal source of local and regional air pollution is generally the combustion of fossil fuels. The most common air pollutants in local environment in particular are sulphur dioxide (SO_2) nitrogen oxides (NO and NO_2 , collectively named as NO_X), carbon monoxide (CO) and particulates. Local air pollutants can cause different types of damages, but the most disturbance is the one on human beings.

Air pollutants can also have regional impact – that is impacts far away from sources of emission. This is because many polluting substances persist in the atmosphere long enough to be carried considerable distances by the wind. An example of such long-range environmental effect SO_2, for instance, is acidification of soil, groundwater and freshwater ecosystems caused by the deposition of sulphur and nitrogen compounds (WEC, 1995).

4.3 Impacts on Land and Soil

Construction Impact

Generally a thermal power plant may include gas-fired steam, oil-fired steam, combined cycles, gas turbines and diesel power plants. Negative impacts can occur both during construction and operation of thermal plants. Construction impacts occur during clearing, excavation, earth moving, dredging and in the process of impounding streams and other water bodies.

Waste Heat and Other Effects

Very large wastewater streams are typically clean cooling water for recycling or discharge. Such discharges have little effect on the chemical quality of receiving water bodies. Physical effects may however be important. Heated water discharges can raise the ambient water temperatures. Such temperatures can affect existing aquatic plant and animal communities. Organisms, which are suited to higher temperatures, may be favoured. Water for cooling systems may also have a consumptive loss and reduce the water available for drinking, irrigation, navigation and so forth.

Noise and Aesthetics

In addition to the impacts on land, water, and air use and quality, expected changes in electricity generation and the associated need for fuel raise other environmental issues. Most notable among these are noise and aesthetics. Noise and aesthetics impacts are generally attributable to the siting, construction and operation of new generating facilities. The major sources of noise associated with plant operations include ventilation fans, cooling towers and substations. Cooling towers, air emission stacks, raw material storage and handling areas, and often plant components have the potential to detract from surrounding landscapes. Particularly in rural areas, new power plants may intrude on the landscape. Similarly visual impacts of new transmission lines, access roads and pipelines can detract from the surrounding environment. As with noise changes, aesthetic impacts are site specific in nature. The magnitude of the change depends largely on the characteristics of the particular area.

4.4 Environmental Effects of Hydroelectric Power Projects

Potential Environmental Impacts

The main source of direct impacts in a hydroelectric project is the construction of and operation of a dam and reservoir. Large dam projects, like that of Akosombo in Ghana, can cause irreversible environmental changes over extensive geographical areas. The area of influence of both dam and reservoir can be very extensive. It starts from the upper limits of the reservoir and extends to as far downstream as the estuarine, coastal and offshore zones. It includes the dam, the reservoir and the river valley below the dam.

Indirect effects of a dam are associated with the building, maintenance and functioning of the dam. Access roads, construction camps and the development of agricultural, industrial or urban activities made possible by the dam.

Hydrological Effects

With dam creation, changes including the timing of flow of water, quality, quantity and use of water, aquatic biota, and sedimentation dynamics of the river basin may set in. The decomposition of organic matter may create a nutrient rich environment as has occurred in the Volta River. However, it may also deplete the oxygen levels if the inundated land is heavily wooded. For the sake of aquatic biota, heavily wooded land must be sufficiently cleared prior to inundation. While oxygen depletion has not occurred in the Volta River, wood stumps remain to date and impede other uses like navigation.

Fisheries and Wildlife

River fish population can decline due to changes in river flow, deterioration of water quality, loss of spawning grounds and barriers to fish migration. The loss of fish may affect the nutritional status of those who relied on the river for fish. Loss of habitat to wildlife may also result from inundation and land use changes in the watershed area. Migratory pattern of wildlife may also be disrupted by hydroelectric power reservoirs and associated development.

In Ghana, the largest lagoons lie at the mouth of the river Volta. According to the Environmental Protection Agency (EPA), the construction of the Akosombo and Kpong dams have radically altered the hydrology, morphology and the ecology of the estuarine region, (EPA 1994). The significance of this impact on coastal wetlands could be high. The series of lagoons provide unique ecological conditions and habitats for large populations of migratory waterfowl.

Watershed Management

On site environmental deterioration is real. Reduction in water quality and increased sedimentation rates in the reservoir occur. These are caused by the clearing of forest for agriculture, grazing pressure, use of agricultural chemicals and tree cutting for timber or fuelwood. To avoid these impacts, dam projects must be planned and managed with overall river basin and regional or district plan. Some of the strategies adopted by the VRA include a tree cover depletion project involved in the replanting of trees in communities around the catchment area.

The integrated plan must include both upland catchment area above the dam and watershed areas downstream. The provision, in Ghana, within the national development planning system for joint development planning boards will be most useful in these circumstances.

In order to minimise environmental effects of hydroelectric projects the potential negative impacts both direct and indirect must be well understood and addressed. Appendix 1 sets out some of these impacts and the mitigating measures that could be undertaken.

Socio-economic Impacts

Hydroelectric projects include dams, reservoirs, canals, powerhouses and switchyards for the generation of electricity. In project areas where rainfall and stream flow characteristics in the watershed permit, hydroelectric projects can provide other services. These services may include irrigation. Water supply, recreation, fisheries, navigation, flood control and sediment control. It may be noted that some of these are competing uses for the water stored behind the dam.

Limited experience by the VRA in some of the services may be illustrative. The VRA has shown what could be done with irrigation, recreation and navigation facilities at its dam sites at Akosombo. In addition, the Kpong dam is a source of water supply to Accra. Hydroelectric projects also entail the construction of transmission lines as with other projects. The environmental effects of transmission lines in general are dealt with in a separate section later. The inhabitants of inundated areas bear the heaviest environmental and social cost of dam construction. Certainly the 80,000 people who had to vacate over 700 villages when the Volta Basin was inundated bore the brunt of that development.

In Ghana, theoretically, resettlement should pose no problem as there are expanses of land that could be used for the purpose. However, relocation of people involves more than a mere change in available land use. Large hydroelectric power plants have come under attack due to the environmental and social impacts. The Namarda hydroelectric dam project in India has been virtually stopped due to opposition from those affected, and environmental groups.

Since Akosombo's experience in the 1960s a lot of rethinking on methodology of resettlement has occurred. For instance, in Sri Lanka, innovations introduced included the choice of resettlement location by those affected and cash receipts by those who agree to find their own land for resettlement, (Munasinghe and Meier, 1993). This methodology has the advantages of giving evacuees the opportunity to resettle in their area of choice and reduces pressure on government organisations to meet the demand of evacuees. The methodology will be particularly suitable to independent power producers (IPPs) who will welcome the reduced pressure.

Environmental effects or problems results from the influx of people such as construction workers, power plant employees, seasonal labourers for other dam induced activities. Some of the consequences are health problems, overstretched public services, social conflicts, and negative environmental impacts on watershed reservoir and downstream river basin.

The construction of the hydroelectric dams for power generation has resulted in many environmental consequences (GOG, 1989) On the negative side it has resulted in the displacement of 80,000 people in 700 villages, the spread of schistosomiasis, and the reduction of prawn and clam populations in the river. On the positive side, fish catches behind the dam have risen dramatically, breeding grounds for the black fly that transmits river blindness have been eliminated and the potential for irrigated agriculture has increased.

The Bui gorge has been found to be viable for hydroelectric power development and may add 400 MW of power to the existing capacity. However, apart from other effects, it will inundate about 382 square kilometres of the Bui National Park.

4.5 Environmental Effects of Electricity Transmission Lines

Electric power transmission systems comprise the transmission line, its right of way (ROW), switchyards, substations and access or maintenance roads. The main structures usually include the line itself, conductors, towers and supports. Transmission lines range from several kilometres to thousands of kilometres. For both import and export purposes the transmission system of the country has been linked to those of Côte d'Ivoire, Togo and Benin. This forms an extensive network of power transmission lines within the West African region. The right of way in which the transmission line is constructed can range from 20 metres to 500 metres.

Transmission lines are developed mainly overland. As linear facilities they affect natural and socio-cultural resources. In general, the environmental impacts to the natural, social and cultural resources vary directly with line length. Lines can be constructed to span or cross wetlands, streams, rivers, lakes, lagoons, bays and so on. Underground transmission lines are technically feasible but are too expensive. Negative environmental impacts of transmission lines are caused by construction, operation and maintenance of the whole system. Clearing vegetation from sites and for the right-of-way s and the construction of access roads, towers, and substations are some of the sources of construction related impacts (see Appendix 2).

Effects on Land Use

Electricity power transmission lines have the greatest impact on land resources. Grazing and other agricultural activities are possible under the right-of-way though other uses are generally not. For instance residential development within the right-of-way is prohibited by the VRA which has acquired such land. The reason is that some evidence suggests that health hazards may exist due to electromagnetic fields created by the transmission lines. Although not wide right-of-way s can interfere with or fragment existing land uses. Construction of right-of-way can result in the loss of habitat and vegetation if the minimum ecological balance for survival of certain species is disturbed.

5 Estimating Emissions in the Electric Utility Industry

5.1 Introduction

As can already be seen from the previous chapter, power generation, transmission and distribution can raise issues concerning the construction and production activities they generate and the effects of these on the environment. With sufficient care, however, the provision of the infrastructure necessary for growth and poverty reduction can be consistent with concern for the natural resources and the global environment (World Bank, 1994). The range of environmental issues varies not only with the type of power plant, but also with each location. As more thermal plants are constructed in the country, major environmental issues will shift towards those associated with such plants. Air and thermal discharge will be more important with such plants. In this chapter our focus is on three air pollutants - CO_2, SO_2 and NO_X.

5.2 Estimation of Emissions from Power Generation

All fossil fuel power generating technologies have the serious drawback of producing substantial amounts of air pollutants, and there is a large amount of solid waste in the case of coal. The most notable air pollutants are nitrogen oxides, sulphur dioxide and carbon dioxide, which contribute to acid rain and global warming. In meeting its growing electricity needs, Ghana has already introduced fossil fuel-based power generation into its electricity system. This is based on a long-term power expansion programme that VRA has planned to undertake. Different scenarios have been developed under which power plants of different sizes would be brought on stream. The estimation exercise will be based on these capacity expansion scenarios. Attempt is made to factor in potential impact of the reform through tariff rationalisation. It is assumed that the likely increase in tariffs as a result of the reform would have impact on electricity consumption among the different customer classes.

5.3 Model, Data and Underlying Assumptions

The model simulates generation systems over a 16-year period in order to determine emission levels. The model is designed by specifying the following information:

- Electricity demand (existing and projected) and/or generation required.
- Generation development plans including plant types.
- Plant efficiency figures (for hydro system and thermal systems).
- Emission factors for CO_2, SO_2 and NO_X. The IPCC default emission factors (IPCC, 1996) are used.
- Load factors over the simulation period (1997/98 - 2013).
- Sulphur content of natural gas of 0.2% as indicated in the VRA study (GOG/VRA, 1992) was used. We also assumed 0.2% sulphur content for the distillate oil.

The authors relied on an internal study of the VRA to determine impact of rate increases, estimate rate of decline or growth of such price changes. These figures would be used to adjust the projection accordingly, and hence timing of new plant installation. To achieve the aforementioned objective, a simple simulation model was developed to estimate the emission levels under the different scenarios.

Electricity Demand Growth Rates

Electricity demand growth rates has an important impact on the level of future power plant construction, utility generation, fuel consumption and emissions4. The Acres's study, from which data input for the model are drawn, stipulates that every one percentage point of GNP growth causes 0.9 percentage point of domestic electricity demand growth. For the period 1995-2011, a projected GNP growth rate of 7% was used for the high load forecast (GOG/VRA, 1992). The low load forecast reflects the reduction in demand that would result if the higher long-run marginal cost (LRMC) tariffs are imposed. It is our proposition in this model, and indeed in the study, that the reform of the power sector will make the implementation of the LRMC tariff possible. It is assumed that with the implementation of the LRMC, demand will be reduced accordingly. The values used in the GOG/VRA's study for VRA for the elasticity of demand in response to price changes are -0.25 for residential loads and-0.10 for all other loads (GOG/VRA, 1992).

Power Plants Lifetimes

Power plant lifetimes are important factors affecting base case projections. Shorter lifetimes for fossil-fired plants would reduce projected baseline emissions. Similarly, longer lifetimes would result in higher baseline emissions. The continuing operation of the two hydroplants - Akosombo and Kpong - through refurbishing means fewer new additions of fossil-fired plants and/or development of new hydro sites.

Data Sources & Description

Most of the data for the simulation were from the VRA feasibility study for thermal power generation in Ghana (GOG/VRA, 1992). These include peak load forecast (in MW), energy forecast (in GWh) over the planning horizon used, and the generation plan. Central to the generation plan is the optimum timing of generation additions and the optimum generation plant type. In the GOG/VRA's study, quite a number of scenarios were developed. For the purpose of this study, we restrict ourselves to four main scenarios, namely, the base case, the high growth, the low growth and new hydro-thermal-import.

1. **Base case Scenario**: meeting domestic demand and contracted exports only.
2. **High Growth Scenario**: This scenario assumes a projected GNP growth rate of 7%, with a resultant energy growth rate of 6.3% between 1995-2011.

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4 Lower peak demand growth and electricity sales will result in fewer new power plants being constructed and lower utilisation of existing facilities. Higher peak demand growth and electricity sales will result in more new power plant construction, and utilisation of existing plants will affect fuel consumption and emission levels

3. **Low Growth Scenario**: This scenario reflects the reduction in demand that would result from price rationalisation associated with the reform of the power sector. Here electricity rates are assumed to be adjusted to reflect the long run marginal cost of supply of electricity.
4. **Hydro-thermal-import**: This assumes a different generation plan to meet the electricity demand in the base case.

Table 5.1 below shows the generation plans for each of the scenarios presented above. The dates in the table below have been adjusted to reflect the time the thermal plant at Takoradi came on stream. The original schedule was 1996. In view of the delay, and the start period being late 1997, we have assumed that the generation plan starts in 1997/98 and continues to 2013.

Table 5.1. Generation Plan for Different Scenarios

Year	Base Case	High Growth	Low Growth	Hydro-thermal-import**
1997/98	200 GT	200 GT	100 GT	200 GT
1999	200 CC/GT	200 CC/GT	200 GT	200 CC/GT
2000				
2001		100 OFS		
2002				
2003	100 OFS	100 OFS		
2004			100 CC	
2005		100 OFS		
2006	100 OFS			200 HP
2007		100 OFS	100 OFS	
2008		100 OFS		150 HP
2009	100 OFS			
2010		100 OFS	100 OFS	
2011	200 OFS	200 OFS	100 OFS	150 IM
2012				
2013				
Total (MW)	900	1200	700	900

GT - Gas Turbine; CC - Combined Cycle; OFS - Oil-Fired Steam; HP - Hydroplant; IM - Import of electricity
Source: Acres Feasibility Study, 1992
** Authors' own construction

The hydroplants included in column 5 are assumed to be at Bui (minimum of 200 MW) and the two sites at Juale (100 & 50 MW). The 150 MW import is assumed to be imported from the Côte d'Ivoire. The incorporation of gas turbine in the generation plan in the four scenarios presented earlier was based on the assumption that gas would come from the GNPC gas fields and/or import from Nigeria and Côte d'Ivoire. As the present operation of the thermal plant uses distillate oil instead of gas, we look at four other scenarios that assume the use of oil throughout the entire study period. These four scenarios are exactly the same as the four above. The only difference is the use of oil as feedstock to all the thermal plants in the generation plans.

5.4 Results and Analyses

This section shows projected emissions for the base case and the three other scenarios for the following pollutants: CO_2, SO_2 and NO_x. The emissions projections represent plant level generation output from the simulation model and the assumed emission factors. Tables 5.2 and 5.3 show emission levels for each of the three representative years (1998, 2005 and 2013) for each of the three pollutants under thermal generation with gas- and oil-fired plants and those with only oil-fired plants. For the purpose of the discussions in this section, these two simulation results are termed module 1 and module 2 for thermal generation with gas- and oil-fired plants and those with oil-fired plants respectively. The simulation results in module 1 are presented in Table 5.2.

Table 5.2. Selected Air Pollutant Levels - 1998 – 2013

Scenario	1998	2005	2013	1998	2005	2013	1998	2005	2013
	CO_2 Emissions 1000 tonnes/year			SO_2 Emissions 1000 tonnes/year			NO_x Emissions 1000 tonnes/year		
1	645.0	1261.9	2875.2	0.018	0.475	2453.0	1725	3343	7517
2	645.0	1978.8	4028.1	0.018	1390.0	3925.0	1725	5196	10498
3	329.4	828.3	2026.1	0.018	0.018	1472.0	0.881	2215	5315
4	645.0	1125.8	1426.0	0.018	0.018	0.000	1725	3010	3813

Under module 1, the main observations are:

- All the pollutants show an upward trend over the study period as it is expected. Furthermore, the results show that there are significant increase and decrease of all pollutants relative to the base case with respect to high growth and low growth scenarios respectively.
- Taking 2013, for instance, the CO_2 emission under the high growth scenario is projected to increase by 40% over the base case; in the low growth case, CO_2 emissions is projected to fall by 29%. It is projected to fall by 50% under the hydro-thermal-import scenario (see Figure 5.1). In absolute terms, power plants in the high growth scenario would emit in 2013 about 4 million tonnes of CO2 into the atmosphere; and about half of that under low growth scenario.
- For the same year (2013), SO_2 emissions are projected to increase by 60% under the high growth scenario; to fall by 40% and 100% under the low growth and hydro-thermal-import scenarios respectively (see Figure 5.2) all in relation to the base case.
- Similar observations can be made for NO_X emissions as well (see Figure 5.3). In 2013, fossil-fired power plants in Ghana would be emitting close to 10.5 million tonnes of NO_X into the atmosphere under the high growth scenario, and over 5 million tonnes under the low growth scenario.
- While Figures 5.1, 5.2 and 5.3 give a pictorial impression of the trend in the 3 pollutants, they also show the differences in emission levels of the three scenarios relative to the base case.

From the standpoint of the focus of the study, the electricity tariff rationalisation that results from the restructure of the power sector can have significant impact on the levels of emissions of these 3 pollutants as the simulation results clearly show. Since there has not been any significant fossil-fired power plants, we have no basis to compare these emissions. The Climate and Africa, Ghana Country Report (1994) cited earlier does not show the contributions of the different energy sector institutions to the those pollutants levels projected, the data produced cannot be used to do any meaningful comparative analysis.

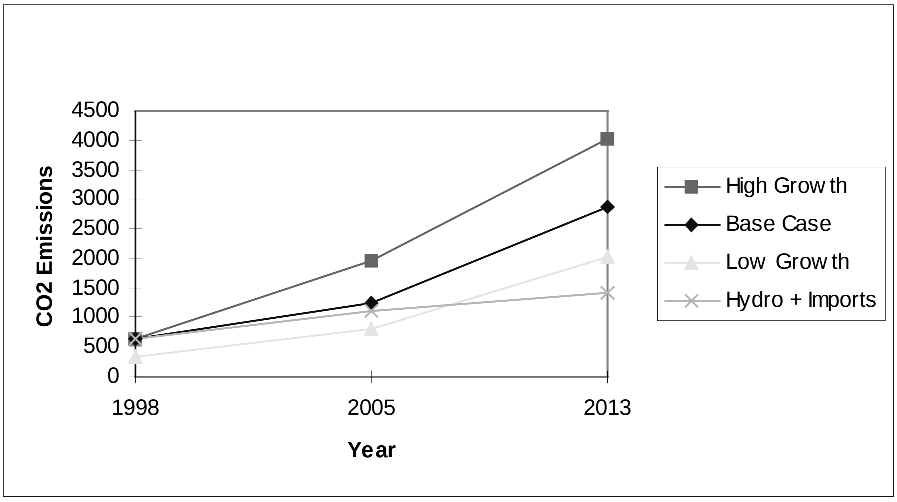

Figure 5.1. CO_2 Emission Levels-1998-2013 (1000 tonnes)

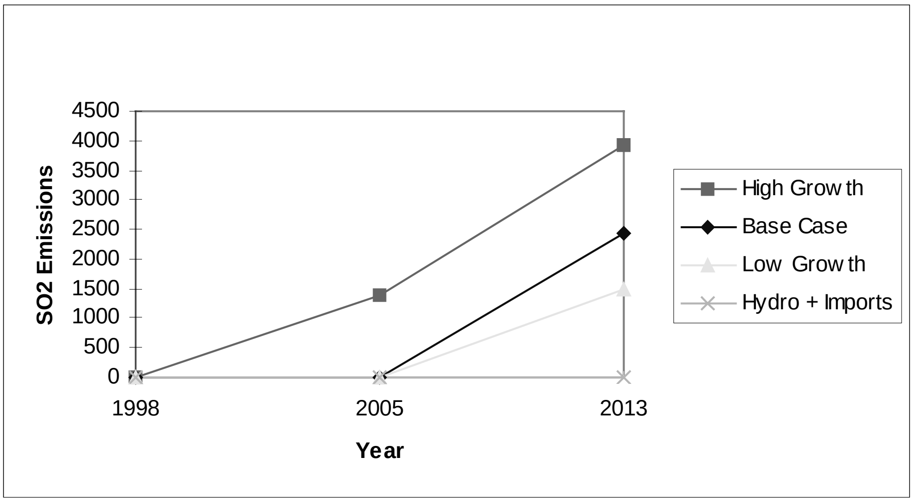

Figure 5.2. SO_2 Emission Levels-1998-2013 (1000 tonnes)

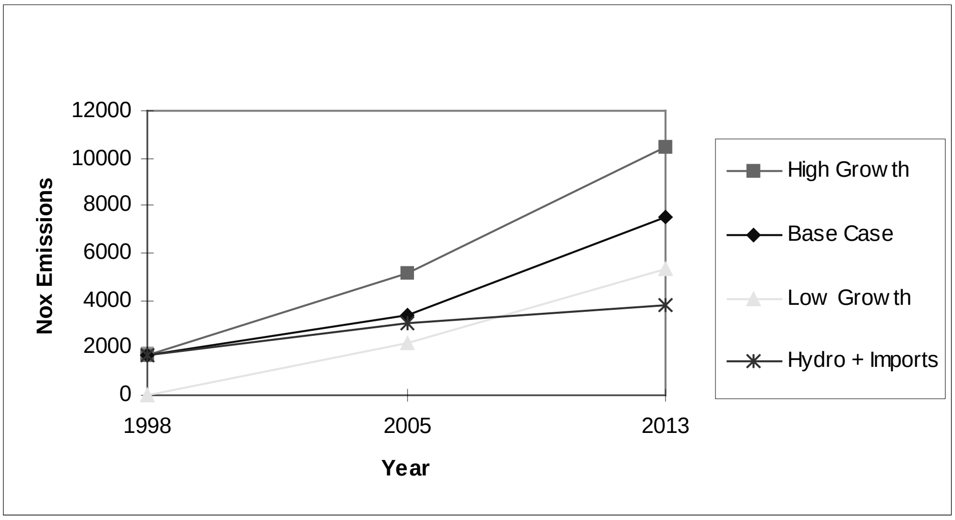

Figure 5.3. NO_X Emission Levels-1998-2013 (1000 tonnes)

As stated earlier, the scenarios developed under module 2 are based on the assumption that oil-fired plants are used in power generation in all the generation plans considered in the different scenarios. The extensive use of natural gas in the generation plans developed in the VRA study is based on the building of gas pipeline from Nigeria and Côte d'Ivoire to Ghana, and the use of domestically produced natural gas. We are assuming that this may not happen before 2013. With the assumption of oil-fired thermal plants, the simulation model results indicate that the levels of the emission of the 3 pollutants increase for all scenarios (see Table 5.3).

Table 5.3. Selected Air Pollutant Levels - 1998 - 2013 (Only Oil as input)

Scenario	1998	2005	2013	1998	2005	2013	1998	2005	2013
	CO_2 Emissions 1000 tonnes/year			SO_2 Emissions 1000 tonnes/year			NO_X Emissions 1000 tonnes/year		
1	884.2	1599.1	3236.7	1129.0	2041.0	4132.0	2287	4135	8367
2	884.2	2316.0	4389.6	1129.0	2956.0	5604.0	2287	5989	11348
3	449.0	1137.0	2357.1	0.573	1451.0	3009.0	1162	2941	6093
4	884.2	1547.3	1966.5	1129.0	1975.0	2510.0	2287	4001	5084

Similar observations can be made for all the scenarios in module 2 as was in module 1. Figures 5.4, 5.5 and 5.6 show that the scenarios in this module (i.e. module 2) exhibit a similar trends as those in module 1. The interest is in the changes that results from the changes in assumption. Comparisons of the base case, high growth and low growth scenarios in module 1 with the same scenarios in module 2 show that, in 2013 for instance, CO_2 emissions in the base case (module 2) is projected to increase by 13% over the base case in module 1; and similarly have a projected increase of 9% and 16% for the high growth and low growth scenarios respectively. Significant increases are, however, seen under SO_2 emissions. For instance, in 2013, a 69% projected increase in base case SO_2 emissions in module 2 over that of the module 1 base case. A 104% increase in low growth scenario in module 2 over that of module 1. In the hydro-thermal-import scenario, the results show a zero SO_2 emissions (module 1) in 2013 to 2.5 million tonnes of SO_2 emissions in the same year under module 2.

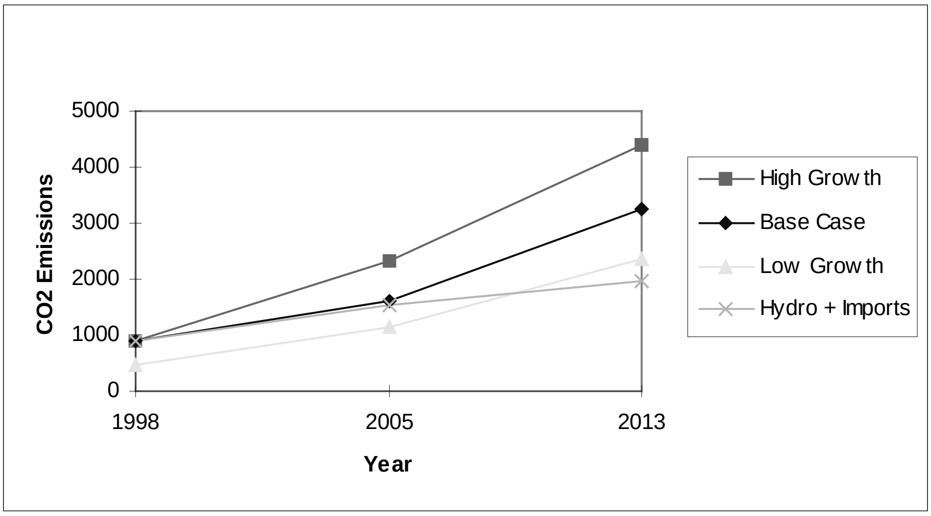

Figure 5.4. CO_2 Emission Levels-1998-2013 (1000 tonnes)

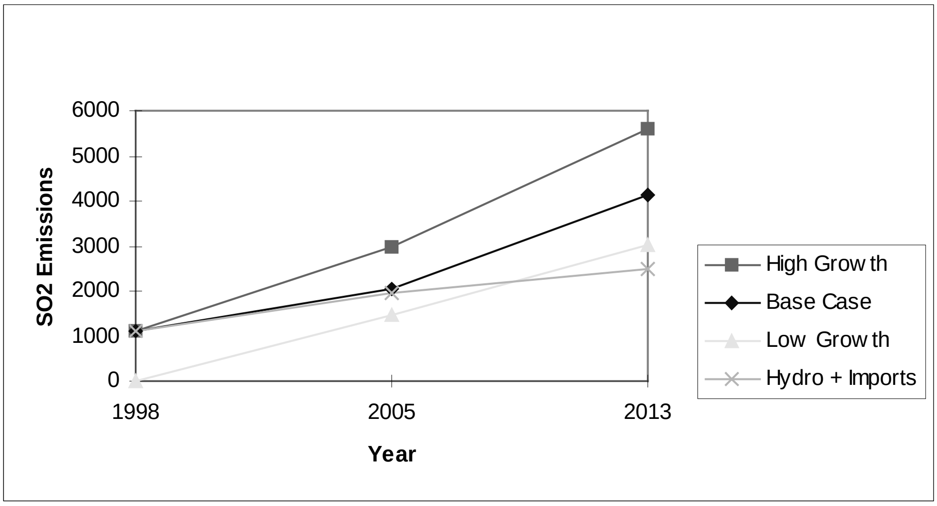

Figure 5.5. SO_2 Emission Levels-1998-2013 (1000 tonnes)

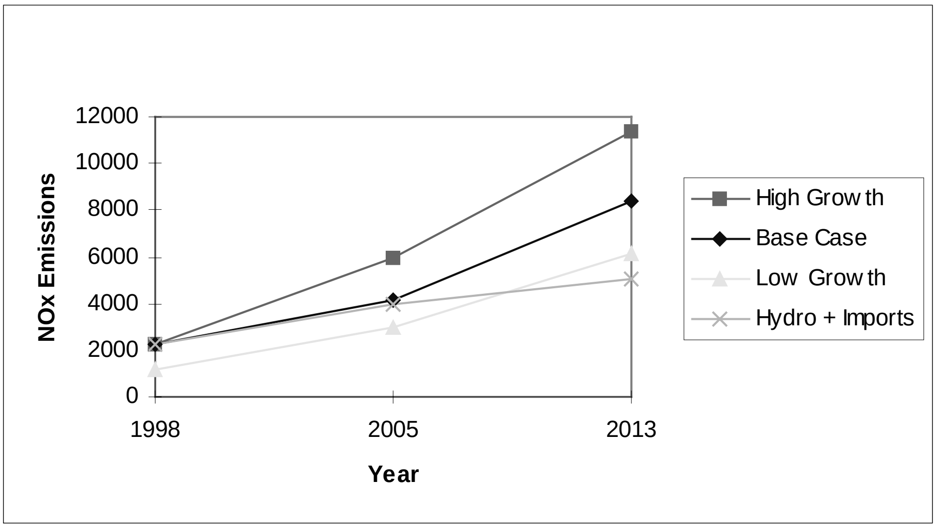

Figure 5.6. NO_X Emission Levels-1988-2013 (1000 tonnes)

5.5 Remarks on the Results

The results of the model serve as a pointer to the trend in the levels of three pollutants as Ghana strives to meet the increasing domestic demand for electricity and commitment to export markets. Comparing projected emissions under the base case to the high growth scenario, impacts attributable to the high growth scenario are projected to be quite significant, that is, there are high emissions for all the pollutants. Similar comparison between the base case and the low growth scenario show significant decrease in projected emissions for all pollutants. This is even more significant as Ghana's potential hydro sites, with the exception of a couple of sites, cannot generate more than 100 MW. Power sector development would need to consider the impact of alternative expansion strategies on these air pollutants.

As Ghana restructures its power sector, with the introduction of LRMC pricing as an important aspect, scenario 3 could well be the most attractive option to the extent that the pricing system sends a better signal to prospective investors, and also causes demand for electricity to fall or grow at a slower pace. This could lead to less thermal additions and by implication low emissions of these and other pollutants.

The results of the model show the future trend of these emissions. They show increasing trends in these emissions, albeit at different rates in relation to the different scenarios. At this stage in the power sector development, the choice of fuel for power generation may not be a serious concern. However, as new generation capacities are installed to meet growing domestic and external electricity demand, attention would definitely shift to the contributions of power plants to emissions (notably CO_2) and other pollutants such as NO_X and SO_2. This then would call for more regulatory measures to deal with them.

Trends in energy use are good indicators of future emission trends. This has been clearly shown by the results of the simulation model. As more fossil-fired plants are built, by implication, more fossil fuel - oil and natural gas - would be used, and consequently more GHG pollutants would be emitted.

Protecting health by reducing high levels of pollution is only one of many challenges. Air quality programmes compete with the need for housing, sanitation, education, safe drinking water, medical care, transportation and economic development (Hall, 1995). These are the reasons why, as Ghana introduces fossil-fired power generation systems, efforts have to be made to ensure that realistic air quality standards are set and enforced. A careful combination of Command and Control mechanisms and economic instruments are necessary in order to avoid the situation of spending huge sums of money in the future to clean up the air. The next part deals with the framework and capacity available in Ghana to undertake the appropriate regulatory activities.

Part 3

Mitigating the Environmental Impacts of the Power Sector Reform

6 Environmental Regulatory Frame work and Power Sector Activities

6.1 Introduction

In general, regulatory and economic instruments are both needed to implement environmental policy. Economic instruments including pollution charges, marketable permits, subsidies, deposit and penalties and liabilities are some of the available instruments/tools for environmental regulation. In this chapter we examine the extent to which existing institutions can apply any of these in Ghana. The structure, functions and capacities of the institutions are examined first.

6.2 Existing Environmental Regulatory Institutions

The Environmental Protection Agency

The Environmental Protection Agency (EPA) was created by Act 494. The EPA law rightly transformed the Environmental Protection Council (EPC) from an organisation that was primarily concerned with research and advisory functions without power to enforce any measures for improving the environment or preventing damage to it. The EPC had been established in 1974 by the military government through the National Redemption Council Decree 239 (NRCD 239).

The change in the law that allows for enforcement of environmental regulations and other instruments is a significant one. The EPA law has been seen as a product of changing times and the emergence of fresh challenges and ideas. More importantly it is a response to the deficiencies experienced in the operations of NRCD 239. The main functions of the EPA as provided by the law are given in Box 6.1.

Box 6.1. Environmental Protection Agency Act, 1994, (Act 490)

> In 1994 the functions of the Environmental Protection Council were reformulated and the council itself renamed the Environmental Protection Agency through the promulgation of the Act 495. The functions of the Agency include:
>
> a) to advise the Minister responsible for the environment on the formulation of policies on all aspects of the environment and in particular make recommendations for the protection of the environment.;
> b) to co-ordinate the activities of bodies concerned with the technical or practical aspects of the environment and serve as a channel of communication between such bodies and the Ministry;
> c) to co-ordinate the activities of such bodies as it considers appropriate for the purpose of controlling the generation, treatment, storage, transportation and industrial waste;
> d) to secure the collaboration with such persons as it may determine the control and prevention of discharge of waste into the environment and the protection and improvement of the quality of the environment;
> e) to issue environmental permits and pollution abatement notices for controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or other source of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or any segment of the environment;
> f) to issue notice in the form of directives, procedures or warnings to such bodies as it may determine for the purpose of controlling the volume, intensity and quality of noise in the environment;
> g) to prescribe standards and guidelines relating to the pollution of air, water, land and other forms of environmental pollution including the discharge of wastes and the control of toxic substances;
> h) to ensure compliance with any laid down environmental impact assessment procedures in the planning and execution of development projects, including compliance in respect of existing projects;
> i) to conduct investigations into environmental issues and advise the Minister thereon;
> j) promote studies, research and analysis for the improvement and protection of the environment and the maintenance of sound ecological systems in Ghana;
> k) to initiate and pursue formal and non-formal education programmes for the creation of public awareness of the environment and its importance to the economic and social life of the country;
> l) to promote effective planning in the management of the environment
> m) to develop a comprehensive database on the environment and environmental protection for the information of the public;
> n) to conduct seminars and training programmes and gather and publish reports and information relating to the environment;
> o) to impose and collect environmental protection levies in accordance with this Act or any other regulations made under this Act;
> p) to co-ordinate with such international agencies as the Agency considers necessary for the purpose of this Act; and
> q) to perform any other functions conferred on it under this Act.

By the powers conferred on the EPA by this Act, the agency has drawn up guidelines for implementation of environmental regulation. It stresses the need to promote socio-economic development within the context of prescribed acceptable environmental standards and safeguards.

6.3 Activities of the EPA

Act 490 mandates the agency to ensure compliance of all investments and undertakings with laid down environmental impact assessment procedures in the planning and execution of projects including existing ones. In 1989, environmental impact assessment (EIA) became a requirement to enable the EPA screen, and evaluate all developments, undertakings, projects and programmes which have the potential to give rise to significant environmental impacts.

The EPA has issued procedures for EIA in Ghana. An Environmental Assessment form has been designed and can be obtained from EPA offices in all the ten regions of Ghana, district, municipal and metropolitan assemblies. EIA procedures include those for registration, screening, scoping, terms of reference, environmental impact statement preparation, environment impact statement review, environmental permitting decision, preliminary environmental report, fees, post-audit, environmental management plans, annual environmental report, and penalties, (See Box 6.2)

Box 6.2. Environmental Protection Procedures in Ghana

1. Registration with EPA
2. Screening within 25 days from registration in which the EPA makes one of the following decisions
    - Objection to the project
    - No objection to the project
    - Preliminary EA required
    - EA required
3. Scoping which identifies all key issues of concern. If adverse impacts are likely environmental impact statement (EIS) is required
4. Terms of reference

    Must indicates what EIS will include

    10 copies must be submitted to the EPA

    EPA must review outcomes within 15 days and indicate if
    - Rejection
    - Revision/Modification is required
    - Acceptance/approval
5. Draft EIS preparation
6. Draft EIS review
    - 10 copies submitted to EPA
    - Copies made available to appropriate district, municipal and metropolitan assemblies
    - 21-day public notice of EIS publication served by the EPA
    - If strong public concern, public meeting is held
7. Environmental Permitting Decision

    (a) EIS of not more than 150 pages is required
    - If draft EIS is acceptable, a final one is prepared
    - 10 hard copies and a soft copy are required
    - Investor is issued with Environmental Permit (EP) in 15 days
    - If draft EIS is not acceptable, a revised EIS may be submitted later

    (b) Preliminary Environmental Report (PER)
    - This must provide sufficient information on the project whether an EIS is required or not. If EIS is required, then EP cannot be issued.
    - If PER is acceptable, then EP may be issued

    (c) Registration
    - If no information is required beyond registration, an EP is issued.
8. A fee is paid prior to receiving an EP.
9. EPA undertakes environmental audits during programme activities.
10. The first Environmental Management Plan (EMP) is required after the first year of operation. One is required every three years.
11. Projects covered by EIS and/or EMPs must submit annual reports on operations.
12. Penalties are imposed on violations of any of the above requirements.

Source: Constructed from EPA Guidelines

6.4 Collaborating Agencies in Environmental Protection

More agencies are concerned with environmental issues than is often realised. In some cases the agencies themselves are probably not aware of the environmental issues they ought to address. Below, in Table 6.1, is a table of some agencies and their areas of concern, which may impact on the environment.

Table 6.1. The Environment and Institutions

AGENCY	RESPONSIBILITY	COMMENTS
National Development Planning Commission	Policy, planning, implementation and monitoring all aspects of development to fulfil long term objectives	Will be concerned that the national long term perspectives enshrined in Vision 2020 are not lost to short run exploitation
Department of Forestry	Primarily, management of forest reserves	Monitors effects of power supply on forests. Will encourage best practice
Game and Wildlife	Preservation of primary and natural forests and other natural habitats	May argue for restraining where game and wildlife are threatened
Town and Country Planning Department	Responsible for order in land use development	Restraining through use of zoning and other regulatory provisions
The Environmental Protection Agency	Advises government on environmental matters	Umbrella organisation for restraining institutions
Ghana Water and Sewerage Corporation	Overall responsibility for ensuring good quality water supply	Together with others will act as principal institution
Volta River Authority	Electricity power generation, transmission and distribution	Has already initiated environmental protection practices. Others are expected to build upon this experience
Environmental NGOs	Concerned with environmental issues and also promoting public awareness	May be a strong force for initiating resistance to environmental degradation
Ministry of Mines and Energy	Policy, planning, co-ordination and funding energy supply e.g. the NES	In pushing its mandate towards the achievement of increased power supply the Ministry may be more supportive irrespective of consequences
Ministry of Environment, Science and Technology	Overall oversight of environmental issues and policies	Will provide ministerial support to EPA in environmental protection
Police and Legal system and DAs, RCCs	Enforcement of law and order	Tough, credible enforcement of general laws will be important

Source: Authors' construct

DAs = District Assemblies; RCCs = Regional Co-ordinating Councils

All these institutions could be important in ensuring that the power sector restructuring will not lead to compromising the their defence of an aspect of the environment. In order to achieve this, the institutions may have to be integrated in the planning of the power sector restructuring. Concerted efforts through national, regional and district institutions, laws and regulations, expertise and delivery mechanisms will enhance environmental protection.

6.5 Strengths and Weaknesses: Environmental Regulatory Institutions

The main environmental institution is the EPA. In the discussions that follow we will examine whether the structure, activities or provisions of law represent a key weakness or strength in environmental protection in the power industry.

Composition of the Governing Body of EPA

The law provides for a board as the governing body of the agency. The carefully defined representation on the board represents a major strength of the regulatory framework. The chairman of the board, to be appointed by the President in consultation with the Council of State, must be knowledgeable in environmental matters. Other members of the Board include the executive director of the Agency, a representative each from the Ghana Standards Board, and the Council for Scientific and Industrial Research (CSIR) with ranks not below principal scientific and research officers respectively.

Representatives not below the rank of director must come from the ministries of responsible for environment, local government, finance, health and education. In addition, there must be a representative from the Association of Ghana Industries (AGI) and three other persons one of whom shall be a woman. Of these last three, one person must be knowledgeable in finance or commerce. All these people must have knowledge, expertise and experience in matters relating to the environment.

The National Environmental Action Programme

One of the main outputs of the Environmental Protection Agency is the national Environmental Action Plan, EAP. The formulation of an environmental action plan as far back as 1994 is a positive step in itself. It indicates that there is a great awareness of the need for environmental protection.

A close examination of the action plan reveals that a lot more work needs to be done as far as energy production and its effect on the environment is concerned. The EAP has outlined a number of activities and their environmental impacts on various receiving media. The activities are agriculture (crops, grazing, forestry, hunting) and industry (mining, manufacturing and urbanisation). There is no mention of energy production.

The clearest statement concerning energy and the environment in Ghana’s environmental action programme (EAP) relates to the need for environmental education and management of natural resources. For Ghana, a country that constructed the world’s largest dam for hydroelectricity with all its attendant environmental effects, the omission is serious. With the size of projected energy needs the environmental impacts will be large and without an effective regulatory framework for environmental protection the country could be heading for an environmental disaster.

Committees and Regional Offices

The EPA law makes provision for the establishment of committees for such functions as the Board may determine. In addition, the Agency must establish offices in all ten regional capitals of the country. In some special cases offices may to be established in districts. Properly constituted, committees could be a strong link in environmental protection especially at the local level. Again, potentially, this is a strong provision for environmental protection. However staffing and skill levels of the regional offices make them incapable of undertaking effective environmental protection activities.

Environmental Impact Assessment

In the provision for enforcement, the law vests the agency with power to request for environmental impact assessment and prohibit any activity based on the results of the impact assessment. There are penalties for non-compliance. The procedures developed and outlined above are a powerful tool for protecting the environment. In addition to the EIA, the EPA can request for information, from any person, it considers reasonably necessary for the purposes of this Act. Non-compliance is punishable by a fine of ¢2 million or imprisonment or both. The stated monetary penalty has become useless as a deterrent for any industry due to the rapid erosion of the value of the domestic currency. Using 1998 foreign exchange rates, this works to only $850.

National Environment Fund

The law provides for the establishment of a national environment fund to be used for environmental education of the general public, research studies and investigations relating to the functions of the Agency, human resource development and other purposes as may be determined by the Board in consultation with the Minister responsible for the environment. Three years after the promulgation of the law, no NEF has been set up. While the provision for the establishment of the fund for the stated purposes is a major strength for environmental protection the inability to carry out essential provisions is symptomatic of a general weakness on the part of the Agency.

Coherence and Independence of Institutions

Converry (1995) has observed that effectiveness of the institution responsible for the [environment] will come from a structure that is coherent and sets the standards and norms for protection. Such an institution must be free from political interference in evaluating individual cases.

So far EPA has not experienced any direct interference. This could be because regulations currently applied are not stringent enough to warrant such methods of evasion from compliance. Indeed political interference may come in the form of an over-emphasis on the importance of a particular economic sector that tends to override environmental considerations. One may rightly suspect that this is already the case with the mining sector. It is likely to be so with power production as the current electric power crisis continues.

Institutional Interaction

Legally, environmental protection of new industrial establishments leaves much to be desired. Establishments are approved and then required to obtain clearance from the EPA. It is almost impossible not to approve an activity that has been given the green light by another government institution. The sequence for environmental approval is clearly faulty and may largely be ineffective. An example of such a situation is the granting of licenses for mining. In this case, the Mining and Minerals Law requires the applicant for minerals rights to show financial, employment and other particulars to of his operations with copies to the Minerals Commission, Lands Commission and the Forestry Commission. There is no mention of the requirement for submission to the EPA.. Nothing is said about what will be done with such submissions but the Chief Inspector of Mines is empowered to inspect the area of mineral operations and ascertain whether any nuisance is created.

Electricity Laws

The existing electricity laws do not explicitly provide for environmental protection. The relevant ones are the ECG, VRA, National Energy Board (NEB), the PURC and Energy Commission laws. All these laws have references to the efficiency in the production of electric power. This may be taken to include efficiency in the utilisation of natural resources which implies environmental protection. But this could probably be a leap in faith as utility companies may simply strive for efficiency in terms of their costs and revenues, which at the same time may be detrimental to the environment.

Both VRA and ECG are required by their respective laws to ensure environmental protection. Indeed, the VRA has over the years pursued environmental protection activities. The latest is the tree cover project for the watershed area of the Volta Basin. However, this may not always be the case.

Another important point that must be made here is that at that time, all government institutions were thought to act in the interest of society and so neither VRA nor ECG could do anything to the contrary. Such a view, whether expressed or implied has not been borne out by experience. Indeed one of the world's most damaging environmental disasters is the pollution of the Aral Sea, which was caused by public companies in the Former Soviet Union. Clearly, the absence of a specific law for electricity production with provision for environmental protection is a major weakness. General environmental protection laws are not specific enough to deal with power production effects.

Relevant guidelines

The EPA, the Energy Commission and the Public Utilities Regulatory Commission have the mandate to issue specific guidelines for the development of the power sector and this is a very strong point for the regulatory institutions.

Guidelines on the power sector must recognise the fact that electrical power development causes environmental impact. Secondly it must recognise that environmental impact can be minimised by planning, design and management. The Ministry of Mines and Energy, the EPA and the Minerals Commission have experience in drawing up such guidelines as indicated earlier. To be really effective, guidelines drawn up must address both the existing power institutions and those yet to be established including IPPs. Projects must be planned in an environmentally sensitive manner with appropriate pre-emptive or mitigating measures and safeguards in the design.

6.6 Environmental Protection Instruments

No matter the structure of the environmental protection institutions both regulatory and economic instruments are vital for its success.

Regulatory Instruments

Regulatory instruments or as they are called, command and control methods are often a necessary complement. Command and control instruments include standards, permits and licenses and land and water use controls. Regulation requires detailed knowledge and continual monitoring of the activity concerned. The regulatory menu includes problem identification, fact-finding, rule making and enforcement. These requirements underscore the importance for correcting the weaknesses identified above. The strengths must further be supported for the EPA and others, to enable them carry out their duties.

Standards for Environmental Regulation

There are four types of standards that the regulator could use:

- ambient environmental quality standards, AEQs
- emission (to air) standards or effluent (to water or land) standards
- technology-based standards
- product based standards

Ambient environmental quality (AEQ)

AEQ and emissions are inversely related. The higher the emissions the lower the AEQ. The aim of regulation is to set AEQ at a desirable level. Emissions and output are often linked through technical coefficients of production for example tonnes of SO2 per unit of energy output and quantity of energy per unit of economic output.

Emission and Effluent Standards

These take the form of the maximum allowable concentration or quantities of pollutants that may be emitted. These standards are more suited for point sources in which there is a single point of emission and difficult for non-point sources in which pollution emanates from different sources. Emission standards are easier to monitor where there are established emission coefficients as with energy sources.

The main characteristics of emission standards are:

1. Standards are technology based
2. Standards are often specific to industry
3. Standards distinguish between old and new sources
4. Standards are usually uniform

Technology-based standards

Best Available Technology (BAT) is one of the most popular environmental protection standards. It requires the use of a pollution prevention technology that has been defined for producers. This tends to lock the polluter in high cost solutions to the problem at hand. Some exemption is given for old plants understandably because of too high a cost of retrofitting or the old plant is given a time schedule to catch up. One effect of this procedure is to delay the introduction of new plants. The existing plant is used more intensively and may actually increase pollution. Technology-based standards therefore tend to be inefficient due to high cost of compliance and possibly higher levels of pollution than might have occurred

Zoning and land use control

Pollution tends to be regulated through the use of AEQs in combination with prescriptions of the best available technology. Pollution may be regulated by land use control whereby certain uses of land or technology are not allowed in particular zones. In general a large number of considerations may be useful to the regulator in environmental protection and include Life cycle and Intergenerational impact; Cumulative and Impact Equity; Proxy site analysis; Research and Development; Innovations; Technical Assistance and technology transfer; Auditing; Monitoring and Disclosure; and Co-operation with other agencies. These are considered in turn below.

Life Cycle and Intergenerational Impact

This criterion deals with both time and geography. Both are less certain and important for a proposed policy. Such impacts can be evident during project assessment. Producers must clearly indicate how these considerations affect their production activities.

Cumulative Impact and Equity

This involves the estimate of current impact of generating and transmission facilities. It also estimates the cumulative impact of upgrading and adding new facilities. Baseline environmental data is required to assess current levels of environmental impact.

Proxy Site Analysis

Proxy site analysis enables producers to anticipate what site-specific impacts might be. Proxy site analysis reveals the type of site required for a facility and provides some idea of the constraints on location. For example, certain thermal plants must be located near the sea in order to have adequate water for cooling.

Research and Development

Systematic studies undertaken to establish facts or principles to discover and to make technological advances. Research must not be left to only research institutions. Research by producers, perhaps in collaboration with established research institutes and the universities are important.

Innovations

Innovations transform scientific discoveries into beneficial uses. Producers could be required to introduce innovations in generation, transmission and distribution of power.

Technical Assistance and Technological Transfer

Environmental regulation could be more effective with more knowledge about mitigation factors to those who cause the problems. Best management practices must be available to producers or professionals assigned to mitigation activities. While it could be a requirement on producers to initiate mitigation measures, the transfer of appropriate technology for that purpose from probably a regulatory body is most helpful.

Auditing

Environmental auditing are visits by experts to sites where pollution is generated, for example electricity generating plant, where experts could meet to observe and suggest improvements.

Monitoring and Disclosure

This is a scheme that requires polluters to monitor and report emissions to enable government enforcement of rules for example SO_2 from power plants. Public disclosure enhances enforcement through activities of public interest and individual law suits. No programme of controls can be effective without a commitment to monitoring and enforcement.

Co-operation with Other Agencies

More agencies are concerned with environmental issues than is often realised. In some cases the agencies themselves are probably not aware of the environmental issues they ought to address. Below is a table of some agencies and their areas of concern on the environment.

All these institutions could be important in ensuring that the power restructuring will not lead to compromising the their defence of an aspect of the environment. In order to achieve this, the institutions should be able to co-ordinate their activities. Concerted efforts through national, regional and district institutions, laws and regulations, expertise and delivery mechanisms will enhance environmental protection.

6.7 Economic Instruments

Economic instruments are mechanisms in which the cost of a natural resource or receiving environment is adjusted to reflect the external and user costs involved. The process of adjusting the price is beneficial to the environment. The instruments are called economic or market-based instruments because they affect cost and hence market behaviour. The principal attribute is to rely on market forces to induce a change of behaviour and achieve a desired target (e.g. a desired level of pollution, a desired level of protection of biodiversity and so on).

There are two main ways in which cost can be affected. One is through taxes or charges. A tax operates as an additional cost of production. It therefore affects price or profits or both. The other is through tradable quantity restrictions. A quantity restriction that cannot be traded is not an economic instrument but an example of command and control, the regulatory procedure in which environmental quality standards are set and must be obeyed.

The OECD (1991) has provided a useful checklist of economic instruments and the circumstances under which they may be applied . The regulatory body in collaboration with the Environment Protection Agency may need to assess critically which ones could be adopted. In this section the definition, advantages, appropriateness relevance to environmental media and the critical issues that arise in the application of economic instruments are provided.

Fees and Taxes

A fee is assessed on emissions for example SO_2 from a power plant or on a product of a polluting activity for example electricity. Fees are theoretically possible to implement in Ghana but this becomes effective only after the prices of electricity have been rationalised. It is currently very difficult to achieve marginal cost pricing along the traditional view in which environmental considerations have not been factored in.

Subsidies and Tax Credits

Subsidies and tax credits are measures designed to reduce the cost of environmental regulation. The government could provide matching grants for various improvements carried out by companies. This form of regulation will not be feasible for economies trapped for cash like that of Ghana. A clean environment is a public good that may be recognised by the government but the provision of matching funds is almost impossible in the short run.

Emission Charges

The characteristics of emission charges are set out in Table 6.2 below. One potential draw back in its application in Ghana would be the fact that complex monitoring may be required. The EPA does not have the capacity for that at present.

Table 6.2. Emission Charges

Definition
Charges on the discharge of pollution to air, water or soil
Advantages
- savings in compliance cost
- dynamic incentive to reduce pollution
- raise revenues
- flexibility of response
Appropriateness
- mainly stationary sources
- marginal abatement cost must vary
- monitoring of emissions must be feasible
Relevance to Environmental Media
Water: high
Air: medium to high, easiest where emissions are estimated by fuel consumption
Waste: medium
Noise: high
Issues
- complex monitoring may be required
- how to allocate earmarked revenues

Marketable or Tradable Permits

Marketable permits involve quotas, allowances or ceilings on pollution emission. The total amount of pollution is determined or established by regulation by an appropriate authority. Permits are then allotted among polluters. Those generating plants or power companies who reduce pollution below their allotment can sell or trade surplus permits to others. In the USA for instance, the Tennessee Valley Authority (similar to the VRA) has purchased SO_2 permits from Wisconsin Power and Light. The objective of marketable permits is to reach an overall pollution level with maximum efficiency. The characteristics of tradable permits are outlined in Table 6.3 below.

Table 6.3. Tradable or Marketable Permits

Definition Emission or resource use quotas where total of individual quotas equals environmental standard, and where the quotas are tradable.
Advantages Savings in compliance cost Enables economic growth without environmental quality reduction as new polluters can buy from existing polluters Flexibility Price of trades can be varied to reduce overall pollution e. g., price of increased pollution by one unit could be two units of reduction elsewhere
Appropriateness - Compliance cost must vary between polluters - Harvesting cost must vary if quotas relate to a resource - There must be significant number of traders - It is best applied to fixed sources - It has great potential for technical innovation - Environmental impact is independent of source location - Intermediation markets (i.e., brokers) ensure well functioning markets
Relevance to environmental media Water: low Air: high Waste: generally low but may vary with location Noise: low but impact is dependent on source
Issues Difficult to apply to more than one pollutant simultaneously Possible "hot spots" as permits become concentrated in one area Economic rents may arise and accrue to polluters unless permits are auctioned There are potential high transaction costs May be difficult to apply where a relatively sophisticated market does not exist.

Emission trading allows energy production and use for economic growth, which will be hampered under strict direct regulation. Pollution or emission charges and tradable permits are in theory, very similar. Emission charges fix the price of emissions and let the polluter determine the quantity of emissions at that price. Tradable permits fix the quantity of emissions and let the market determine the price of emissions.

6.8 Comparison of Command and Control and Economic Instruments

Although it is not suggested that either be used alone, a comparison between pure command and control instruments using various criteria may be informative. The following criteria in Table 6.4 could be considered (See OECD, 1991 and 1993):

Table 6.4. Criteria for Environmental Protection Policy

1)	***Static efficiency***. This measures the social cost of achieving a given level of environmental impact
2)	***Information Intensity***. This is the amount and availability of information necessary for the use of the instrument properly
3)	***Ease of implementation***. This deals with monitoring and enforcement issues
4)	***Flexibility***. This measures the flexibility of the instrument to changing economic conditions
5)	***Dynamic efficiency***. Incentives that the instrument creates to adopt new technology.
6)	Equity. Distributional considerations

Table 6.4. Comparison of Command & Control and Pollution Charges and Tradable Permits

Types of Instrument / Criteria	Command and control	Pollution Charges	Tradable Permits
Static efficiency	No	Yes	Yes
Information intensity	Very	Average	Low
Ease of implementation	No	No	No
Flexibility	None	Some	Very
Dynamic efficiency	No	Yes	Yes
Equity	?	?	?

Technology Based Command and Control Measures

Command and control measures have different degrees of flexibility. In one, the regulator sets the emission or receiving standard and allows the producer to choose the technology or technique to achieve such a standard. This is flexible. In another instance, the polluter is given no choice at all. After setting the standard, the regulator determines which technology or technique is best from an environmental point of view. Provided that an appropriate technology is available, that becomes the best available technology (or BAT). This is known as the technology based Command and Control and is perhaps the least flexible form of environmental regulation.

6.9 Conclusion

The EPA law is silent about the type of instrument to use for environmental protection in Ghana. However, from its operations the Agency is using C&C instruments to achieve compliance. This is supported by the standards the EPA has published with regards to affluent discharges into natural water bodies. In the attempt to introduce market-based instruments for environmental protection, efficiency and cost-effectiveness considerations should not be the only criteria, but considerations such as overall effectiveness of the economic tools, ease of implementation, equity, information requirement, monitoring and enforcement capability of the agency, political feasibility and clarity to the general public.

The preference for incentive-based or market-based instruments over C&C is largely based on theoretical efficiency advantages attributed to market-based instruments in a highly stylised situations. However, given political and technological constraints, there are some environmental problems for which incentive-based approaches are poorly suited. For example, a highly localised pollution problems, source-specific standards may be appropriate whereas for pollution problems characterised by more uniform mixing over a larger geographical areas, market-based approaches may be particularly desirable.

7 Conclusions and Policy Recommendations

7.1 Conclusions

The Ghanaian economy revived from decline in the 1970s and early 1980s to positive growth through a vigorously implemented structural adjustment programme (SAP). The SAP was essentially reform that improved economic management. A similarly matched effort has been programmed to transform the country, through greater growth rates, into a middle income country by the year 2020. Prospects for future economic growth is expected to come from increased private sector investment, which will rise from 8% of GDP in 1991 to about 20% of GDP by 2020. Total energy production has been growing steadily for twenty years from 1974. In absolute figures total energy output rose from 2850 tons of oil equivalent to 5260 tons of oil equivalent within that period.

Regardless of reform of power sector organisation, structure, regulation, emission standards from power plants and their enforcement are a key factor in determining environmental performance. Fossil fuel based generating technologies produce substantial amounts of air pollutants. Emissions of air pollutants considered in this study - carbon dioxide, sulphur dioxide and nitrogen oxides - would result from thermal addition to the existing hydro-based electrical system in Ghana. The results of the estimations done show that all the pollutants show the expected upward trend. The results indicate that the power plants would emit 4 million tonnes of $C0_2$ under High Growth Scenario and about half that under Low Growth Scenario. Similarly NO_X emissions would be 10.5 million tonnes under the High Growth Scenario and over 5 million tonnes in the Low Growth Scenario.

Remark on Results

Power Sector development would need to consider impact of alternative expansion strategies on the three air pollutants. With reform, scenario 3 becomes the most attractive option to the extent that the pricing system sends profitable signals to prospective investors. The pricing system would also cause demand to fall or grow at a slower pace.

In Ghana, there are institutions with mandates to protect the environment, the most important of which is he Environmental Protection Agency, EPA. Other institutions such as the National Development Planning Commission, NDPC the Town and Country Planning Department, the Department of Game and wildlife and so on have various interests for protecting the environment. For instance the NDPC would be interested for the environment to be protected to ensure sustainable development. With the existence of these institutions, a clear assignment of authority, adequate funding mechanisms, and institutional capacity among regulatory bodies are necessary for successfully implementing and enforcing environmental legislation.

The EPA has issued procedures for EIA in Ghana, which include those for registration, screening, scoping, terms of reference, environmental impact statement preparation, environmental management plans and penalties. It has also produced an environment action plan (EAP) for Ghana. Despite these provisions, the EPA, while operating under trying circumstances, does not appear to have adequate capacity to inspect, investigate and enforce environmental issues.

The EIA requirements are seriously weakened by the penalty for non-compliance, which is pegged at ¢2 million or about $850 (1998 exchange rate.). A National Environment Fund provided for by the law for activities related to the functions of the EPA has not been established.

7.2 Policy Recommendations

Legal Provisions

A general and unified legal framework for electric power production, transmission and distribution is needed. This must draw together all the requirements for electric power supply activities whether in the private or public sector. This may require the repeal of certain sections of the laws of existing utilities as they have become redundant. An electric power supply law will be essential to tie in all loose ends to ensure efficiency. The law must spell out all the various options of ownership, operations regulation (including price, social, economic and environmental issues).

Guidelines and Standards for Environmental Protection

Experience by EPA in producing guidelines and standards with relevant institutions for environmental protection must be utilised to produce similar ones for the electric power supply industry. Guidelines on the power sector must recognise the fact that electrical power development causes environmental damages. Secondly it must recognise that environmental damages can be minimised by planning, design and management.

Guidelines drawn up must address both the existing power institutions and those yet to be established. Provisions in guidelines must require that projects are planned in an environmentally sensitive manner with appropriate pre-emptive or mitigating measures and safeguards in the design. Some of these measures are suggested in appendices 1 to 3. Each provider may be required to institute an environmental approach guided by the following principles:

i) integrate environmental factors into business analysis and activities

ii) monitor their own compliance with environmental regulations and try to perform better than they are required to

iii) improve environmental performance continuously

iv) review regularly at board levels and make public the provider's environmental performance

v) establish a reputation for effective environmental management.

These principles may serve as the starting points and will require providers to clearly understand the impacts of their operations on the environment. Providers must design strategies to manage environmental impacts cost-effectively. As part of a self monitoring or accounting system power providers must communicate their performances and progress to the general public. Where a provider is a link in a chain of production activities, guidelines could require that the company puts in place programmes to encourage other companies along the supply chain to improve their environmental protection activities.

Because the institutional capacity for developing and enforcing environmental regulation is relatively weak, creating internal incentives for the power sector companies to expand in an environmentally- sustainable manner would avoid undue reliance on environmental regulation

7.3 Concluding Remarks

While provision of the electric power in Ghana is urgent care must be taken to avoid introducing technologies that have serious environmental effects without mitigating plans. Protecting health by reducing high levels of pollution is only one of many challenges that face a nation. Air quality programmes compete with the need for housing, sanitation, medical care, transportation, and general economic development. When considered rather late and separate from power provision expenditure, air quality improvement programmes may not be accorded the priority it deserves.

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Appendix 1

Potential Negative Impacts of Hydroelectric Projects

Potential Negative Impacts	Mitigating Measures
Direct 1. Negative environmental effects of construction : ■ air and water pollution from construction and waste disposal. ■ soil erosion ■ destruction of vegetation ■ sanitary and health problems.	1. Utilise appropriate clearing techniques, (e.g., hand clearing versus mechanised clearing). ■ Maintain native ground cover beneath lines. ■ Replant disturbed sites. ■ Manage ROWs to maximise wildlife benefits.
2. Habitat fragmentation or disturbance.	2. Select ROW to avoid important natural areas such as wildlands and sensitive habitats. ■ Maintain habitat (i.e., native vegetation) beneath lines. ■ Make provisions to avoid interfering with natural fire regimes.
3. Increased access to wildlands.	3. Select ROW to avoid sensitive wildlands. ■ Develop protection and management plans for these areas. ■ Use discontinuous maintenance roads.
4. Runoff and sedimentation from grading for access roads, tower pads, and substation facilities, and alteration of hydrological patterns due to maintenance roads.	4. Select ROW to avoid impacts to water bodies, and wetlands. ■ Install sediment traps or screens to control runoff and sedimentation. ■ Minimise use of fill dirt. ■ Use ample culverts. ■ Design drainage ditches to avoid affecting nearby lands.
5. Loss of land use and population relocation due to placement of towers and substations	5. Select ROW to avoid important social, agricultural, and cultural resources. ■ Utilise alternative tower designs to reduce ROW width requirements and minimise land use impacts. ■ Adjust the length of the span to avoid site-specific tower pad impacts. ■ Manage resettlement to minimise adverse social effects

6. Chemical contamination from chemical maintenance techniques.	6. Utilise mechanical clearing techniques, grazing and / or selective chemical applications. ■ Select herbicides with minimal undesired effects. ■ Do not apply herbicides with broadcast aerial spraying. ■ Maintain naturally low-growing vege-tation along ROW.
7. Avian hazards from transmission lines and towers.	7. Select ROW to avoid important bird habitats and flight routes. ■ install towers and lines to minimise risk for avian hazards. ■ Install deflectors on lines in areas with potential for bird collisions.
8. Aircraft hazards from transmission lines and towers.	8. Select ROW to avoid airport flight paths. ■ Install markers to minimise risk of low-flying aircraft.
9. Induced effects from electromagnetic fields.	9. Select ROW to avoid areas of human activity.
0. Impaired cultural or aesthetic resources because of visual impacts	0. Select Row to avoid sensitive areas, including tourist sites and vistas. ■ Construct visual buffers. ■ Select appropriate support structure design, materials, and finishes. ■ Use lower voltage, DC system, or underground cable to reduce or eliminate visual impacts of lines, structures, and ROWs.
Indirect 1. Induced secondary development during construction in the surrounding area.	1. Provide comprehensive plans for handling induced development. ■ Construct facilities to reduce demand. ■ Provide technical assistance in land use planning and control to local governments.
2. Increased access to wildlands.	2. Route ROW away from wildlands. ■ Provide access control

Appendix 2

Electric Power Transmission Systems

Potential Negative Impacts	Mitigating Measures
Direct 1. Vegetation damage, habitat loss, and invasion by exotic species along the ROW and access roads and around substation sites.	1. Utilise appropriate clearing techniques, (e.g., hand clearing versus mechanised clearing). ■ Maintain native ground cover beneath lines. ■ Replant disturbed sites. ■ Manage ROWs to maximise wildlife benefits.
2. Habitat fragmentation or disturbance.	2. Select ROW to avoid important natural areas such as wildlands and sensitive habitats. ■ Maintain habitat (i.e., native vegetation) beneath lines. ■ Make provisions to avoid interfering with natural fire regimes.
3. Increased access to wildlands.	3. Select ROW to avoid sensitive wildlands. ■ Develop protection and management plans for these areas. ■ Use discontinuous maintenance roads.
4. Runoff and sedimentation from grading for access roads, tower pads, and substation facilities, and alteration of hydrological patterns due to maintenance roads.	4. Select ROW to avoid impacts to water bodies, floodplains and wetlands. ■ Install sediment traps or screens to control runoff and sedimentation. ■ Minimise use of fill dirt. ■ Use ample culverts. ■ Design drainage ditches to avoid affecting nearby lands.

5. Loss of land use and population relocation due to placement of towers and substations	5. Select ROW to avoid important social, agricultural, and cultural resources. ■ Utilise alternative tower designs to reduce ROW width requirements and minimise land use impacts. ■ Adjust the length of the span to avoid sit-specific tower pad impacts. ■ Manage resettlement in accordance with Bank procedures.
6. Chemical contamination from chemical maintenance techniques.	6. Utilise mechanical clearing techniques, grazing and / or selective chemical applications. ■ Select herbicides with minimal undesired effects. ■ Do not apply herbicides with broadcast aerial spraying. ■ Maintain naturally low-growing vegetation along ROW.
7. Avian hazards from transmission lines and towers.	7. Select ROW to avoid important bird habitats and flight routes. ■ install towers and lines to minimise risk for avian hazards. ■ Install deflectors on lines in areas with potential for bird collisions.
8. Aircraft hazards from transmission lines and towers.	8. Select ROW to avoid airport flight paths. ■ Install markers to minimise risk of low-flying aircraft.
9. Induced effects from electromagnetic fields.	9. Select ROW to avoid areas of human activity.
0. Impaired cultural or aesthetic resources because of visual impacts	0. Select Row to avoid sensitive areas, including tourist sites and vistas. ■ Construct visual buffers. ■ Select appropriate support structure design, materials, and finishes. ■ Use lower voltage, DC system, or underground cable to reduce or eliminate visual impacts of lines, structures, and ROWs.

Indirect 1. Induced secondary development during construction in the surrounding area.	1. Provide comprehensive plans for handling induced development. ■ Construct facilities to reduce demand. ■ Provide technical assistance in land use planning and control to local governments.
2. Increased access to wildlands.	2. Route ROW away from wildlands. ■ Provide access control

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Abstract (max. 2000 characters)

The electric utility industries in most African countries are confronted by the twin-problem of deficient capacity and lack of adequate financial resources to undertake capacity expansion of their respective systems. The critical aspects of power sector reform taking place in many countries are the shift away from state-owned monopoly model towards private sector participation and some competition in the industry.

Hydropower plants dominate power systems in most countries in the region. Ghana, which is the focus of this study, has such characteristics. The hydrology of the river on which the two dams (Akosombo and Kpong hydropower plants) are built is increasingly becoming uncertain, and besides, the power output from the two plants is insufficient to meet the increasing electricity demand of the country. The alternative is to build thermal power plants to complement the two hydropower plants.

The purposes of the study are: (i) to assess the environmental (more specifically air pollution) implications of changing fuel mix in power generation in Ghana within the context of the ongoing reform of the power sector and (ii) to assess the capacity of the environment protection agencies to regulate, monitor and enforce regulations in the emerging electricity industry. The study uses a spreadsheet-based simulation model to determine the potential levels of certain air pollutants – CO_2, SO_2 and NO_X – that would result from changes in fuel mix for electricity generation. Using different capacity expansion options proposed for the Volta River Authority (VRA) between 1997-2013, the levels of these air pollutants are estimated. The study further describes other potential environmental impacts of changes in fuel mix in power generation.

Descriptors INIS/EDB

AIR POLLUTION; ELECTRIC POWER INDUSTRY; ENERGY DEMAND; ENVIRONMENTAL IMPACTS; FOSSIL FUELS; GHANA; HYDROELECTRIC POWER; INSTITUTIONAL FACTORS; POWER SYSTEMS

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