Chapter 4

Electricity Infrastructure and Demand in Accra
4.1 Powering Megacities in the Developing World

Efficient power supply and energy demands will be central questions in the 21st century and beyond. Mankind’s energy consumption is rising continuously and presents enormous challenges for climate protection and energy security. The International Energy Agency (IEA) predicts that worldwide energy consumption in the year 2030 will be more than 60% higher than it was in 2002. Approximately 85% of the future power supply will still be based on fossil fuels, the burning of which represents the most important driving force for climate change. Also, urban agglomerations, and in particular, megacities in developing and newly industrialized countries are important arenas for energy use and production. While cities take up only 2% of the earth’s land surface, they are responsible for three quarters of global energy consumption as well as approximately 85% of the global production of greenhouse gases. The underlying trend to urbanization (with an approximate 1.8% increase per year in the global urban population) and to the spreading of megacities is continuous. (NKGCF 2008)

Megacities offer strategic starting points for energy efficiency and climate protection. On the one hand, the concentration of people, material flows and residential districts in megacities makes it possible to reduce the consumption of resources because modern governance, planning and service concepts mean that more people can be supplied more economically using the same amount of transport, energy and space. Such gains in efficiency can flow into the surrounding suburban and rural areas, as well as into the national economy, to which large cities are integrated by means of resource flows and supply corridors. Also, the functional integration of urban industries, infrastructures and networks make the accelerated dissemination of innovations possible, not at least in the energy sector. An integrated approach to urban development is required which takes into account the overlapping fields of responsibility such as buildings, transportation networks, energy technologies, and citizen lifestyles, and integrates these into a long range planning approach. (NKGCF 2008)

Accra, Ghana is a good example of the aforementioned, following in the footsteps of its Nigerian mega-city neighbor, Lagos, and transitioning towards income inequality. While its continued expansion will further fuel energy consumption demands, innovation in technology and urban planning could set up sustainable structures and guidelines for energy demand and production which would decouple economic growth from energy consumption and lead emissions from an exponential increase to at least a flattening growth curve.

4.1.1 Electricity and the Development Context

Perhaps the most important factor in the modernization of Ghana from a third world country to an industrialized nation is the presence of modern electricity systems in its urban centers. Of all the western world’s appurtenances, none has a more profound potential to improve quality of life standards than of a modern electricity infrastructure. The presence of electricity facilities supports all public infrastructures, from transportation systems to potable water and sanitary sewer services, from medical and public education to police, fire, and telecommunications. A reliable electricity supply is critical to the realization of a modern Ghana. (National Development Planning Commission of Ghana, 2005; United Nations, 2006)

Currently there are many plans to improve electricity supply throughout West Africa. The Economic Community of West Africa States (ECOWAS) has commissioned activity that will promote the West African Gas Pipeline Project (WAGP), a primarily submarine natural gas pipe that runs about 30 kilometers off the coast from Nigeria through the Gulf of Guinea west alongside Ghana with spurs to Tema and Takoradi. ECOWAS has also promoted plans for improved transmission through its West Africa Regional Transmission Stability Study, which includes upgrading transmission lines from Volta to Aboadze and then on to Prestea from 161kV to 330kV. Both of these studies include Ghana as part of the larger ECOWAS plan for
the West African Power Pool (WAPP) which envisions a deregulated electricity market that includes all West African states and would operate in a manner similar to power markets in South Africa, Europe, or the Americas. (Nexant Inc., 2004b; The World Bank & MIGA, 2004)

There are also national commissioned plans seeking to improve electricity services across Ghana such as the Bui Dam hydro project on the Black Volta River or proposals to increase generation capacity at the Takoradi Thermal Plant. The national government has also taken steps towards consolidating and restructuring the Electricity Company of Ghana (ECG) and the Northern Electricity Department (NED) of the Volta River Authority (VRA) to promote efficient management. The Public Regulatory Commission (PURC) is considering appropriate tariffs for hydro, thermal, and renewable power generators within a system that is moving towards deregulation, and the Energy Commission of Ghana is working towards a supervisory structure to govern spot and day-ahead market operations and regulation of carbon-dioxide emissions. There have also been commissioned studies seeking to project: electricity affordability for Ghana’s largest economic sector, residential households; reduction of wood-fuel consumption when electricity services are made available; and improved indoor air quality as well as women and children’s respiratory health. (Energy Commission of Ghana, 2006; Nexant Inc., 2004b)

Currently most Ghanaians rely on wood-fuels as their primary source of energy. Of the nearly 6.6 million Tons of Oil Equivalent (TOE) produced in terms of indigenous energy, approximately 3.8 TOE was derived from wood-fuels. Of this 3.8 TOE derived from wood-fuel, about 75% is by the residential sector in the form of firewood or charcoal and predominantly used for cooking. Household consumption of wood-fuels is also one of the primary contributors to Ghana’s rapid deforestation, a loss of more than 6000 sq.km of forests since the year 2000 and 20,000 sq.km since 1990. Comparatively, only 0.5 TOE of indigenous primary energy was produced in the form of electricity from hydro and thermal sources in 2004. Of the approximately 6000 GWhs generated in 2004, more than 50% of all distribution was to residential households and more than 5000 GWhs were consumed by customers of ECG and NED. It should also be noted that the industrial and services sectors, which together account for nearly 75% of Ghana’s GDP, rely critically on electricity. (Energy Commission of Ghana, 2006; Royal Danish Ministry of Foreign Affairs & Energy Commission of Ghana, 2003; The World Bank & MIGA, 2004; United Nations, 2006)

4.2 Electricity Supply in Ghana

The key players in Ghana’s power sector are the Volta River Authority (VRA) responsible for power generation, transmission and system operation for the entire country; the Electricity Company of Ghana (ECG) responsible for distribution in southern Ghana, where most of the electricity is consumed; and the Northern Electricity Department (NED), which is a VRA subsidiary responsible for power distribution in northern Ghana. All of these agencies are owned by the Government of Ghana and regulated by the Energy Commission and the Public Utility Regulatory Commission (PURC). VALCO, which had traditionally been the largest privately owned bulk consumer of electricity, closed its Tema aluminum smelters in 2002. (Nexant Inc., 2004b; The World Bank & MIGA, 2004)

Until recently, the sole sources of power supply in Ghana were from the VRA owned hydroelectric plants of Akosombo (1038 MW, commissioned in 1965) and Kpong (160MW, commissioned in 1982), and imports from Cote d’Ivoire. Since demand was outstripping the supply from the two hydro generation stations and poor hydrologic conditions were increasingly resulting in severe power shortages (such as in 1997 and 1998), the Government commissioned a 330-MW Combined Cycle thermal plant at Takoradi in 1999. The Government followed this by further diversifying its electricity production capabilities with a second thermal plant at the same site in 2000. This second plant, which was developed through a joint-venture partnership between the VRA and CMS Energy (Jackson, Michigan, USA) is a 220-MW Simple Cy-
cle thermal plant, with the option for an additional 110-MW steam turbine, once natural gas becomes available. Currently both plants are run on light crude oil imported from Nigeria. (Energy Commission of Ghana, 2006; Nexant Inc., 2004b)

At present, the total generation capacity of the VRA is 1038-MW and 160-MW from the two hydro stations and 550-MW from the two thermal stations. The firm energy supply is made up of 4800 GWh hydro and 2500 GWh thermal, however depending on water inflows into Lake Volta, the hydro output can reach up to 6100 GWh per year. The VRA transmission network is comprised of 36 substations and approximately 4000 km of transmission lines in a loop that covers most of the country. Standard transmission voltages are 161kv and 69kv. Major transmission lines run from the hydro stations at Akosombo and Kpong to Accra and also Kumasi. Additional 161kv lines run from the thermal stations at Takoradi to Accra and also to Kumasi. Ghana’s transmission system also has major interconnections with the national electricity grids of Cote d’Ivoire and Togo extending from Prestea and Akosombo respectively. A single circuit 161kv line extends from Kumasi supplying power to northern Ghana, including a minor connection to Burkina Faso. An additional upgrade to the Burkina Faso connection has been planned as an ECOWAS-WAPP priority project. (Energy Commission of Ghana, 2006; Nexant Inc., 2004b; The World Bank & MIGA, 2004)
VRA operates a fully automated modern control center at the Tema substation. A generation pre-schedule, which covers all the generating plants of the VRA as well as in Cote d’Ivoire and Togo, is prepared daily and shared to ensure coordinated operations. All generating units and substations can be monitored from the control center. VRA also has contracts for buying and selling energy with Cote d’Ivoire and Togo, as well as the joint venture with CMS Energy at Takoradi. Tariffs for bulk consumers, including ECG, are also regulated by the Energy Commission and PURC. Action has been taken towards restructuring and cleaning up the VRA and ECG balance sheets, including debt restructuring to settle all accounts among Government entities and reduce some of the debt burden of these companies. This restructuring will enable ECG to start matching electricity demand with the necessary network upgrades and expansions. In the past, ECG has been burdened by under-investment in their power distribution system, overloaded transformers and distribution networks, and the continued use of obsolete equipment, all of which resulted in high distribution system losses and poor electricity supply, quality, and reliability. (Energy Commission of Ghana, 2006; Nexant Inc., 2004b; The World Bank & MIGA, 2004)

In parallel, Ghana is in the process of deregulating its electricity sector, which will include the introduction of an Independent System Operator for transmission management as well as private companies for improved distribution and new thermal generation facilities. This includes plans for CMS Energy to increase electricity production at the Takoradi power complex to 660-MW and operate the plant under a performance based contract. There are also plans to introduce a third, privately owned 330-MW Combined Cycle generation facility once the WAGP spur is completed to Tema. The Ghanaian Government is moving towards tighter coordination in a competitive market environment, which is expected to progress in all areas of development including institutional, legal, and regulatory arrangements. By 2020, Ghana is expecting to conduct electricity trading through day-ahead and hour-ahead markets. (Energy Commission of Ghana, 2006; Nexant Inc., 2004b; The World Bank & MIGA, 2004)

4.2.2 Electricity Sector Issues
For the past 10 years, Ghana has been struggling to meet an increasing electricity demand. From 1988 to 2002, Ghana’s electricity consumption increased at an average rate of over 8% per annum, with peak

* With the exception of G4 Takoradi Thermal 220 MW, all Electricity Generation, Transmission, and Distribution Authorities, Companies, Departments and Systems are owned by the Republic of Ghana. G4 Takoradi Thermal 220 MW is a joint venture between CMS Energy USA and the VRA.

Figure 4.2 Electricity System Status Quo in Ghana: Illustrative representation of the current state structure
power supplied by the VRA network reaching 1200 MW and total energy consumed for 2002 at 7400 GWhs. Meeting these demands has been neither cheap nor easy, with costs to generate electricity averaging 8c/kw from imported light crude oil for the Takoradi plants coupled with the severe drought conditions of the recent years which have resulted in structural deficits and the resultant load shedding. Making matters worse, both the VRA and ECG have been characterized by lack of financial discipline, below potential performance, low resource mobilization, and under-investment. This poor fiscal management is evidenced by the 144.9 million USD debt relief granted to the VRA and 95.06 million USD to ECG. (The World Bank & MIGA, 2004)

Infrastructure improvement is badly needed in order to better serve all areas of the country. Major transmission line upgrades are underway, which will increase line voltages from 161kv to 330kv. These include a third line from Volta to Abaadze (Takoradi) to transmit power east-west across the VRA network. This line will eventually tie into an upgraded 330kv line extending from Volta to Mome Hagou, Togo, east to Sakete, Benin, and on to Ikeja West, Nigeria. Along the western coast of Ghana a third line will also be installed to upgrade transmission between Abaadze and Prestea (with the Cote d’Ivoire interconnection) and on to Kumasi. Plans are also in the early stages for connecting Bolgatanga to Ouagadougou, and thus making a circuit with the Cote d’Ivoire network through Burkina Faso. (Nexant Inc., 2004b)

In 2001-2002 Purdue University undertook a Planning Study that comprehensively modeled data and information on West Africa electricity trade and capacity expansion options for the entire region. The West Africa Power Pool Electricity Data Set #6, is a ready source of technical data for modeling generation, transmission and international transactions. In 2004 Nexant incorporated the Purdue model as a primary source of information for its review of the electricity demand/supply balances in its Regional Power System Master Plan. Nexant’s analysis of generation and transmission requirements was conducted using

![Figure 4.3 VRA Supply / Demand Balance Forecast](image)
The Nexant Elfin model projects peak and energy demand forecasts for the period 2003 to 2020. In summary, total domestic consumption is expected to grow at an annual average of 6.3 percent from 2000 to 2020. The economy is also expected to grow at a rate of five percent until 2020, based on the growth rate of the past decade. It is also expected that Ghana will move toward a sustainable electricity pricing policy representing long-run marginal cost to ensure that the VRA meets its financial obligations, including commitments to purchase natural gas. A key uncertainty in the demand forecast is the supply to VALCO, which was closed in 2002 with no signs of restarting the plant in the near term. Demand forecasts in Figure 2 assume VALCO will not reopen in the near future. (Nexant Inc., 2004c, 2004d)

4.3 Electricity Demand in Accra

The Electricity Company of Ghana has subdivided Accra into 2 Regions, Accra West and Accra East, which is then further subdivided into 12 districts: Makola, Legon, Roman Ridge, Teshie, Korle Bu, Achimota, Bortianor, Dansoman, and three other districts that were unnamed at the time of the data collection. Tema is a separate region unto itself. For the purposes of the electricity demand model which will be presented in a later chapter, the following discussion of electricity demand will focus on the Korle Bu district, which is located in the Accra West Region.

4.3.1 Korle Bu District Described in Terms of Location, Area and Population

According to the 2000 census, the Korle Bu district had a population of 186,593 persons. The district is bordered by Kwame Nkrumah Boulevard along the eastern boundary, Kwame Nkrumah Circle at the

Figure 4.4 Korle Bu District and the Communities Comprising this part of Accra
northwest corner, Ring Road and then Obetsebi Lamptey Circle to the north, Eduardo Mohdlana Road along the western side, and the Gulf of Guinea to the south. The nearly 190,000 persons living in Korle Bu comprise 43,763 households of which 89,857 are men and 96,736 are women. Of these approximately 44,000 households, they occupy 10,964 residential structures which total 1,359,837 square meters in total floor area.

The property itself is subdivided from the district boundary which is 12.6 km² in area into five blocks, which have then been subsequently subdivided into rounds and ultimately into plots where buildings or structures are located. James Town and Ussher Town are two of the older communities in Accra and are also primarily residential in nature with fishing along the shoreside. Korle Gonno is one of the more heavily populated subdivisions, which is located across the lagoon. Agbogbloshie and Adedenkpo are the location of the largest market in Accra, the end of the rail line as well as one of the largest slums in Ghana. The South Industrial area is characterized by a number of large businesses including many foreign ones, while the Adabraka is directly adjacent to Kwame Nkrumah Circle to the south-west and is significantly characterized by the local business activities typical to Circle as well as some residential land uses.

Two of the more densely populated parts of Korle Bu are Ussher Town near the terminus of Kwame Nkrumah Boulevard as it intersects High Street, and Sabon Zongo to the south of Obetsebi-Lamptey Circle. Ussher Town is one of the oldest section of Accra and is the location of Ussher Fort, a British Prison that predates the Republic of Ghana. Sabon Zongo has also received notoriety for being a destination for immigrants. Much different in terms of land use composition, the South Industrial Area is characterized by a number of large businesses operating in Accra and throughout Ghana. These are some of the most
Figure 4.6 Density and Land Use in Ussher Town and Abossey Okai

Figure 4.7 Land Use in the South Industrial Park
4.3.2 Consumption by Plot and Land Use

The following figure illustrates the total electricity consumption in Kilowatt-Hours for the time period from October 2006 until January 2008. The highest power consumption is in the area of the South Industrial Area, while the commercial center on the west side of Kwame Nkrumah Boulevard (Swanzy Shopping Arcade and multiple office buildings adjacent to the south) also consumed significant amounts of electricity during this time period. The mixed commercial and residential land uses to the west of Obetsebi-Lamptey Circle in Abossey Okai, also consumed significant amounts of power.

Electricity consumption in the South Industrial Area typically ranges from 5,000 to 35,000 kWh per month, but two of the plots consumed considerably more electricity. Plot 0030 in the South Industrial Area, which is the site of Super Industries Ghana, African Concrete Products, Vicon Processing, Prestige Steel, Carbon Products, Meriplastic Manufacturing, Crown Rice Mills and many other industrial land uses, demonstrated a remarkable increase in electricity consumption. Land uses located within this plot exhibited an increase in consumption of more than 12 fold on average and a more than 200 times increase from the lower amounts of demand late in 2006 and early in 2007 to the highest mark in more than 5,000,000 kWh in August 2007, at the height of the global economic boom.
Figure 4.8. Electricity Consumption Profiles of Plots in the South Industrial Park from October 2006 until January 2008
Plots 0190 and 0200 in the South Industrial Park are also remarkable since they have demonstrated increases in electricity consumption, and strong peaks in certain months. While the consumption averages are not as significant as Plot 0030, they demands are still more than the typical consumption profile. A number of automobile dealerships are located in this area, including Nissan, Japan Motors, Kia Motors, Honda Motors as well as Silver Star, Rainbow Trading Company, Bonsu and Brothers, Presbyterian Press, Pepsi, Accra Machine Shop and Princes Cold Stock, among others. The more typical electricity consumption profile is exhibited by Plots 0090, 0100 and 0120 as illustrated in the previous figure.

Some of the more intense commercial land uses are located along both sides of Kwame Nkrumah Avenue heading south from Circle towards High Street and the Gulf of Guinea. For the purposes of this inquiry, the focus will be upon the west side of Kwame Nkrumah Avenue, since it is the eastern boundary of the Korle Bu district. Agbogbloshie and Korle Dudor are the larger communities where many commercial developments and aggregations of local commercial activities as well as informal businesses are located. The Swanzy Shopping Center, the Cocoa Board, and adjacent businesses are located in this area, as well as Ghana’s main railroad, which terminates amidst the businesses located along Graphic Road and in immediate proximity to Katamanto Market. A number of large banks are located in this vicinity, and even more so in the approach to High Street.

Typical consumption for commercial land uses are similar to those for the industrial land uses found in the South Industrial Park. While individual uses which have higher peaks are not as extreme compared with industrial activities, on the whole, commercial land uses trend towards slighter higher consumption rates, averaging from 10,000 kWh per month upwards to 50,000 kWh. The plot where the Swanzy Shopping Arcade is located exhibited the highest consumption rates, as well as noticeable increases in demand during this time period. Averages consumption rates for the local shopping center approximated 60,000 or 70,000 kWh per month late in 2006 while increasing more towards 90,000 early in 2008. Similar increases should be expected for other commercial shopping centers such as the Accra Mall at Tetteh Quarshie Interchange.

Residential electricity consumption rates typically range from 5,000 to 15,000 kWh per month as illustrated by consumption in the predominantly residential subdivision of Korle Gonno, which is directly to the south of the large institutional complex, the Korle Bu Teaching Hospital. A number of churches and schools are interspersed throughout the area, as well as commercial establishments of various sizes. Plot 130 which borders Guggisberg Avenue had a significant peak of electricity consumption (nearly 1,000,000 kWh in a single month) which approaches the outlying peaks demands from the industrial and commercial land uses. This is unusual, especially since the only significant commercial use is the Mobile Filling station and a number of other smaller commercial activities. The majority of buildings in this plot are residential as well.
Figure 4.9 Consumption Profiles of Commercial Land Uses per Plot in Agbogbloshie and Korle Dudor
Figure 4.10 Consumption Profiles of Residential Plots in Korle Gonno