ENERGY COMMISSION, GHANA

2011 ENERGY (SUPPLY AND DEMAND) OUTLOOK FOR GHANA

April, 2011

Executive Summary

Energy Commission presents 2011 forecasts for electricity, crude oil, petroleum products and natural gas.

Electricity:

The total electricity requirement of the country would be 13,000-14,000 Gigawatt-hour (GWh) of which 11,000-12,000 GWh could come from the grid or public electricity. The shortfall would largely come from private and back-up generation.

The peak demand on the grid transmission system would range from 1,610-1,720 Megawatt (MW).

Petroleum

Average price that Ghana would buy crude oil could be $93 per barrel or would lie within the range $90 and 97 per barrel.

At this crude oil price range, the supply requirement of petroleum products would likely be as follows[1]:

Total Gasoline	800,000 - 850,000 tonnes
Total Diesel	1,600,000 - 1,700,000 tonnes
Kerosene/ATK	250,000 - 300,000 tonnes
LPG	220,000 - 250,000 tonnes

NB: Total gasoline includes Premix;

Total diesel includes supplies to the mining companies and bunkering

For LPG, the total national requirement could likely be in the range of 250,000-300,000 tonnes per year due to the growing demand for LPG particularly as transport fuel. However, limited nation-wide storage capacity and the inadequate revenues generated from its sales due to cross-subsidization would constrain demand to the 220,000-250,000 tonnes range in 2011.

[1] Effective demand means the real demand would be higher but would not be met due to import and distribution constraints as average crude oil price goes over $80 per barrel.

Total crude oil requirements to meet both power and refinery operations would vary from 2.2-2.6 million tonnes (about 16-20 million barrels) of which 60-70% would be required for refinery operations depending upon the availability of the Tema Oil Refinery.

Natural gas

The current WAGPCo[2] tariff for transporting natural gas via the West African Gas Pipeline is $2.68 per MMBtu ($2.73 per mscf) for Foundation customers and $2.78 per MMBtu ($2.83 per mscf) for Standard Customers. These charges are however adjusted for inflation every calendar year and for this reason, the tariffs are being reviewed this year. If approved, the new rates for 2011 would be $3.80 per MMBtu ($3.87 per mscf) for Foundation customers and $3.90 per MMBtu ($3.97 per mscf) for Standard Customers.

Total delivered gas price to Foundation customers is currently $6.21 per MMBTU ($6.33 per mscf) and $6.67 per MMBTU ($6.79 per mscf) to Standard customers. The delivered gas prices would be adjusted correspondently when the new transportation tariffs are approved.

Total natural gas supply required to run all the dual-fuelled thermal plant in optimum mode would range from 180-200 million standard cubic feet per day (mmscfd).

The average volume of natural gas expected from the West Africa Gas Pipeline (WAGP) would range from 90-100 mmscfd and could reach 120 mmscfd upon completion of additional compressor stations on the pipeline by the middle of the year.

The following recommendations are made:

i. *Government expedite development of the natural gas expected from the offshore Jubilee oil fields. Since the thermal plants are now the marginal generators, natural gas, which is largely less expensive than LCO will help supplement oil-based generation and consequently reduce average generation cost.*

[2] West African Gas Pipeline Company Ltd.

ii. *Government speed up the passage of the Renewable Energy Law to allow wind and other bulk power renewable sources to be developed quickly to access the grid and augment supply.*

iii. *Government ensure strict enforcement of quality standards for compact fluorescent lamps.*

iv. *BOST*[3] *initiate steps to include storage of crude oil as part of the strategic stock of the country as soon as possible. Storing crude oil is quicker, far cheaper, stable and more durable compared to storing products.*

v. *Government creates attractive investment climate to encourage construction of new oil refineries to serve both the local and export markets.*

vi. *National Petroleum Authority re-introduces the national LPG promotion programme periodically to raise awareness of the dangers of careless handling of LPG accessories and usage.*

vii. *National Petroleum Authority encourages the Oil Marketing Companies to set up more LPG distribution centres to increase access and consumption.*

viii. *Government looks for alternative sources of natural gas for the power plants, besides supplies from the West African Gas Pipeline to increase gas supply security.*

ix. *In this respect, Government should proactively create incentives to encourage investment in LNG regas facility built at her coast at the shortest possible time.*

[3] Bulk Oil Storage and Transport company

Foreword

THE ENERGY COMMISSION by law, prepares, reviews and updates periodically indicative national plans to ensure that all reasonable demands for energy are met in a sustainable manner. In 2006, it released the Strategic National Energy Plan for Ghana (SNEP) covering the period 2006-2020. In addition, the Energy Commission is mandated to secure and maintain a comprehensive data base for national decision making for the efficient development and utilisation of energy resources available to the nation. Energy Commission's jurisdiction include promoting and ensuring uniform rules of practice for the transmission, wholesale supply, distribution and sale of electricity and natural gas.

In the process of implementing the above mandates, the Energy Commission, since 2009 has been preparing annual energy demand and supply forecasts to provide some guide to the energy sector operators and potential investors as well as the wider business community wishing to operate in the country. The purpose of the 2011 Annual Energy Outlook therefore is intended to give industry and business, indications of the levels/quantities of electricity, liquid and gaseous fuels that would be required and also be provided by the energy producers.

The document covers demand and supply of electricity, crude oil and products as well as natural gas. It does not cover woodfuels because we have inadequate information to make a reliable forecast. Data from the field are now being analysed and therefore hopeful, that we would able to present some results and make forecast for woodfuels in 2012 and beyond.

Petroleum products form part of government revenue sources and so prices are masked by taxes and levies. In such instances, forecast was only made for product quantities besides crude oil.

Even though, no forecast for electricity prices, higher thermal generation mix leads to higher generation cost due to increasing cost of fuel. The rate of increase is lower if more natural gas is made available to replace oil fuels in the generation mix.

In the document, 'Demand' is used when directly referring to needs of a demand sector, e.g. Residential, Commercial, or Industry. 'Supply' is used when referring to direct supply from say generation plant or refinery before transmission or distribution losses.

'Supply Requirement' is Supply or Generation/Production + transmission/transport losses. In cases of uncertainty in transport/transmission or losses, 'Supply Requirement' is used. For further elaboration, please refer to Annex of document for a schematic overview of Ghana's Energy Demand and Supply System.

This report was prepared by Strategic Planning and Policy Division of the Energy Commission and therefore answerable to all the information provided. General questions about the report should be referred to Mr. Michael Opam, (mopam@energycom.gov.gh, michaelopam@yahoo.com) Director of Planning and Policy Directorate. Specific questions about the content may be directed to Dr. Joseph Essandoh-Yeddu (essandohyj@energycom.gov.gh, jeyeddu@hotmail.com), head of Strategic Planning and Policy Division.

Comments are most welcome.

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1.0 Power Subsector

1.1 Overview of public (grid) power supply in 2010

Installed power capacity of the country increased from about 1,860 Megawatt (MW) in early 2010 to 2,185.5 MW, i.e. about 17.5% growth by December, 2010 (Table 1).

Table 1. Generation Capacity as of December 2010

GENERATION PLANT	FUEL TYPE	CAPACITY (MW)	
		Installed*	Available
Hydro Power Plants			
Akosombo	Hydro	1,020	960
Kpong	Hydro	160	140
Sub-Total		*1,180*	*1,040*
Thermal Power Plants[4]			
Takoradi Power Company (TAPCO)	LCO/NG/diesel	330	200
Takoradi International Company (TICO)	LCO/NG/diesel	220	200
Sunon–Asogli Power (SAPP)	NG	200	180
Tema Thermal Plant1 (TT1P)	LCO/NG/diesel	126	100
Mines Reserve Plant (MRP)	NG/diesel	80	45
Tema Thermal Plant2 (TT2P)	NG/diesel	49.5	40
Sub – Total		*1005.5*	*765*
Total		**2,185.5**	**1,865**

**As licensed by Energy Commission.*
NG-Natural gas; LCO – Light crude oil

Source: GridCo, 2011

Availability of TAPCO improved from 24.57% in 2009 to 52.14% in 2010[5]. This is significant because the average availability had been below 30% per annum for some time.

The total electricity generated in 2010 was 10,232.11 GWh; comprising 6,994.84 GWh (68.28%) hydropower, 3,134 GWh (30.73%) of thermal power and 95 GWh (0.98%) of imports. Hydropower generation share increased by about 8 percentage points over 2009 and energy also increased about 118 GWh due to significant water inflows into the Akosombo

[4] TAPCO is Takoradi Power Company, a combined cycle (CC) thermal plant; TICO is Takoradi International Power Company, a single cycle (SC) thermal plant
[5] Ghana Grid Company Ltd, 2011 Electricity Supply Plan.

reservoir in 2010, resulting in forced spillage of excess water from the lake[6]. Net power exported increased by 67.5% over 2009 (Table 2).

Table 2. Net Power exports since 2008.

Year	2008	2009	2010
Net export (GWh)	263	555	930

Total power transmission losses increased from 3.9% in 2009 to 4.0% in 2010 [5].

Although, there was an increase in supply to industries, the share dropped by 0.6 percentage points whilst supply to the residential sector increased by 2 percentage points in 2010 compared to the previous year. In quantitative terms, the households (residential sector) received a net more electricity of 117 GWh than the industrial sector in 2010 (Table 3)[7].

Table 3. Share of Grid Electricity Supply to the Demand Sectors since 2008

YEAR	SECTORS						TOTAL
	Industrial		Non Residential		Residential		
	GWh	*% Share*	GWh	*% Share*	GWh	*% Share*	GWh
2008	2,966	*48.1*	928	*15.1*	2,269	*36.8*	6,163
2009	2,943	*47.2*	878	*14.1*	2,408	*38.7*	6,229
2010	3,156	*46.6*	966	*14.3*	2,738	*40.4*	6,772

1.2 Comparing 2009 and 2010 forecasts

For electricity consumption in 2009, we projected under SNEP[8] that power generation required would range between 13,000–16,660 GWh (*with corresponding maximum projected demand of 1,592 MW*)[9]. This was downgraded to 8,500-10,000 GWh (*and 1,400 MW maximum demand*) due to the global credit crunch in 2008. It was assumed that VALCO smelter operations would shut down completely in 2009.

[6] Ghana Grid Company, 2011 Electricity Supply Plan.
[7] Industry (3156 less 2943=213) – Households (2,738 less 2408=330) =117 GWh
[8] Strategic National Energy Plan (2006-2020) published by the Energy Commission, 2006.
[9] if the Ghanaian economy had been growing over 7% per annum

The actual grid electricity supplied (transmitted) and our forecast for 2009 and 2010 compared as in **Table 4**. Public/grid electricity supplied thus was about 18% less than what was projected.

Table 4. Comparing Electricity forecasts and the actuals for 2009 and 2010.

	2009		2010	
	Energy (GWh)	**Maximum Demand (MW)**	**Energy (GWh)**	**Maximum Demand (MW)**
SNEP	13,161-16,660	1,592	13,848-17,484	1,691-2,051
Revised*	8,500-10,000	1,400-1,500	10,500-12,500	1,610-1,720
Actual**	8,940	1,391-1,423	10,232	1,391-1,506

**Low-side is without VALCO operations.*

*** Actuals data obtained from GridCo.[10] Low-side is Ghana/local and high-side is total system peak*

Natural gas from Nigeria for power generation was 36-38 million cubic feet per day (mmscfd) on the average, or about 30% of the contract volume of gas for Ghana. The flow picked up in April, from about 29 mmscfd to 99 mmscfd in December.

1.3 Forecast for 2011

With current GDP growth at over 7% per annum, we projected under SNEP that the total electricity generation[11] required for the country in 2011 would be 13,300-14,488 GWh with corresponding maximum peak (including suppressed demand) between 1,787-2,207 MW[12]. However, this is not attainable considering the limited installed grid power capacity in the country and also lack of significant potential import. The available demand capacity and the expected generation in 2011 are estimated at 1,865 MW and 14,051.5 GWh respectively (Table 5).

[10] 2011 Electricity Supply Plan, Ghana Grid Company.
[11] Total electricity generation=grid/public generation + private back-up generation
[12] In 2009, GridCO projected 1,777-1,978 MW for 2011.

Table 5. Generation Capacity available for 2011

GENERATION PLANT	CAPACITY (MW)		Reliability Factor	Expected Energy (GWh)
	Installed	Available		
Hydro Power Plants				
Akosombo	1,020	960	0.94	7,905.02
Kpong	160	140	0.90	1,103.76
Sub-Total	*1,180*	*1,100*		*9,008.78*
Thermal Power Plants[13]				
TAPCO (CC)	330	200	0.70	1,226.40
TICO (SC)	220	200	0.80	1,401.60
Sunon – Asogli (gas)	200	180	0.68	1,072.22
Tema Thermal Plant – TT1P	126	100	0.85	744.60
Tema Thermal Plant – TT2P	50	45	0.85	335.07
Mines Reserve Plant (MRP)	80	40	0.75	262.60
Sub – Total	*1,006*	*765*		*5,042.69*
Total	**2,186**	**1,865**		**14,051.48**

Source: Adapted from 2011 Electricity Supply Plan, GridCo, 2011.

The Potential Drivers

We project that the potential drivers for electricity consumption will be the following:

- Aluminium production should VALCO be allowed to resume operation.
- Industry besides VALCO, largely influenced by gold production.
- On going national electrification scheme.

The share of electricity supplied to the industrial sector (VALCO inclusive) been decreasing since 2000 and indeed it was the sector most severely affected during the load shedding in 2003-4 and 2007 (Table 6). The country underwent a nationwide load shedding from 2002-2004 due to low inflows into the Volta reservoir which culminated into reduced generation (about one-third to half capacity less) from nation's hydropower.

[13] TAPCO is Takoradi Power Company, a combined cycle (CC) thermal plant; TICO is Takoradi International Power Company, a single cycle (SC) thermal plant

Table 6. Grid Electricity supply, share and growth to the Demand Sectors since 2000

YEAR	DEMAND SECTORS										
	Industry			Non Residential			Residential			Total	
	1000 GWh	% Share	% Gr	1000 GWh	% share	% Gr	1000 GWh	% share	% Gr	1000 GWh	% Gr
2000	4.31	68.0	*0*	0.55	8.5	0	1.49	24	*0*	**6.34**	***0***
2001	4.33	66.4	*0.7*	0.58	8.9	*8.0*	1.61	25	*7.9*	**6.53**	***3***
2002	3.90	63.2	*-10.0*	0.60	9.8	*4.0*	1.67	27	*3.7*	**6.17**	***-5.4***
2003	2.21	48.4	*-43.5*	0.62	13.6	*3.0*	1,73	38	*3.4*	**4.55**	***-26.3***
2004	2.03	46.0	*-8.0*	0.66	14.6	*6.6*	1.78	39	*3.2*	**4.53**	***-0.5***
2005	2.54	49.3	*25.3*	0.70	13.5	*5.6*	1.92	37	*7.5*	**5.16**	***13.9***
2006	3.59	55.2	*41.4*	0.79	12.1	*13.3*	2.13	33	*11.2*	**6.51**	***26.3***
2007	2.70	48.2	*-25.2*	0. 80	14.4	*1.5*	2.10	37	*-1.6*	**5.59**	***-14.1***
2008	2.97	48.1	*10.3*	0.93	15.1	*15.6*	2.27	37	*8.3*	**6.16**	***10.2***
2009	2.94	47.2	*-1.5*	0.88	14.1	*-5.4*	2.41	39	*6.1*	**6,23**	***1.1***
2010	3.16	46.6	*8.1*	0.97	14.3	*10.0*	2.74	40	*13.7*	**6.77**	***8.7***
Average Growth			***-0.3***			***6.2***			***6.3***		***1.7***

Note: Gr is growth

Aluminium production

Anytime however the nation experienced major or nationwide load shedding as in 2003-2004, VALCO which then accounted for 26-40% of the nation's total electricity consumption and about 50% of electricity consumed by industry was called upon to either shut down or reduced production significantly. The end thereof is that VALCO had been almost out of the electricity consumption share since 2004 except in 2006 when it was made to come on line. Since then it had never been allowed to operate beyond two potlines due to inadequate power.

For most of the local industries and also in times of supply unreliability, they had relied on own standby diesel generation where possible, or suspended production but imported finished products to maintain market shares[14].

The Volta Aluminium Company, VALCO is the country's single largest non-utility customer when in operation. The smelter has an installed capacity of 200,000 tonnes of primary aluminium production at a maximum power demand of 320 Megawatt per annum via five

[14] Association of Ghana Industries, 2010.

potlines. The fifth pot however, has not been fully available and hence the plant operated a maximum of four and a half potlines with maximum production of 180,000 tonnes per annum.

Primary aluminium production in general is energy-intensive. Electricity intensity of production at VALCO averaged 17 Megawatt-hour per tonne of aluminium in the early 1990s but has improved to the present average of 16.2 Megawatt-hour per tonne.

Aluminium smelting worldwide is very sensitive to electricity pricing and are highly correlated. Typical European smelters of similar capacities as VALCO producing between 160,000 – 180,000 tonnes of aluminium per year operate at average power prices of 2.5-3.0 US cent per unit of electricity. Plants of over 200, 000 – 250,000 tonnes capacity can operate at power prices ranging from 3 US cents to as high as 5 US cents per unit of electricity.

Aluminium has become the world's second most used metal after iron and is today the single-most important non-ferrous metal. Global demand was about 39 million tonnes in 2010 and this is projected to hit between 73 and over 100 million tonnes by 2020 with an estimated annual growth rate ranging between 6.5-10%[15] Total global aluminium production in 2010 was about 30 million tonnes, comprising 24.3 million tonnes from primary production (such as VALCO) and recycling which averaged 5 million tonnes annually. The shortfall was however saved by the global inventory which was about 15 million tonnes as at March, 2011.

Global annual aluminium demand in 2011 is estimated to range from 41-43 million tonnes. There is however enough global production capacity (including that of VALCO) estimated to expand from 64 million tonnes in 2010 to 66 million tonnes by end of 2011. Average world market price of the metal is projected to range from $2,600-$2,800 per tonne in 2011 from $2,400-2,650 per tonne in 2010 on expectations that rising oil prices would increase production costs. At these high prices and for production of 160,000-180,000 tonnes of aluminium per annum, i.e. operates three or more potlines ,VALCO could still be in business

[15] International Aluminium Institute, https://stats.world-aluminium.org/iai/stats; Alcoa group, www.alcoa.com/ extracted in March, 2011.

even at a tariff of 5-6 cents per kWh[16]. The downside is that there would not be enough electricity generation capacity to support VALCO's operations at that production level (see Table 5 above).

For VALCO to operate a maximum of two potlines, we estimate electricity requirement of **170-260 GWh** for one potline and **1,200-1,300 GWh** for two potlines in 2011.

With the almost exit of VALCO from the power consumption share, the Mining subsector of Industry which is dominated by the gold mining subsector and then the Other industries[17] have taken over the shares with the latter having the largest (Table 7).

Table 7. Industrial Sector Grid Electricity supply and shares since 2000

YEAR	INDUSTRY SECTOR								
	VALCO			MINES			INDUSTRY less VALCO less MINES		
	1000 GWh	% Share of Industry	% Share of Total Energy	1000 GWh	% Share of Industry	% Share of Total Energy	1000 GWh	% Share of Industry	% Share of Total Energy
2000	2.50	58.2	*39.5*	0.63	35.0	*10.0*	1.17	6.8	*50.5*
2001	2.56	59.1	*39.3*	0.57	32.1	*8.7*	1.20	8.8	*52.0*
2002	2.06	52.8	*33.4*	0.56	30.5	*9.1*	1.28	16.7	*57.5*
2003	0.25	11.3	*5.5*	0.57	29.3	*12.6*	1.38	59.4	*81.9*
2004	0.01	0.5	*0.2*	0.60	29.7	*13.2*	1.42	69.8	*86.6*
2005	0.26	10.2	*5.0*	0.75	33.0	*14.6*	1.53	56.8	*80.4*
2006	1.20	33.4	*18.4*	0.87	36.5	*13.4*	1.52	30.1	*68.2*
2007	0.21	7.6	*3.7*	1.00	40.4	*17.9*	1.48	52.0	*78.4*
2008	0.17	5.8	*2.8*	1.14	40.9	*18.6*	1.65	53.3	*78.6*
2009	0.01	0.4	*0.2*	1.25	43.0	*20.1*	1.66	56.6	*79.7*
2010	0.01	0.2	*0.1*	1.24	39.5	*18.1*	1.91	60.3	*81.8*

Even though the Mining subsector had lagged behind Other Industries in terms of shares, it has higher average annual consumption growth due to the increasing growth of the gold industry which accounts for about 95% of energy use in the Mining subsector[18] (Table 8).

[16] Aluminium smelter economics is as such that the high the production levels, the easier to operate on higher tariffs. Refer to SNEP

[17] i.e. excluding the mines, besides VALCO.

[18] Ghana Chamber of Mines, 2010 bulletin; SNEP (2006-2020).

Even though, Other Industry particularly manufacturing accounts for the largest (share of the Industrial GDP compared to Mining, it has been dwindling, from 49% in 2006 to about 38% in 2010. The Mining subsector which is largely the Gold industry, accounts for only about 13% of the Industrial GDP share, but the average annual growth from 2006 to 2010 was 6.8% compared to manufacturing of just 0.8%.

Table 8. Comparing annual growth rates of Industry with Residential Sector since 2000

YEAR	INDUSTRY less VALCO	MINES	*Other INDUSTRY	INDUSTRY TOTAL	RESIDENTIAL
	Percentage Growth Rate				
2000	*0*	*0*	*0*	*0*	*0*
2001	*-1.6*	*-9.8*	*2.8*	*0.7*	*7.9*
2002	*3.9*	*-1.2*	*6.3*	*-10.0*	*3.7*
2003	*6.2*	*1.9*	*8.1*	*-43.5*	*3.4*
2004	*3.2*	*4.6*	*2.7*	*-8.0*	*3.2*
2005	*13.1*	*25.7*	*7.8*	*25.3*	*7.5*
2006	*4.9*	*16.0*	*-0.6*	*41.4*	*11.2*
2007	*3.7*	*14.6*	*-2.6*	*-25.2*	*-1.6*
2008	*12.5*	*14.1*	*11.4*	*10.3*	*8.3*
2009	*4.2*	*9.51*	*0.5*	*-1.5*	*6.1*
2010	*8.2*	*0.7*	*14.9*	*8.1*	*13.7*
Av.Gr	***5.8***	*7.5*	*5.1*	***-0.3***	***6.3***

**Other INDUSTRY implies INDUSTRY less VALCO less MINES*
Av. Gr. Implies Average Growth

Gold production

Gold is a rare but precious metal. Global gold output has averaged between 2,500 – 2,600 tonnes every year since the beginning of the decade[19]. Ghana, ranks as the world's 10th – 12th producer, and at an average production of 100 tonnes per annum, Ghana's proven reserve is estimated to last for about 20 years.

Gold surpassed cocoa as the country's number one foreign exchange earner in the 1990s, and had accounted for 43-47% of merchandised export earnings since 2006[20]. Ghana's annual gold production increased from 77 tonnes in 2007 to 79.5 tonnes in 2008. We predicted that

[19] Compare with VALCO producing between 150,000 – 160,000 tonnes of primary aluminium per year
[20] Bank of Ghana Statistical Bulletin, February, 2011.

it could exceed 80 tonnes in 2010 due to favourable global price and it did, in fact reaching over 92 tonnes (2.97 million ounces) in 2010[21].

Four main factors influence gold production technology, particularly, as whether to opt for surface or underground mining. They are the richness or concentration of the ore; production costs, world market price of gold and energy price. For most surface mines in Ghana, the concentration of gold is between 2–3 grammes per tonne of ore, reducing to 1–2 grammes per tonne for workable tailings. For underground mining, concentration could go as high as 8–12 grammes per tonne of ore on the average in Obuasi underground but drops to a range of 3–5 grammes per tonne of ore for other areas of the country. In general for any given mining area, the ore is richer as one goes underground.

Electricity consumption for underground operations is about thrice that for surface mining operations. Energy intensity of surface gold mining in the country is 8-9 GWh per tonne of finished gold whilst underground mining requires between 28-29 GWh per tonne of finished gold [22].

Electricity supply for surface mining is mainly for pumping and grinding of the ore. For underground mining, besides pumping and grinding, electricity is required for operating the transport-elevators, drilling, air-conditioning and ventilation underground.

The general observation is that the ambient temperature increases by 10 degrees Celsius for every kilometre below the surface of the earth.

Most operations thus shift from underground to surface mining, when cost of electricity per production of ounce of gold exceeds about 10 percent of the prevailing world market price of gold. Surface mining is a relatively cheaper technology but has more serious environmental consequences for surrounding communities and the nation as a whole.

Gold which was around $400 per ounce in 2004 hit a record average of about $1,400 per ounce at the beginning of the year and it is projected to reach $2000 per ounce by end of

[21] 2010 Energy Outlook, Energy Commission; Ghana Chamber of Mines, 2010 report.
[22] SNEP 2006-2020, Volume 1, Energy Commission, 2006. page 34. (point 160)

2011 as the precious metal provides safe haven as well as alternative to the United States dollar (*which is said to be losing in value*) for investors worried by the general global economic uncertainty particularly of the United States [23].

Ghana's gold output in 2011 is projected to exceed 93 tonnes (3 million ounces) and could come from either surface or deep mining largely depending on the cost of energy which is elaborated below.

For the additional or marginal production of about 300,000 ounces expected this year, we forecast a range of **80-290 GWh** where the low-side represent production from surface mining and the high-side, production from deep or underground mining.

Meeting the additional power requirement however is likely to come mainly from the mining industry's own 80 MW diesel thermal plant located at Tema, the relatively most expensive grid source compared to light crude or natural gas based thermal plants. Higher electricity costs on the other hand could crimp the country's expected increasing gold output in the future.

National Electrification Scheme

The Ministry of Energy in 1989 instituted the National Electrification Scheme (NES) as Government's principal policy to extend electricity to all parts of the country over a 30-year period from 1990-2020. Around 4,813 communities have been connected to the grid achieving a national average coverage of about 67% as of December 2010[24]. All regional and district capitals have been connected to the national grid. The on-going remaining electrification is thus largely rural and also donor-driven and funding arrangement had been secured for about 3,515 communities earmarked for electrification in 2011 and beyond.

It is not likely however that all the 3,515 can be connected to the grid in 2011, but using the national average residential electricity consumption rate from 2000-2010 as the minimum growth rate and the consumption growth rate between 2009-2010 as maximum, we estimate a net electricity requirement of **172-375 GWh** for 2011.

[23] Moneynews.com, March, 2011

[24] Ministry of Energy, Power Sector, National Electrification Scheme, 2010, www.energymin.gov.gh

Also allowing for natural demand growth due the expansion of the economic, using national electricity growth from 2000-2010 as minimum and growth between 2009-2010 as maximum, we estimate additional 187-1,050 GWh to be required.

Table 9 presents the summary of the additional electricity requirement to top up the 2010 production in order the meet that of 2011.

Table 9: Summary of estimating the additional electricity requirement for 2011

Demand Drivers	**Minimum**	**Maximum**
VALCO	*One Potline*	*Two Potline*
	170 – 260 GWh	1,200 – 1300 GWh
Gold	*Surface mining*	*Deep mining*
	80 – 90 GWh	280-290 GWh
	National Average 2000-2010growth	*2009-2010 growth*
Electrification	172 GWh	373
Natural GDP growth	187 GWh	1,048 GWh
Total	**609-709**	**2,901-3,011**

We thus project that the total grid electricity required would range between **13,000-14,000 GWh,** if the average WAGP gas level is at least, 90 mmcf per day whilst crude oil price is within $90-97 per barrel and both figures stay there for 80% of the year (Table 10)[25].

Table 10. Grid Power Generation and Peak Demand forecasts for 2011.

Generation requirements GWh	**Generation Capacity GWh**	**System Peak/Maximum Demand (MW)***	**Forecasting Agency**
13,000-14,000	14,051	1,610-1,720	Energy Commission
11,959		1,509-1,748	GridCo.

**Low-side and high-side represent Ghana/local and system peaks respectively*.

[25] Ghana sourced mean crude oil price for 2010 was $80 per barrel whilst the median was $77.7 per barrel. The range through out the year was $74.7-92.4 per barrel. Source of data is Bank of Ghana. We project the $90-97 for Ghana CIf in 2011.

13,000-14,500 GWh was estimated under SNEP 2006-2020 for 2011. About 12,000 GWh is estimated to come from the grid. Shortfalls are likely to come from privately owned generation.

With the prevailing high cost of thermal fuel but with the expected good rains in 2011, we project that 65-67% of the required generation would come from hydro power, subject to availability of the generating units at 90%.

Oil required for thermal generation would range from a minimum of 600,000 tonnes to a maximum of one million tonnes, about 4-7 million barrels during the year, depending upon the availability of the thermal plants and the volatility of the oil price.

Tables 5 and 10 however suggest that supply-demand balance would be very tight due to limited reserve margin and would be difficult for plants to go on scheduled maintenance without significant impact on grid supply.

Priority Issues

We are in the fourth year since the Government distributed about 6 million energy-efficient lamps including compact fluorescent lamps (CFLs) that led to power savings of about 124MW in 2008. This however means most of the lamps are about their reaching their life span if not already done so. There may be the need to inject new high-quality CFLs by 2012 to maintain the demand-side savings cycle. We need however to monitor the quality standards of the lamps to reduce influx of fake types, since such inhibits the necessary savings.

Wind is a renewable source that can supply bulk power and be deployed within a year. but this will require enacting of the Renewable Energy Law to provide legal support for private generators accessing the national grids.

1.4 Recommendations

We reiterate as in 2010, that:

i. *Government expedite development of the natural gas expected from the offshore Jubilee oil fields. Since the thermal plants are now the marginal generators, natural gas, which is largely less expensive than LCO will supplement oil-based generation and consequently reduce average generation cost.*
ii. *The nation looks for alternative sources of natural gas for the power plants to increase and improve supply security. (This is well elaborated in 3.0 Petroleum Subsector: Natural Gas)*
iii. *Government speed up the passage of the Renewable Energy Law to allow wind and other bulk power renewable energy sources to be developed quickly to access the grid.*
iv. *Government ensure strict enforcement of quality standards for CFLs.*

2.0 Petroleum Subsector: Oil

2.1 Overview of petroleum supply in 2010

Ghana officially commissioned her first oil from the Jubilee Fields on 15th December, 2010 and lifted her first share of oil cargo of 995,259 barrels on 9th March, 2011. Initial oil production really began on 28th November, 2010 with a production of 1,792 barrels ramping up to 45,148 barrels on 30th November, 2011. Mean production in December, 2011 was 35,374 barrels a day. Oil production had averaged 55,000 barrels per day (bbl/d) since and is expected to ramp up to 120,000 bbl/d by end of 2011[26].

Total production from both the Jubilee and the Saltpond fields amounted to 1.27 million barrels in 2010 whilst 1.20 million barrels were exported. Export included about 100,000 barrels accumulated stocks at the Saltpond fields.

Imported crude however was about 11.75 million barrels in 2010 and was for primary refinery operations (56.3%) and for thermal electricity production (43.7%). Import in 2009 was about 6.6 million barrels but 28% for refinery operations.

Monthly average prices of crude oil sourced for Ghana in 2010 ranged between $74.4 per barrel (in February) and 92.35 per barrel (in December). The mean and the median were $80 per barrel and $77.7 per barrel respectively. **Table 11** compares the Ghanaian sourced prices and those of West Texas Intermediate (WTI) representing the United States and the London Brent representing Europe.

Table 11. Comparing crude oil prices Ghana traded in to those of Gulf of Mexico and the North Sea

	Ghana	**WTI Gulf Coast/ United States**	**Brent Crude North Sea/ United Kingdom**
2009	62.0	62.0	50.0
2010	80.0	79.0	70.0

Source: Bank of Ghana, LondonGasPrice.com, tradingnrg.com

[26] Source, GNPC, Press Release, 10 March, 2011.

Capacity utilisation at Tema Oil Refinery (TOR) in 2010 was about 77% which was a significant improvement over 2009[27]. However, based on international standards, 95% capacity utilization is required for refineries to achieve economic viability. Technical operational capacity of TOR is 1,995,000 per year, but actual crude throughput per year had range from 1 million to 1.6 million tonnes during regular operations since 2000, except in 2006, 2009 and 2010.

TOR refines all the crude oil needs of the country, except for consignments meant for power generation. It is a simple hydro skimming plant with a Crude Distillation Unit (CDU) of production capacity 45,000 barrels per day (bpd) and a 14,000 bpd Residual Fluid Catalytic Cracker (RFCC) unit to process RFO, a by-product of crude oil processed by the CDU, into diesel, gasoline and LPG.

The country's petroleum product requirement has however far exceeded the capacity of TOR and the shortfall currently could be estimated to range between 26-30% assuming TOR is operating at over 90% capacity utilisation[28]. Products import in 2010 was about 1.6 million tonnes[29].

2.2 Comparing 2009 and 2010 and forecasts

For 2010, we predicted that the global crude oil prices would be between $74-80 per barrel by end of September and would rise to $81-86 per barrel from October to December, 2010 and that we did not expect the average world crude oil price to go beyond $90 per barrel since the total global economy was still fragile to sustain considerable spike in price hike for more than a month. We further predicted that high crude oil prices would inhibit significant growth in consumption of petroleum products and consequently economic growth onshore.

[27] It was 25.6% in 2009.
[28] i.e. crude distillation unit, RFCC, catalytic reformer unit all working.
[29] 2000-2010 National Energy Statistics, Energy Commission, Ghana, 2011, www.energycom.gov.gh

Monthly average crude oil prices in the country were between $74.7-79.9 per barrel from January to September, 2010 except in April where monthly average was $85.65. October, November and December were $83.5, $86.1, and $92.35 per barrel respectively. These were thus within our predictions for 2010.

Except for gasoline, our forecasts for 2010 were above actual products supplied to the economy in the year (Table 12). Shortages of LPG and diesel evident by vivid vehicular queues at the various service stations during the year were indications that there supply shortfalls in the economy.

In 2009 however, LPG consumption exceeded our forecast range for that year by 60,000-70,000 tonnes whilst gasoline consumption fell by 43,000 – 63,000 tonnes. In energy terms, the shortfall in gasoline consumption was close to within the net excess consumption of LPG. This could suggest that significant number of vehicle users have shifted from gasoline to LPG as vehicular fuel.

Table 12. Comparing petroleum products supplied to the economy in 2009 and 2010[30]

PRODUCTS	2009 CONSUMPTION			2010 CONSUMPTION		
	1000 Tonnes		Net /shortfall	1000 Tonnes		Net /shortfall
	Forecast	Actual	1000 Tonnes	Forecast	Actual	1000 Tonnes
Gasoline	800- 820	757.0	(43-63)	750-800	770.2	**Within**
Diesel	1,600–1,700	1,362.5	(237.5-337.5)	1,600-1,700	1,272	(328-428)
Kerosene /ATK	330-400	214.5	(115.5-215.5)	250-300	157.7	(92.3-142.3)
LPG	150-160	220.6	60.6-70.6	220-250	178.4	(41.6-71.6)

NB: Total diesel consumption includes sales to the mining companies and bunkering.
Total gasoline consumption includes premix and other premium formulations.
Petroleum supply shortfall in brackets- red

Demand for LPG would continue to grow due to vehicle fuel-switch from gasoline to the LPG. What could curtail the LPG consumption is Government's potential inability to raise the required and adequate funds for import due to cross-subsidisation enjoyed by the product and also, physical constraint inhibiting nationwide distribution.

[30] In this analysis, products supplied to the economy were assumed to be consumed.

Fuel is a major input for economic production. It is clear from **Table 13**, that for a developing economy like Ghana, economic growth is directly and strongly related to injection of adequate energy. Experts projected real GDP growth for Ghana to increase from 4.7% in 2009 to over 12% in 2010 [31] but end of year GDP growth was 7.7%[32].

Table 13. Ghana's Oil Imports, costs and GDP growth compared

Year	Crude oil imported (million bbl)	Products imported (1000 tonnes)	Petroleum imported in US$1000 (cif)	Average Crude oil price	Real GDP at 2006 constant prices GH Cedis	Real GDP growth Rate
2006	15.0	906	1,686	66	18,705	6.4%
2007	14.6	1,200	2,145	73	19,913	5.7%
2008	13.6	1,096	2,413	98	21,592	7.3%
2009	6.6	1,890	1,472	62	22,598*	4.7%
2010	11.7	1,450	2,134	80	24,094	7.7%

Data source: Bank of Ghana, Ghana Statistical Services, 2011

2.3 Forecast for 2011

The main driver for oil forecast this year is a mix of geopolitics and petroleum demand supply fundamentals. There is also the speculation factor due to trade in oil futures. The challenge is determining the right balance.

Geopolitical issues have moved to the top of the energy agenda due to the political unrest across the Middle East and North Africa and could turn out to be as important for the global geopolitics of oil as the events in 1971 that led to nationalization of many international oil companies, and the events in Iran in 1979 which led to dramatic increases in oil prices. Thus supply security, geopolitical sensitivity, price volatility are back on the energy agenda and serve as fuel for oil and commodity price speculation. One is not sure however how long the unrest in the largely OPEC region is going to last but it is certainly likely to occupy this year.

[31] Business Monitor International, 2010
[32] Ghana Statistical Services, March, 2011, First Quarter GDP Newsletter.

Irrespective however of the geopolitical events, demand and supply fundamentals still serve as the major drivers for crude oil price volatility. We elaborate the oil and gas fundamentals as follows:

i. **Global demand growth**: The world is expected to see an increase in demand for Oil in 2011, demand worldwide would increase from 86.7-87.4 million barrels per day in 2010 to between 88.4-88.8 million barrels per day in 2011[33].

   The global demand currently would continue to be driven by Asia's demand which is responsible for 70% of the world energy growth in the past 10-15 years and in which China was responsible for 40% of it. Even though China's growth in demand for crude oil is expected to decrease between 2011 and 2012 as the country fights to cool down her economy to control growing inflation.

   Higher oil forecast is also made for Japan due to the Fukushima nuclear power accident which knocked out about 2% from her entire power capacity of 279 Gigawatt (GW). Japan's nuclear disaster has also influenced demand for energy, besides leading to new questions around nuclear safety. The obvious alternative in Japan is thermal plants for power and fuel oil for heating. This means the country would have to buy more LNG (liquefied natural gas), oil and coal to make up the nuclear energy loss. These would be pushing up the price of oil and natural gas consequently.

ii. **U.S. economy and dollar**: Despite the economic downturn, the United States is still the largest and the most important economy in the world and was responsible for about 20% of the global economy in 2010. The prevailing economic situation is still said to be sluggish and as the dollar continue to loose its global appeal and worth, investors would keep on relying on the commodity market, especially gold and consequentially, driving commodities prices up, including crude oil price. U.S EIA forecasts an average crude oil price of $102-104 per barrel in 2011 rising to $107-108

[33] IEA short term forecast, 2011; U.S EIA 2011 Short term Energy Outlook.

per barrel in 2012 for the United States[34]. This of course would cover North America, Canada though, is usually on the low-side.

iii. **Europe's recovery**: the Euro zone economy which is a key player in consuming crude oil is as large as that of the United States and for that matter equally important comprising about 21% of the global economy. Europe's recovery from the recent economic slow down could affect crude oil demand and price, but still threatened by economic and political events in Ireland and Greece and potentially Spain and Portugal. Europe is also directly and more affected by the geopolitical events in the Middle East and Maghreb region of Africa, since it gets most of its supplies from the affected regions than the United States. We therefore estimate an average crude oil price in the Euro-zone to be a wide swing ranging from $106-115 per barrel for 2011 and spilling over to early 2012, depending upon member countries' interventions using their strategic reserve stocks.

iv. **Meeting the global demand**: Global consumption has exceeded production for the past two decades and the gap on the average, is widening annually; from about 1.6 million barrels in 2002 to over 4 million barrels a day in 2010[35]. Meeting the growing demand would to come from production in OPEC and Non-OPEC countries as well as existing inventories and strategic stocks. With this trend, price is definitely going to increase in accordance with basic laws of economics.

v. **Supplies from OPEC countries** are expected to decline in 2011 due to the on-going crisis in the region but could increase again in 2012. OPEC is responsible for about 40% of the world crude oil supply. With supplies from Libya, a OPEC member almost shut, the world has to look for the alternative supply for 1.6 million barrels per day, that Libya delivers. U.S. EIA however assumes that about one-half of Libya's pre-disruption production would resume by the end of 2012. OPEC even though, has

[34] Total U.S. average price and U.S. West Texas Intermediate (WTI) average spot price
[35] BP Statistical Review for 2010.

indicated that it would sustain its current quota of 24.845 million barrels a day[36], has failed to make up the loss. Increasing prices however means more revenue for producing countries for that matter plays into the interest of some of the member countries.

vi. **Supplies from non-OPEC countries** on the other hand are expected to increase to make up the global shortfall. U.S. EIA estimates between 490-590 thousand barrels per day extra production in non-OPEC countries from 2011-2012 and is largely going to come from Brazil, Canada, China and countries that were formerly part of the former Soviet Union. However, since the extra production would still not be enough, the richest partners of the non-OPEC group who are largely OECD member countries would be called upon to dip into their strategic stocks[37].

vii. **Price speculation** due to activities of traders in oil futures cannot be ignored, unscientific, though**.** Current fundamentals place the global oil price range to between US$75-80 per barrel[38]. Speculation s estimated to account for 20-26% of the current world market oil price range.

The global economy has yet not recovered from the 2008 economic meltdown and experts believe that it can hardly contain the increasing crude oil prices. The prevailing uphill prices therefore are not sustainable and could collapse the fragile global economy on hitting $120 per barrel. Therefore, in order to curb the increasing prices, we expect interventions from OECD countries and perhaps from major OPEC members like Saudi Arabia which has the adequate spare production capacity and the reserves to do so.

Energy price forecasts are highly uncertain, yet from developments elsewhere, we expect at most two interventions from OECD countries and at least one from Saudi Arabia to make up the global shortfall and as well keep the prevailing average crude oil prices within $95-105 per barrel.

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[36] The quota was set in 2008 by OPEC. www.opec.org.
[37] Every OECD member is expected to maintain a minimum of six month daily oil consumption in strategic stock.
[38] Personal communication with Prof. Krishan Malik, President, Institute of Petroleum Development, Austin Texas and of Department of Petroleum and Geosystems Engineering, The University of Texas at Austin, April, 2011.

EIA projects that OECD inventories and stocks will fall by about 330 million barrels between 2011 and 2012 as the crisis in North Africa and Middle East continue. This means, we expect OECD to cover the global supply shortfall for 4-5 months from 2011-2012 assuming no significant rise in demand by 2012.

Global forecast: It is therefore possible that we would see between 60-120 million barrels (from OECD) and if lucky another 60-120 million barrels extra from Saudi Arabia in 2011. These should be able to maintain the global price in the range of $95-$105 per barrel, if not dipping it to $95-100 per barrel by end of 2011 as the geopolitical crisis continues.

Forecast for Ghana: Since Ghana supplies largely come from Nigeria (an OPEC country) and Equatorial Guinea (a non-OPEC country) all in West Africa, we forecast that average crude oil price that Ghana buys would be $93 per barrel, the corresponding lower and upper limits of the 95-percent confidence interval are $90 and 97 per barrel.

We do not expect our county Ghana to source her crude oil from the Jubilee fields, a high premium oil[39] which sell between $110-122 per barrel in Europe and $105-110 in the United States. Rather, it sounds more prudent to use part of Ghana's proceeds from the sales to mitigate the impact of consequential high product prices at home.

At these expected high crude oil prices, product requirements remain same as for 2010 except for gasoline. For 2011 therefore, we forecast the product requirements as follows[40]:

Total Gasoline	**800,000 - 850,000 tonnes**
Total Diesel	**1,600,000 - 1,700,000 tonnes**
Kerosene/ATK	**250,000 - 300,000 tonnes**
LPG	**220,000 - 250,000 tonnes**

NB: Total gasoline includes Premix;

Total diesel includes supplies to the mining companies and bunkering

[39] With API equal or greater that 39.

[40] Total supply requirement would be higher but would not be met due to import and distribution constraints.

Crude oil required for refinery operations would vary from 1.6-1.8 million tonnes (12-13 million barrels) during the year, depending upon the availability of the Tema Oil Refinery.

The total LPG requirement could be half met if TOR is operating at over 90% capacity on the average during the year (Table 14). This would also reduce the LPG import requirement to half of the national requirement.

Table 14. Operating performance of Tema Oil Refinery with and without the RFCC[41]

	Without RFCC		With RFCC	
	Tonne per year	**Weight %**	**Tonne per year**	**Weight %**
Technical operational capacity in tonnes	1,995,000	100	1,995,000	100
Products				
LPG	26,136	1.3	114,944	5.8
Gasoline	300,273	15.1	580,615	29.1
Naphtha	38,595	1.9	0	1.9
ATK/kerosene	270,629	13.6	270,629	13.6
Diesel	716,206	35.9	798,034	40.0
Fuel Oil	582,994	29.2	71,575	3.6
Consumption/Losses	60,379	3.0	119,930	6.0

Adapted from Tema Oil Refinery data

However, local production in the range of 30,000-70,000 tonnes since 2006 means about two-thirds or more of the national requirement would be imported. Cross-subsidization of the ex-depot price of LPG means gasoline and diesel are made to carry most of the tax and levy burden[42]. The shift from gasoline to LPG by the vehicle users also suggests the necessary revenues expected are not generated from the gasoline sales to augment or beef up LPG imports[43].

Total national LPG storage capacity is also a challenge. In summary, storage limitations and insufficient revenue generation would constrain the supply to 220,000-250,000 tonnes in

[41] RFCC is Residual Fuel Catalytic Cracker.
[42] Gasoline carries most of the levies and taxes, whilst LPG is taxed for only excise duty and debt recovery levy.
[43] LPG price for vehicular fuel is slightly higher than for domestic cylinders but still far lower in energy terms when compared to gasoline.

2011. Otherwise, total LPG requirement of the country could exceed 250,000 tonnes up to 300,000 tonnes due to the increasing requirement by the transport sector as fuel, considering that demand growth for LPG as fuel for transport in southern sector had ranged from 11-26% per year since 2006[44].

Priority Issues

We reiterate some of the areas mentioned in the 2010 Energy Outlook since they were hardly implemented.

i. Include Crude oil in strategic stocks

We are of the opinion that existing strategic stock based on products storage alone is more expensive to stockpile and in addition limits the country's ability to take advantage of any falling oil prices to the fullest. Besides, products have limited shelf life.

After 1983, most developed countries' petroleum strategic storage has been shifting towards crude oil. At the end of 2008, the United States petroleum stocks totaled 1.7 billion barrels, 59% crude oil and 41% products.[45]

ii. Expand refinery capacity as soon as possible

Crude oil in stock would still have to be refined into usable end products. With the commercial oil production, Ghana stands to gain immensely if immediate steps are taken to expand the refinery capacity of the country. It costs less to import crude oil for refining locally than importing the finished products as shown in **Table 15**.

Table 15. International Price Scale: Ratio of prices of refined product against crude oil

Products	F.O.B	C.I.F*
Crude oil	1.0	-
Gasoline	1.3	1.5 – 1.6
Diesel	1.25	1.3 – 1.4
Kerosene/ATK	1.35	1.4 – 1.5
Fuel oil	0.6 – 0.7	0.8 – 0.9
LPG	1.4	1.5 – 1.7

* *Depending upon distance for delivery*

[44] Energy Commission, Liquefied Petroleum Consumption survey, 2003-2007. Energy Survey in Households, Industries, Commercial and Services, 2011.
[45] EIA, 2009

Ghana announced her intention to expand the Tema Oil Refinery (TOR) as well as building a new refinery in the late 1990s but virtually no firm contract has been announced.

Export opportunities in the West Africa sub-region abounds and an expanded refining capacity would therefore position the country to take advantage of the inadequate refinery capacity in West Africa. Total consumption in non-refinery countries[46] in West Africa has exceeded 80,000 barrels per day (*about 4 million tonnes per annum*). Besides, Nigeria has total refinery capacity of about between 500,000 BPD (about 20 million tonnes) but production has been below 50% capacity due largely to operational difficulties. Ghana could quickly use its comparative advantage to expand TOR whilst it makes plans to construct a new refinery to meet local demand as well as targeting the economies within the sub-region, particularly those without refineries and at least, capturing 50% of market by 2020. Since, building a new refinery of about100,000 bbl per day capacity takes between 4 – 5 years, such a facility in Ghana could be operational by 2016 if construction starts in 2012.

With the limited refining capacity within the West African sub-region for the short-to-medium term, it is prudent that the right and attractive investment climate is created to encourage investment in new refineries in the country.

It must however be noted that the profitability of refinery operations is very sensitive to the capacity utilisation; 90% capacity utilisation has been accepted as benchmark for economic operations of most refineries. It will therefore not be economically wise to build say 100,000 barrel per day refinery in the short term, where capacity utilisation will be less than 80%, unless an export market is guaranteed. In this stance, locating such a 100,000 barrel per day refinery plant in the Export Processing Zone with export market as the initial target makes sense.

[46] Benin, Burkina Faso, The Gambia, Guinea Bissau, Equatorial Guinea, Liberia, Niger, Mali, Mauritania, Togo

iii. LPG Supply

Increasing refinery capacity and revamping of TOR will increase the production of LPG at TOR. Limited storage capacity however will continue to constrain local consumption as well as export.

Further, with the increasing demand for residential and commercial cooking as well as fuel for vehicles, there are fears of corresponding increment in potential fatal accidents. This however could be mitigated if the National Petroleum Authority (NPA) and Industry assist technical institutions in providing training in LPG handling and technology. Also, encourage oil marketing companies (OMCs) and the private sector to set up LPG training facilities for would-be LPG service operators, whilst NPA and OMC certify trained LPG operators.

2.4 Recommendations

We recommended therefore that[47]

i. *BOST[48] initiate steps to include storage of crude oil as part of the strategic stock of the country as soon as possible. Storing crude oil is quicker, far cheaper, stable and more durable compared to storing products.*
ii. *Government creates attractive investment climate to encourage construction of new oil refineries to serve both the local and export markets.*
iii. *National Petroleum Authority re-introduces the national LPG promotion programme periodically to raise awareness of the dangers of careless handling of LPG accessories and usage.*
iv. *National Petroleum Authority encourages the OMCs to set up more LPG distribution centres to increase access and consumption.*

[47] SNEP, 2006
[48] Bulk Oil Storage and Transport company

3.0 Petroleum Subsector: Natural Gas

3.1 Overview of natural gas supply in 2010

The volume of natural gas from the West Africa Gas Pipeline (WAGP) rose from an average of approximately 30 million standard cubic feet per day (mmscfd) in April 2010 to an average of almost 100 mmscfd in December 2010. Mean daily supply in 2010 was however about 37 mmscf (median was about 38 mmscfd), most of it (about 30 mmscfd) going to the Aboadze thermal power plant during the year. Supplies to the 200 MW Sunon–Asogli Power (SAPP) plant at Tema [49] commenced during the third quarter of the year.

The WAGPCo[50] tariff for transporting natural gas via the West African Gas Pipeline was $2.68 per MMBtu ($2.73 per mscf) for Foundation customers and $2.78 per MMBtu ($2.83 per mscf) for Standard Customers[51].

Total delivered gas price to Foundation customers was $6.21 per MMBtu ($6.33 per mscf) and $6.67 per MMBtu ($6.79 per mscf) to Standard customers.

Comparatively, average spot (Henry Hub) price in the United States was $4.38 per MMBtu ($4.46 per mcf) whilst Europe had an average of $10 per MMBtu ($10.20 per mcf) during the year[52].

Associated gas from the Saltpond fields dropped from an average range of 5-7 mmscfd during the first of the year to below 1 mmscfd during the last quarter of the year. Currently, the gas is just flared and total production during the year was 1.2 billion standard cubic feet.

Ghana commenced commercial oil production from the Jubilee field on in late November, 2011. Mean associated gas production was 26 mmscfd (median was 28 mmscfd) in

[49] Sourced information from VRA, WAGPCO and Reuter s, April 2010.
[50] West African Gas Pipeline Company Ltd.
[51] WAGPCO source, 2011.
[52] Spot prices usually do not include transportation cost.

December 2010. Oil production currently is largely within 60,000-77,000 barrels per day with the mean at around 70,000 barrels a day. The target is to reach 120,000 barrels per day by the end of the year. For every barrel of oil produced, between 1.3-1.35 mscf of associated gas is produced[53].

3.2 Comparing 2009 and 2010 forecasts

Volume of gas flowing was approximately 30 mmscfd in early 2010 and we did not expect this supply-level from Nigeria to increase significantly during the year – 2010 due to demand constraints in Nigeria. For WAGP gas therefore to increase to an average of 99 mmscfd in December was very encouraging.

Average global natural gas spot price in 2009 was between $4-4.5 per mmBtu ($4.07-4.58 per mcf). Average (Henry Hub) spot price in the United States was $4.3-$4.4 per MMBtu in 2010.

3.3 Forecast for 2011 and beyond

With the encouraging flows in December, 2010, average supply-level from Nigeria is likely to be maintained in the range of 90-100 mmscfd in early 2011 an probably ramp up to an average range of 100-120 mmscfd when the planned compressor stations are completed and become operational by mid 2011[54].

Sustainability of the high supply levels would however depend upon demand and political developments in Nigeria due to demand constraints in Nigeria (Figure). Nigeria herself is unable to achieve its domestic supply and export plans. Supply requirement totals about 5 billion cubic feet per day (bcfd) for domestic consumption, LNG contractual shipments and WAGP commitments. The country needs to develop new fields and bring on line to meet the

[53] GNPC Jubilee production reports, 2011.
[54] WAGPCo plans to commission new compressors on the pipeline by June, 2011. Information also available at www.wagpco.com

projected demand but experts in the industry do not expect even up to half supply to happen until 2016-2017 (Figure).

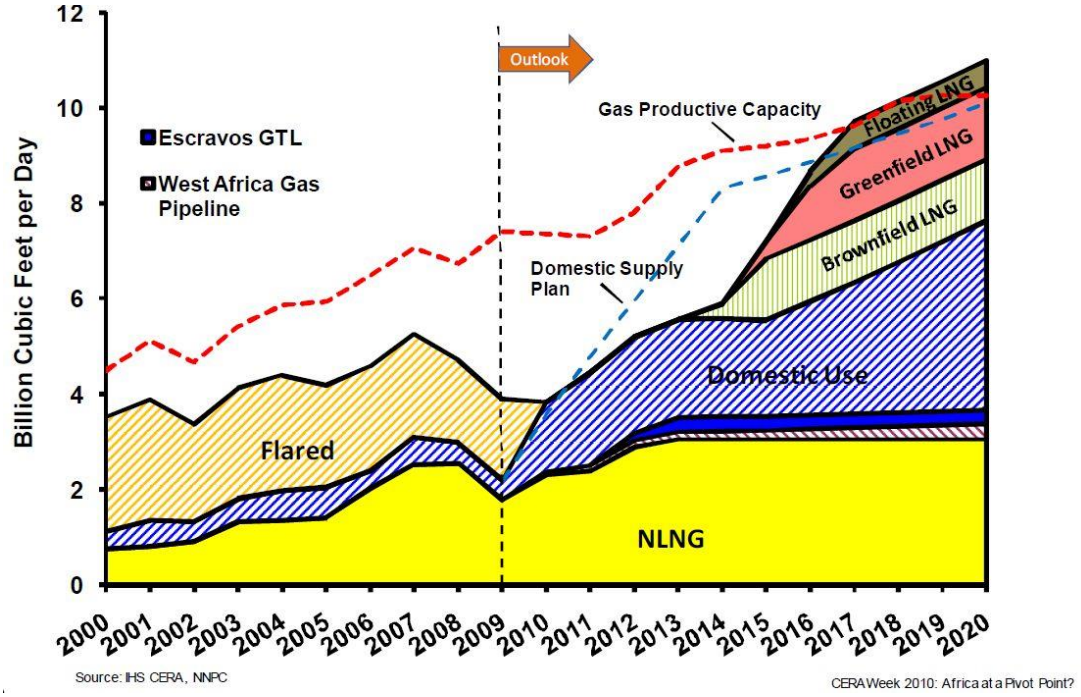

Figure . Projected Nigerian natural gas supply plan. Courtesy of CERA, 2010

Unlike crude oil, the geopolitical crisis in the Maghreb region and Middle East has affected largely natural gas supplies to Europe. International supply to North America is the least affected, thanks to productions from shale gas fields.

The WAGPCo tariffs are adjusted for inflation every calendar year and for this reason, the tariffs in 2010 are being reviewed this year. If approved, the new rates for 2011 would be $3.80 per MMBtu ($3.87 per mscf) for Foundation customers and $3.90 per MMBtu ($3.97 per mscf) for Standard Customers. The delivered gas prices would be adjusted correspondently when the new transportation tariffs are approved.

From the proposed tariffs by WAGPCo, we estimate that the new delivery gas price to Foundation and Standard customers would be in the range of **$8.8-9.35 per MMBtu** ($8.96-9.52 per mscf) all things being equal.

U.S. EIA estimates that spot price would average $4.25 per MMBtu in 2011, rising to $4.58 per MMBtu in 2012. Europe however is different, natural gas spot prices had range from $10-11 per MMBtu in 2010 and it's expected to increase to $11-12 per MMBtu in 2011.

Unlike North America and besides the high impact due to the North African crisis, Europe is yet to commence significant commercial operations in its shale gas fields due to strong debate on environmental concerns.

Priority Issues

There is currently no pipeline infrastructure to transport the associated gas being produced from the Jubilee fields, from the FPSO[55], onshore for processing. The minimal infrastructure to utilize the associated gas would consist of a pipeline to the shore and a processing plant to strip the heavier molecules for largely LPG production and other chemicals. GNPC had constructed a 14-kilometre deepwater pipeline from the FPSO, out of the 50-kilometre distance from the vessel to onshore[56].

The initial natural gas demand at Takoradi Thermal Power Plant if the pipeline were to be operational in 2006 was 36 mmscfd. With the number of thermal power plants currently installed and expected to be in operation by 2015, the current demand is between 180-200 mmscfd which is about the breakeven point for a typical 200-250 mmscfd LNG re-gasification facility. The local demand is expected to ramp up to 280-300 mmscfd by 2015 and (Table 16)[57].

[55] Floating Production, Storage and Offloading (FPSO) Kwame Nkrumah MV 21

[56] URL: http://www.ghanaweb.com/GhanaHomerPage/NewsArchive/Date: 2011-06-17, 'Energy Minister foils Hijack'

[57] See 2010 Energy Outlook, Energy Commission, 2010.

Table 16. Natural gas forecast for Ghana in mmscfd, 2011-2015

Year	2011	2012	2013	2014	2015
Min	182	200	200	256	279
Max	201	250	250	282	307

Source: Energy Commission, 2010

3.4 Alternative natural gas supply sources

Supply from the Jubilee field

During oil production, excess associated or natural gas is disposed of by direct (venting) or by controlled burning (flaring). Where technically and economically possible and attractive, the gas is re-injected into the geological formation for latter use and also for secondary recovery to enhance production. The longer however the re-injection, the likelihood of also losing some significant quantities of the gas in the geological formation, and in some extreme cases, if care is not taken, the reservoir can be ruptured consequently losing almost all the commercial operations altogether.

Under normal conditions, flaring would only take place in the start-up phase of production. Flaring of natural gas however, releases carbon dioxide, the most significant greenhouse gas into the atmosphere. Besides, it is also a resource and commodity wasted since the natural gas could be used for power production or as industrial feedstock or exported to earn foreign exchange all depending upon the quantities involved.

At the current production range of 60,000-77,000 barrels of oil a day at the Jubilee field, associated gas produced is 80-104 million cubic feet per day of which largely 4-8% is used as fuel for on-board operations. Associated gas flared had largely been in the range of 74-96% per daily production with the mean around 80%. This is not unusual, when considering that

at a water-depth of over 1,000 metres and further depth of over 3,000 metres beyond the sea floor before reaching the oil, Jubilee field is considered a very deep field oil operation. Further it is the first of it kind in the country and for that matter the geology is still not well studied. For this reason, no serious company would resort to full scale re-injection since it risks damaging the reservoir integrity. There is even uncertainty as to how long the geological formation would allow re-injection beyond 8-24 months of operation.

Flaring the excess associated gas however means the country is 'throwing away' an average of about U.S $400,000 a day if based on the U.S. average natural gas spot price or, about $1 million a day if based on the European average natural gas spot price. The 'foreign exchange' cost or the delayed cost would jump to over $600,000 and almost $2 million per day respectively when production levels at 120,000 barrels of oil (about 160 mmscf) per day.

The fact also is that the associated gas from the Jubilee field even at 160 mmscfd alone is still not adequate to meet the current gas requirements but it will for now, if added to the supplies from Nigeria.
Besides, processing the raw associated gas at 160 mmscfd will yield about 1,000 tonnes of LPG a day, which would be enough to meet the country's short term; 1-2 years demand[58].

Supply from LNG re-gas facility.

There are also opportunities for LNG supply through the following sources:

- Floating Re-gasification plants using grounded LNG vessels which have retired from services.
- Temporary or stop-gap through "Energy Bridge Re-gasification Vessels" (EBRVs)
- Permanent LNG re-gasification plants.

For N-Gas of Nigeria to limit gas supply to WAGP at contract volume of 128 mmscfd instead of the full capacity of 440 mmscfd as originally agreed in the supply contract is of

[58] Assuming short term is 1-2 years; 2011-2013 and medium term; 2013-1016.

concern but not hopeless[59]. The supply balance of 312 mmscfd reinforces the opportunity for the development of a viable LNG terminal. Furthermore, the un-utilised space in the pipeline can be used as gas storage through a technique known as "line packing" to serve as back-up for the potentially alternative gas supply sources but to only to offset very short interruptions in supply.

There are currently about 43 existing 100-200 mmcfd capacity LNG regas plants globally. 11 new ones have either been approved or under construction and 22 new projects announced (Table 17). Of course larger capacity LNG regas plants are also available.

Considering a global average gas price (Henry Hub spot average) of about US $4.3 per MMBtu ($4.4 per mscf). Assuming there is a local re-gasification plant and the re-gasification fee is $0.5-1.0 per mscf, a revenue margin of $0.5-1.0 per mscf and transport cost of $0.5-1.0 per mscf, the total delivery cost is $5.9-7.4 per mscf which translates into about US $33.8-44.5 per barrel of crude oil equivalent, and thus less expensive than the prevailing crude oil price[60].

With significant commercial shale gas discovered in North America demand pressure on global supplies is expected to reduce and natural gas global market average spot is expected to stay within US$5.5-6.5 per MMBtu for the next five years.

[59] Energy Commission source
[60] $5.9-7.4 per mscf gas price will produce electricity at 7-9 cents/kWh for combined cycle and about 8-11 cents/kWh for single cycle plants.

Table 17. Existing 100-200 mmscfd LNG plants worldwide

Continent	Country	Capacity Mmcfd	Number Installed	Existing	Status	
					Announced/ Proposed	Approved/ under construct
Asia	China	200	0	0	1	0
	India	200	0	0	1	0
		100	1	1	0	0
	Indonesia	200	0	0	1	0
	Japan	100	3	3	0	1
		200	2	1	2	0
	New Zealand	200	0	0	1	0
	Philippines	200	0	0	2	0
	Sri Lanka	100	0	0	1	0
	South Korea	200	1	1	0	0
	Taiwan	200	1	1	0	0
Europe	Belgium	100	3	3		1
	Cyprus	100	0	0	1	0
	France	100	2	2	1	0
	Greece	200	1	1	0	0
	Italy	200	1	0	2	0
	Lithuania	200	1	0	1	0
	Poland	200	0	0	1	0
	Spain	100	5	5	1	1
		200	7	7	0	0
	Netherlands	100	1	0	1	1
		200	1	0	0	1
	U.K	100	1	1	1	0
		200	5	5	2	2
North America	Dominican Rep	200	0	0	0	1
	El Salvador	100	0	0	0	1
	Puerto Rico	100	1	1	1	0
	United States	200	3	3	0	0
South America	Brazil	200	1	1	0	
	Chile	200	0	0	0	2
		100	2	2	0	0
Africa	South Africa	200	0	0	1	0
Global Total			**43**	**43**	**22**	**11**

Deployment of LNG regas facility

Permanent LNG discharge/re-gasification terminal

Development of permanent LNG re-gasification plant of 250 mmscfd capacity however require at least two years even if a project is approved and money is available today.

Energy Bridge Regasification Vessels

The energy bridge re-gasification is the one that can be delivered in the shortest possible time; i.e. within a year. Energy Bridge Regasification Vessels, or EBRVs™, are purpose-built LNG tankers that incorporate onboard equipment for the vapourisation of LNG and delivery of high pressure natural gas. These vessels load in the same manner as standard LNG tankers at traditional liquefaction terminals, and also retain the flexibility to discharge the gas in two distinct ways. These are:

- Through the EBRV's connection with subsea buoy in the hull of the ship; and
- through a high pressure gas manifold located in front of the vessel's LNG loading arms.

The maximum rate of discharge of the natural gas from an EBRV into the deepwater port is determined by a combination of the availability of capacity on downstream pipelines and the regasification capabilities of the facilities located on-board each EBRV.

Floating Re-gasification plants

Average lifetime of most LNG vessels is 25 years. This means LNG vessels built more than 25 years ago have become less competitive for transport services. Such an LNG ship is retired and reconfigured as floating LNG re-gasification facility. Typical LNG ship has capacity of 120,000-125,000 liquid cubic metres (lcm). The larger the containment the greater the application for floating storage and regasification applications[61]. Some 59 ships built worldwide before 1983 with containment between 122,000-133,000 lcm are due for retirement.

[61] Zeus Liquefied Natural Gas Report, January 28, 2009

Construction of floating regas terminals has rapidly increased since 2005 when the first one was built in Louisiana, USA. Four units were commissioned between February 2007 and August 2008. Another six are under construction; two in Brazil, one in Italy, one in Dubai, two in Chile all intending to use retired converted LNG carriers[62].

To meet the 200 mmscfd gas for the first year in Ghana will require visits of thirteen (13)-twenty (20) LNG 120,000-125,000 capacity liquid cubic metre (lcm) vessels every year for the next five years assuming natural gas supplies from Nigeria remains limited but with some additional supplies from Ghana's indigenous fields like Jubilee.

In the long term and for permanent LNG regas facility, supplies to Ivory Coast could be included as a potential market to supplement dwindling indigenous supply. One should not be surprised, if such a project end up supplying gas to neighbouring Togo and Benin in the long term, provided the WAGP facility allows reverse directional flow.

3.5 Recommendations

As more shippers move from long term to short term delivery contracts, it makes more LNG carriers readily available for supply contracts.

We reiterate the recommendation made in 2010 that:

> *Government should proactively create incentives to encourage investment in LNG regas facility built in Ghana at the shortest possible time.*

[62] Zeus Liquefied Natural Gas Report, January 28, 2009

Annex – Schematic Overview of Ghana Energy Demand and Supply System

The integrated energy supply feeds the energy-demand economic sectors comprising Residential, Commercial & Services, Agricultural & Fisheries, Transport and Industries. The Energy Supply Sector of Ghana is thus: **Biomass, Petroleum and Power (Electricity),** whilst the Energy Demand sectors of the economy are the **Residential, Commercial & Services, Agricultural & Fisheries, Transport and Industries** (Figure A1).

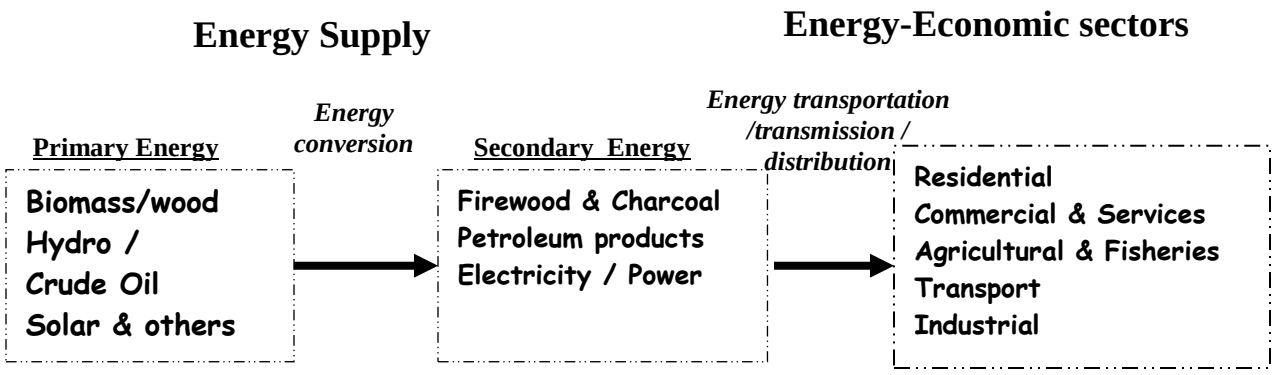

Figure A1. Energy supply continuum

ENERGY SUPPLY SECTOR	ENERGY DEMAND SECTORS OF THE ECONOMY	
	Economic Sectors	**Sub-sector classification**
Woodfuels / Biomass	Residential	Urban, Rural
	Commercial and Services	Schools, hotels, restaurants, hospitals Stores/shops
Petroleum (oil and gas).		
	Agricultural and Fisheries	Irrigation, Land Preparation and Harvest, Spraying and Logging, Post Harvest Processing, Livestock, Fisheries.
	Transport	Road, Rail, Maritime/Water, Air
Power		
	Industries	Manufacturing, Mining, Utilities, Construction, etc