ENERGY COMMISSION, GHANA

2016 ENERGY (SUPPLY AND DEMAND) OUTLOOK FOR GHANA

Final

April, 2016

Executive Summary

Energy Commission presents supply and demand forecasts for electricity, crude oil, petroleum products, natural gas and charcoal for the year 2016. Factors that could influence the demand and supply are also discussed.

Electricity

1. In **2015**, the total electricity made available for gross transmission was only 11,692 GWh as against 13,071 GWh in 2014 and 12,927 GWh in 2013; i.e. 1,379 GWh (about 12%) less than in 2014 and 1,235 GWh (approximately 11%) less in 2013. The net grid electricity transmitted[1] to the country was 11,678 GWh as against 12,906 GWh in 2014; 10% less than that of the last year and about 21-26% less than the projected requirement for the low economic growth (*for VALCO operating even at one potline)*. Consequently and as expected, the economy experienced further drop in growth of below 4%[2] compared to the previous year. Peak load on the transmission grid excluding export[3] was 1,933 Megawatts (MW); roughly 2% less than in 2014. The total (maximum) peak on the transmission grid[4] was however 2,118 MW, which was about 3% more than in 2014.

2. For the year **2016**, the total electricity requirement of the country would be as follows:

   (a) **16,798-16,900 GWh** *with VALCO operating at one potline*; to achieve a marginal economic growth of 4.0-4.5%[5] in 2016 over the previous year*;* and

   (b) **18,185-18,737 GWh** *with VALCO operating at most two potlines*; to raise the economic growth to over 4.5%.

3. The corresponding total peak demand (excluding suppressed demand) and total transmission system peak would be between 2,500-2,736 MW**.**

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[1] Gross transmission –wheeled –exports.
[2] Real GDP growth estimated between 3.5-3.9% for 2015. Sources: African Development Bank, Ministry of Finance Supplementary Budget.
[3] Referred to as Domestic Peak Load by some of the utilities
[4] Ghana Peak load + Exports
[5] Government in its 2016 Budget Statement projected 4.1% for the year

4. The grid electricity available for supply however in **2016** based on the existing and committed generation capacity expansion projects however would be **16,400-16,402 GWh**. The corresponding national peak demand (excluding suppressed demand) and total transmission system peak would be between **2,325 MW** and **2,477 MW** respectively[6].

5. This implies that the most likely achievable is Level (a) *from point 2*; provided there is adequate finance for fuel. About US$1.18 billion is required to procure fuel alone for 2016.

6. This also means there would still be some load-shedding, which might be very limited though, as long as VALCO is restricted to operating only one potline.

7. Any further shortfall in electricity supply on the other hand is likely to keep the economy at a low-growth path of 3.5-3.9% as in 2015.

8. Level (b) is only achievable if there could be significant power imports to augment the estimated local supply.

9. In the light of the prevailing electricity supply deficit, the Government of Ghana, in 2015 went for international thermal power contracts totalling over **1,000 MW** of which about 500 MW had been installed as at the beginning of 2016.

10. An additional 462 MW thermal power plant is expected to be installed in the course of the year.

Fuel for Power Generation

11. In **2015**, total gas flow was 46,911,854 MMBtu (46,912 mmscf), i.e. almost twice that of previous year; about 44% coming from Nigeria (95.4% in 2014) via the WAGP and the remaining 56% (4.6% in 2014) coming from the Atuabo gas processing plant. The total gas flow in 2014 however was 23,633,724 MMBtu (23,631 mmscf).

[6] Including supressed demand, we estimate peak load requirement to be about 2,821 MW

12. For **2016**, we project the average WAGP gas flow to be 60 mmscfd, i.e. same as last year, whilst an average of 90 mmscfd (range of 80-100 mmscfd[7]) is expected from the Atuabo gas making a total average of **150 mmscfd** or **54,900 mmscf** for the whole year.

13. we further estimate that the gas flow required for fuelling the thermal plants **in 2016** would range between **120,000-146,400 mmscf (120-146.4** bcf[8]) **or 328-400 mmscfd[9]** during the year**.**

14. An estimated available gas supply of **54,900 mmscf** in **2016** means, there would be a minimum gas supply deficit of **65,100-91,500 mmscf** which translates into initial total

    - **LCO** requirement of about **5.9 million barrels**;
    - **diesel oil** requirement of about **1.51 million** barrels; and
    - **HFO** requirement of about **2.8 million barrels**, largely by the Karpower barge.

15. 1n 2015, average delivery price of the WAGP gas was $8.75/MMBtu ($9.1/mscf) and that of the Atuabo gas was a uniform $8.84/MMBtu ($9/mscf) throughout the year.

16. For **2016**, we estimate the Atuabo gas price to remain uniform at **$8.84/MMBtu ($9/mscf)** but that of the average annual delivery price of WAGP gas to VRA to drop slightly to **$8.7/MMBtu ($8.9/mscf)** due to its indexation to price of oil[10].

17. However, since the Atuabo gas would be the dominant gas, we estimate that the total cost of gas required for **2016** would range from **$489-489.4 million**.

18. In 2015, the average delivery price[11] of light crude (LCO) for power generation was $60 per barrel.

19. **For 2016**, we expect the delivery price of the light crude to remain about the same as in 2015. The total cost of LCO required would thus be about **$354 million**.

20. For the diesel, we project the average delivery price to be about **$90** per barrel in **2016**. We thus estimate the total cost of diesel required to be around **$136 million.**

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[7] 120 mmscfd high will be reached occasionally but not likely to be in most cases.
[8] bcf is billion cubic feet or mmmscf.
[9] Low-side when the plants are operating at averagely higher efficiencies. High consumption when the plants are operating averagely low efficiencies.
[10] WAPCo sells at a lower price to VRA but the latter apparently adds administrative expenses to it.
[11] i.e. including transportation and treatment.

21. We estimate the delivery price of HFO for the Karpower Barge to be about **$72** per barrel in **2016** bringing the total cost of supply to be about **$201.6 million.**

22. In all, about **$1.18 billion** would thus be needed to procure **fuel** for electricity generation.

<u>Crude oil and Petroleum products</u>

23. In 2015, the average purchase price of Brent crude was $52 per barrel compared to $99 per barrel in 2014. Average price in 2013 was $109 per barrel.

24. Crude oil from the Jubilee field was sold at an average price of $56.6 per barrel. Average prices in 2014 and 2013 were around $96 and $109 per barrel respectively.

25. For **2016**, the average price at which Ghana would source Brent crude is expected to drop further to **$45-50** per barrel. The average price for other light crudes for refinery operations would fall within **$40-45** per barrel. Average delivery price for light crude oil for power generation would range from **$55-60** per barrel.

26. Average oil price from the Jubilee is equally likely to drop to $45-50 per barrel in **2016**.

27. In 2015, total petroleum products pumped into the economy was around 3.52 million tonnes equivalent to about 65,000 barrels per stream day refinery capacity. It comprised largely 33% gasolines and 54% diesel.

28. For the year **2016**, total petroleum products ranging between **3.7-3.9 million tonnes**, equivalent to **70,000-75,000** barrels per stream day refinery capacity would be required to enable the country meet its, projected economic growth of 4-4.5%. It would largely comprise gasoline formulae of 33-38% and diesels of 51-56% excluding products directly destined for grid power generation.

29. Higher economic growth would however demand between **4.5-4.8 million tonnes** which is equivalent to **85,000-90,000** barrels per stream day refinery capacity.

30. In 2015, crude oil production from the Jubilee field jumped slightly to 38.8 million barrels from 38.7 million barrels in 2014. Corresponding daily production averaged 106,938 barrels. It was 105,935 barrels and 91,000 barrels per day in 2014 and 2013 respectively.

31. For **2016**, crude production from the Jubilee is likely to remain about the same as in 2015, or drop slightly to **100,000-105,000** barrels per day.

32. In 2015, LPG supplied was 279,000 tonnes, an improvement of about 38% over the supply in 2014.

33. For **2016** however, between **290,000- 300,000 tonnes** of LPG would be required for the government projected economic growth for the year. High economic growth exceeding 4.5% however would require 300,000-350,000 tonnes due to the growing demand for LPG as cooking fuel in the homes and particularly as transport fuel, just as projected for 2014. Notwithstanding, the limited nation-wide storage capacity could constrain the supply to the low-side in 2015.

Charcoal

34. In 2015, the average prices of charcoal in the country rose to GH¢20 per mini bag and GH¢31 per maxi bag from GH¢17 per mini bag and GH¢25 per maxi bag in 2014 respectively. This represents an increase of about 21% for mini-bag and 24% for the maxi-bag. As usual, the high-price areas were along the coast and the Upper East Region. The low-price areas were also the transitional regions of Brong Ahafo and Northern followed by the forest regions of Ashanti, Eastern and Western. Except for the Ashanti, Western and Upper East, all the regions experienced very high price increment during last year.

35. For **2016**, we estimate that the average charcoal price would increase by 30-35% in the coastal areas of Central, Western and Volta Regions.

36. Greater Accra and the Savanna regions would experience a moderate increase of 20-25%. The average price is likely to increase by 18-20% in the inland or forest regions of Ashanti and Eastern. The difference would be as a result of transportation cost. Nationwide, we estimate an average drop of price change from about 30% in 2015 to about 28% for 2016 due the likely availability of LPG which is a substitute fuel for charcoal in urban areas.

Recommended Actions

Ameliorating the overall power supply shortage

37. To ameliorate the overall power supply shortage prevailing in the country, emanating out of inadequate fuel supply for power generation, investments in liquefied natural gas (LNG) as an alternative gas supply to augment the limited local and unreliable gas from the West Africa Gas Pipeline from Nigeria are being pursued vigorously. Licences have thus been issued and supply contracts already signed, nevertheless the LNG supply is more likely to be available in 2017 and beyond.

38. In the interim:

i. Every effort should be made to complete the on-going power generation projects whilst expediting action on bringing in additional power rentals to offset the power supply deficit.

ii. To ensure system stability and to allow for effective load-following as well as safeguarding its integrity, Akosombo Hydropower Station should as much as possible not be operated beyond three (3) units[12] until adequate rains are realised during the year.

iii. Modalities should also be put in place to ensure that adequate financing is readily and timely available for the purchase of fuel to ensure reliable power supply in 2016.

iv. Planned grid expansion programmes especially those connected with transmission upgrades should be expedited and completed on schedule to facilitate the smooth and efficient evacuation of the available power.

Achieving 50% nationwide penetration of LPG

39. National LPG penetration share increased from 6% in 2000 to 18% in 2010 and is currently around 23%. The sector ministry is targeting 50% penetration by 2020 but it is not likely to be achieved if limited distribution outlets nationwide remain the same.

[12] Not going beyond 375 MW

40. This can however be achieved by implementing the measures to support and accelerate the supply and use of LPG outlined in the Energy Sector Strategy and Development Plan, and the LPG Policy Paper. These include:

(a) Deliberate government policy to make the LPG produced available for local consumption as against export;

(b) Removal of price distortions which has already been done.

(c) Re-capitalising Ghana Cylinder Manufacturing Company (GCMC) to expand production capacity with the production of cylinders focused on small sized cylinders that would be portable and affordable to households in rural communities.

(d) Constructing LPG storage and supply infrastructure in all regional and district capitals in the long term.

41. In this light, the Ministry of Petroleum and the National Petroleum Authority need to consider investment incentives to encourage the Oil Marketing Companies and other interested investors to set up more LPG storage and distribution centres in-country to increase access and consumption.

Expanding Crude Oil Strategic Reserve

Fuel supply security and erratic fuel prices have compelled countries to set up strategic stocks both for crude oil and refined products. Crude oil storage however, has the comparative advantage of far longer lifespan and could even be indefinite depending upon the blend and state. With the prevailing low global oil prices therefore, many developed countries have taken the opportunity to expand their crude oil reserves.

42. In the same respect, the global low oil price regime is an opportunity for BOST to include crude oil stock in the existing oil reserve stock of the country.

Expanding crude refining operations

As indicated earlier, equivalent of 70,000-75,000 barrels per stream day refinery capacity would be required to enable the country meet its projected economic growth for 2016. Even though, it costs less to import crude oil for refining locally than importing the finished product, capacity utilisation at Tema Oil Refinery (TOR) had worsened from about 64% in 2011 to just around 3.1% in 2015 compared to a minimum capacity utilization of 70% to break even in this current global low oil price environment. Furthermore, the prevailing low oil price regime provides an incentive for the refinery to make some profit, since all things being equal and in a de-regulated market, the lower input (crude oil) prices could result in higher profit margins on the outputs (products).

43. In the light of this, providing input crude of at least **1.5 million tonnes** for the refinery during the year, could help the refinery break-even, even though still dependent on the production configuration. Profit could start emerging as the capacity utilisation increases.

Foreword

ENERGY COMMISSION has the mandate to prepare, review and update periodically indicative national plans to ensure that reasonable demands for energy are met in a sustainable manner. 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 production, transmission, wholesale supply, distribution and sale of electricity and natural gas.

In fulfilment of its mandates, the Commission has been preparing annual energy demand and supply outlook to provide guidelines 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 2016 Annual Energy Outlook therefore is to give government, industry and business, indications of the levels/quantities of electricity, liquid and gaseous fuels that would be required to be provided by the energy producers for this year.

This document covers demand and supply of electricity, crude oil, petroleum products, natural gas as well as charcoal.

In the document, 'Demand' is used when referring to gross fuel or energy required by a demand sector, e.g. Residential, Commercial, or Industry. 'Supply Requirement' is Supply or Generation/Production plus transmission/transport losses.

For further elaboration, please refer to Annex 1 of the document for a schematic overview of Ghana's Energy Demand and Supply System.

This report was prepared by the Strategic Planning and Policy Division of the Energy Commission.

General questions about the report should be referred to Mr. Michael Opam, (mopam@energycom.gov.gh, michaelopam@yahoo.com) the Acting Executive Secretary. Specific questions about the content may be directed to Dr. Joseph Essandoh-Yeddu (essandohyj@energycom.gov.gh, jeyeddu@gmail.com), Head of Strategic Planning and Policy Division.

Your comments are most welcome.

Michael Opam

Ag. Executive Secretary

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Acronyms

GDP	Gross Domestic Product; *measure of wealth of an economy of a nation.*
LPG	Liquefied Petroleum Gas
Solar PV	Solar Photovoltaic; *panel technology for electricity via solar or sunshine*
GWh	Gigawatt-hour, i.e. *million units of electricity*
kWh	Kilowatt-hour, i.e. *one unit of electricity*
MWh	Megawatt-hour, i.e. thousand unit of electricity
NG	Natural Gas
LNG	Liquefied Natural Gas; *natural gas liquefied about 600 times*
mmBTU	Million British Thermal Unit; *an energy unit for gas flow*
mscfd/mcfd	Thousand standard cubic feet per day/ Thousand standard cubic feet per day; *a volumetric unit for gas flow*
mmscfd/mmcfd	Million standard cubic feet per day/ Million standard cubic feet per day; *a volumetric unit for gas flow*
bscfd/bcfd	Billion standard cubic feet per day / Billion standard cubic feet per day; *a volumetric unit for gas flow*
Tcf/tscfd	Trillion standard cubic feet per day / trillion standard cubic feet per day; *a volumetric unit for gas flow*
IPP	Independent Power Producer
BOST	Bulk Oil Storage and Transport company, a state company supposed to manage the country's strategic reserve
ECG	Electricity Company of Ghana, a public power distributor
TAPCO	Takoradi Thermal Power Company, a public power generator
TICO	Takoradi International Company, a public power generator
TOR	Tema Oil Refinery, the only crude oil and public refinery in the country.
VRA	Volta River Authority, a public power generator
VALCO	Volta Aluminium Company, a smelting company
WAGP	West African Gas Pipeline
WAGPCo	West African Gas Pipeline Company

1.0 Power Subsector

1.1 Overview of Grid Power Supply in 2015

Installed generation capacity[13] operational and available for grid power supply as at the end of 2015 was 3,174 Megawatt (MW), about 12% expansion over last year's[14] (*see Table 1*).

Table 1: Installed Grid Electricity Generation Capacity operational as of December 2015.

GENERATION PLANT	FUEL TYPE	CAPACITY (MW)				TOTAL GENERATION	
		Installed (name plate)	**% Share**	**Average Dependable**	**Average Available**	**GWh**	**% Share**
Hydro Power Plants							
Akosombo	Hydro	1,020		900	375	4,156	
Bui	Hydro	400		340	330	870	
Kpong	Hydro	160		140	105	819	
Sub-Total		*1,580*	***49.8***	***1,380***	***760***	***5,845***	***50.86***
Thermal Power Plants[15]							
Takoradi Power Company (TAPCO)	Oil/NG	330		300	300	1,784	
Takoradi International Company (TICO)	Oil/NG	330		320	320	1,336	
Sunon–Asogli Power (SAPP)	NG	200		180	180	1,185	
Tema Thermal Plant1 (TT1P)	Oil/NG	110		100	100	541	
Tema Thermal Plant2 (TT2P)	Oil/NG	49.5		45	30	215	
CENIT Energy Ltd (CEL)	Oil/NG	110		100	100	317	
Mines Reserve Plant	Oil/NG	80		70	40	170	
Takoradi T3[#]	Oil	132		36	3.6	31	
Karpower*	HFO	250		225	225	64	
Sub – Total		*1,591.50*	***50.1***	***1,376***	***1,298.6***	***5,643***	***49.10***
Renewables							
VRA Solar	Solar	2.5		2	1	4	
Sub – Total		*2.5*	***0.1***				***0.04***
Total		**3,174**		**2,756**	**2,058.6**	**11,492**	

*NG is Natural gas, *Estimated.; # Takoradi T3 worked for two months; January and February.*

13 nameplate

14 VRA Ameri though came on line in December, 2015 and produced about 0.02 GWh, it was at its testing phase. So also was the 20 MW BXC Solar Plant near Mankoadze in the Central Region.

15 TAPCO is Takoradi Power Company, a combined cycle (CC) thermal plant; TICO is Takoradi International Power Company, a single cycle (SC) thermal plant.

The generation however was 11,492 Gigawatt-hours (GWh), about 14% lower than in 2014, comprising 50.86% hydro, 49.1% thermal and 0.04% solar power.

The total electricity made available for gross transmission in 2015 was only 11,692 GWh[16] as against 13,071 GWh in 2014 and 12,927 GWh in 2013; i.e. 1,379 GWh (or about 12%) less than in 2014 and 1,235 GWh (or about 11%) less than in 2013. The net grid electricity transmitted[17] to the country was 11,678 GWh as against 12,906 GWh in 2014; about 21-26% less than the projected requirement for *VALCO operating at one potline* and for low economic growth[18], equivalent to 330-410 MW shortfall.

The 2015 grid electricity transmission comprised 98.25% of generation and 1.75% of imports.

Peak load for the supply to Ghana on the transmission grid[19] was 1,933 Megawatts (MW); roughly 2% less than in 2014 but the total (maximum) peak on the transmission grid[20] was 2,118 MW; about 3% more than in 2014.

Total power transmission loss in 2015 was 3.8% of gross transmission, 0.5 percentage point lower than in 2014 (*see Table 2*).

Table 2: Grid Power Transmission losses since 2008.

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Transmission losses as % of gross transmission	3.7	3.8	3.7	4.7	4.3	4.4	4.3	3.8

1.2 2015 Forecast and Actuals

Ghana's real Gross Domestic Product (GDP) growth has been dropping since 2012. The GDP was 4.2% in 2014, a drop from 7.1% in 2013 and 8.8% in 2012[21] and further dropped to 3.5-3.9% in 2015. As has been the case in the previous years, the dip in the GDP growth is attributed to the negative growth in the Manufacturing subsector and Industry in general. This is largely due to the aggravating inadequate grid power supplied during the year.

[16] Does not include generation from solar since the latter is at the distribution grid level.
[17] Gross transmission less wheeled less exports.
[18] Real GDP growth estimated between 3.5-3.9% for 2015. Sources: African Development Bank, Ministry of Finance Supplementary Budget.
[19] Referred to as Domestic Peak Load by some of the utilities
[20] Ghana Peak load + Exports
[21] Ghana Statistical Service (GSS), March, 2015.

For 2015, we projected that all things being equal, the total electricity required would have ranged as follows:

(c) 14,150-14,730 GWh *with VALCO operating at one potline*; to maintain the economic growth at an average of 4.2-4.5%*;* and

(d) 15,408-16,398 GWh *with VALCO to be operating at more than one potline*; to raise the economic growth from 4.2% in 2014 to 5-6%.

The corresponding national peak demand (including suppressed demand) and total transmission system peak should have been between 1,980-2,399 MW, but just as in the previous years, VALCO did not operate beyond one-potline (*see Tables 3*).

The inability to meet even the minimum electricity and power demand could explain the low economic growth recorded in 2015.

This implies that supply was 17-21% less than the forecasted minimum range required last year compared with 11-16% less for 2014 and 10-15% less for 2013 indicating a worsening trend for the past three years.

It was additionally projected that oil required for thermal power generation would range from a minimum of 800,000 tonnes to a maximum of one million tonnes (about 5-7 million barrels) during the year, depending upon the availability of the thermal plants and the volatility of oil prices. The actual oil used however, was just about 237,000 tonnes (1.7 million barrels), representing only 23-30% of the projected requirement (*see Tables 3*).

Light crude oil (LCO) purchased purposely for power generation averaged $60 per barrel during the year (about half the delivery price in 2014), which was within our projection for 2015 (*see Tables 3*). The delivery price was about $54 per barrel during the first quarter, rising to $69 per barrel in the second quarter and dropping to about $53 per barrel during the last quarter.

The WAGP gas supply in 2015, was within forecast but lower than that of 2014 and for that matter was still below the contracted volume of 123 mmscfd.

Average WAGP gas flow in 2015 was 56 mmscfd compared to 61.8 mmscfd in 2014. Above average supply occurred in August at a maximum of about 88 mmscfd before dropping to a minimum average of 36 mmscfd in December.

Average WAGP delivery gas price to VRA the foundation customer was $8.75 per mmBtu in 2015; it averaged $9.14 per mmBtu for the first half of the year with May having the highest price of $9.17 per mmBtu but dropped to an average of $8.45 during the second half with September having the lowest price of $8.40 per mmBtu.

Table 3: Grid Electricity and associated fuels: Forecast and Actuals for 2015.

	2014	2015 Forecast	2015 Actual
Ghana's Electricity requirement (GWh)			
VALCO at one potline	*14,571-15,351*	*14,150-14,730*	
VALCO at 2 -3 potlines	*15,725-16,500*	*15,408-16,398*	
Grid Electricity available (GWh)	12,906		11,678
Percentage hydro of generation (%) *(GWh)*	64.7 *(8,387)*	50.8 *(7,683)*	50.9 *(5,845)*
Ghana System Peak (MW)*	1,970	2,200-2,400	1,933
GRIDCO Transmission System Peak/Maximum Demand (MW)	2,061	2,700-2,900	2,118
Average WAGP gas flow **(**mmscf per day)	61.8	50-70	56
Average Jubilee/Atuabo gas flow **(**mmscf per day)	35.3	60-100	72
Delivered WAGP gas price * *(other charges included)* US$ per MMBtu *($ per mscf)*	8.47-9.00 *(8.63-9.17)*	8.85-9.00 *(8.99-9.17)*	8.40-9.17 *(8.56-9.34)*
Delivered GhanaGas gas price * *(other charges included)* US$ per mmBtu *($ per mscf)*	N.A	8.82 *(8.99)*	8.84 *(9.00)*
Oil required 1000 Tonnes (Million barrels)	1,158-1,250 (8-9)	*800-1,000* (5-7)	
Oil consumed 1000 Tonnes (Million barrels)	931 (6.5)		237 (1.7)
Average price for Brent crude US$ per bbl *($ per mmBtu gas equiv.)*	99 *(17.01)*	85-90 *(14.6-15.46)*	52 *(8.9)*
Average delivered light crude oil price *dedicated for power production* $ per bbl *($ per mmBtu)*	$110 *(18.9)*	60-65 *(10.31-11.17)*	60 *(10.31)*

** Actual data in $/mmBtu courtesy of WAPCo. Low-side for Foundation customers and high-side for Standard customers. Other charges include delivery fee, ELPS transport fees, insurance, etc.*
***Prices indexed to LCO and negotiated between the buyer and supplier and reviewed every six months. Actual data in $/mmBtu courtesy of WAPCo. Low-side for Foundation customers and high-side for Standard customers.*

Total gas WAGP flow was 20,625,394 mmBtu compared to 22,541,001 mmBtu in 2014. (*see Table 4*). Total WAGP gas flow in 2013 was 11,573,011 mmBtu.

Indigenous gas from Jubilee field gas through Atuabo averaged 72 mmscfd in 2015, about twice that of 2014. Average flow for the first quarter was 54 mmscfd rising to an average of 74 mmscfd by June then increasing to an average of 100 mmscfd with maximum flow 112 mmscfd recorded in December.

Table 4: Monthly and Daily Natural Gas Supply from WAGP in 2015.

Month	Ghana Gas Supply		WAGP Supply	
	Monthly flow in mmBtu	Daily flow in mmscf	Monthly flow in mmBtu	Daily flow in mmscf
January	1,709,081	55.13	1,699,000	54.81
February	1,191,890	42.57	1,430,117	51.08
March	2,033,854	65.61	1,669,679	53.86
April	1,669,648	55.65	1,732,725	57.76
May	2,788,697	89.96	1,442,176	46.52
June	2,326,613	77.55	1,228,384	40.95
July	197,531	6.37	1,823,177	58.81
August	2,614,566	84.34	2,453,109	79.13
September	2,545,273	84.84	2,647,651	88.26
October	2,701,475	87.14	2,163,008	69.77
November	3,027,701	100.92	1,205,502	40.18
December	3,480,132	112.26	1,130,865	36.48
Average	***2,190,538***	***72***	***1,718,783***	***56***
Total	***26,286,461***		***20,625,393***	

Source: Volta River Authority, 2016.

1.3 Forecast for 2016

1.3.1 Electricity Requirement of the Economy

The real GDP growth for **2015** has been estimated to be 4.1%[22] (3.5-3.9%)[23] against the backdrop of the worsened power crisis and fiscal consolidation. Thus a further decline from 4.2% in 2014 and from 7.1% in 2013.

The GDP growth was ideally expected to increase from 7.1% in 2013 to 7.7% in 2014 and to 8% in 2015, however, the existing power crisis made this impossible.

As indicated in the 2015 Outlook, the World Bank[24] has indicated that electricity is the second most important constraint to business activities in the country and that Ghana lost about 1.8% of GDP during the 2007 power crisis.

Also, ISSER[25], in its 2014 study[26] indicated that on the average, the country is losing production worth about US$ 2.1 million per day (or, US$ 55.8 million per month) through the power crisis alone. As an example, the country lost about US$680 million in 2014 translating into about 2% of GDP due to the power crisis. It further indicated that firms that do not have access to sufficient electricity have lower output/sales, and that not having sufficient electricity lowers a firm's annual sales by about 37-48%.

Stable and sufficient electricity supply is thus undoubtedly a key input to firm growth, expansion and development. Ghana's annual electricity consumption per capita since 2010 has been averagely below **400 kWh** compared to the global minimum average of **500 kWh** for lower middle-income developing countries.

With the apparent improvement in the power crisis due to expanded thermal generation capacity, real GDP growth is projected to turn around from the negative growth by rising to **4-4.5%** in 2016[27].

At this projected **GDP growth of 4-4.5%** for Ghana for 2016, the total electricity required for the expansion of the country's economy is expected to be as follows:

(1) **16,798 -16,900 GWh** but VALCO constrained at only one potline. Capacity demand requirement is estimated as **2,486-2,500 MW**.

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[22] Annual Gross Domestic Product-Ghana Statistical Service, September 2015 Edition

[23] Ghana-IMF Three-year Programme report, February, 2016

[24] World Bank, Energizing Economic Growth in Ghana: Making the Power and the Petroleum Sectors Rise to the Challenge, February, 2013

[25] ISSER is Institute of Statistical Social and Economic Research

[26] Electricity Insecurity and its impact on Micro and Small Businesses in Ghana, Charles Ackah, Senior Research fellow, ISSER, University of Ghana, 2015.

[27] Ghana-IMF Three-year Programme report, February, 2016; Ghana Statistical Services December23, 2015; Trading Economics March 17, 2016 (http://www.tradingeconomics.com/ghana/gdp-growth-annual/forecast). However, Government in its 2016 Budget Statement has projected 5.2% (without oil) and 5.4% (with oil).

(2) **18,158-18,737 GWh** for VALCO to operate at most, two potlines. The required capacity demand would fall within **3,979-4,076 MW**.

(3) **20,146-20,698 GWh** for VALCO to be operating more than two potlines. Capacity demand required would range from **4,260-4,357 MW**.

Level (1) would improve the economic growth to achieving the targeted 4-4.5% for 2016.

Level (2) could move the economic growth to over 4.5% in 2016 *but achievable provided the planned capacity additions for this year are timely completed and there is also adequate financial resource to procure all the fuel needed to run the thermal power plants even at higher utilisation factors (see Table 5*); whilst

Level (3) would help raise the economic growth to 5% and above in 2016.[28]

1.4 Available Electricity Supply for 2016[29]

1.4.1 Generation Sources

The sources of generation considered are mainly from the existing generation and the new committed projects expected to come online during the first quarter of 2016.

Existing Generation Sources

Akosombo and Kpong Hydro

The 2015 inflow season for the Volta Lake ended with the Akosombo reservoir attaining a maximum elevation of 244.80 ft. The reservoir elevation of the Akosombo Hydro was 247.13 ft. at the beginning of 2015, with mainly four (4) units being operated during off-peak period and five (5) units during the peak period. There were some occasions when 5 units were operated throughout the day. The reservoir elevation at Akosombo dropped by 10.04 ft. to a minimum elevation of 237.09 ft. before the onset of the inflow season. The total rise in elevation recorded in 2015 was 7.71 ft. The elevation at the beginning of 2016 was 242.4 ft., which is 4.73 ft. lower than the elevation at the beginning of 2015, which was 247.13 ft. At this start elevation, there is only 2.4 ft. of water above the Minimum Operating level of 240 ft. and 7.4 ft. above the Extreme Minimum Operating level of 235 ft. The trajectory of the Akosombo reservoir for 2015 is shown in Figure 1.

[28] Energy consumption is directly related to economic growth for developing and middle income developing countries.
[29] This work adapted from report jointly produced with VRA and GridCo

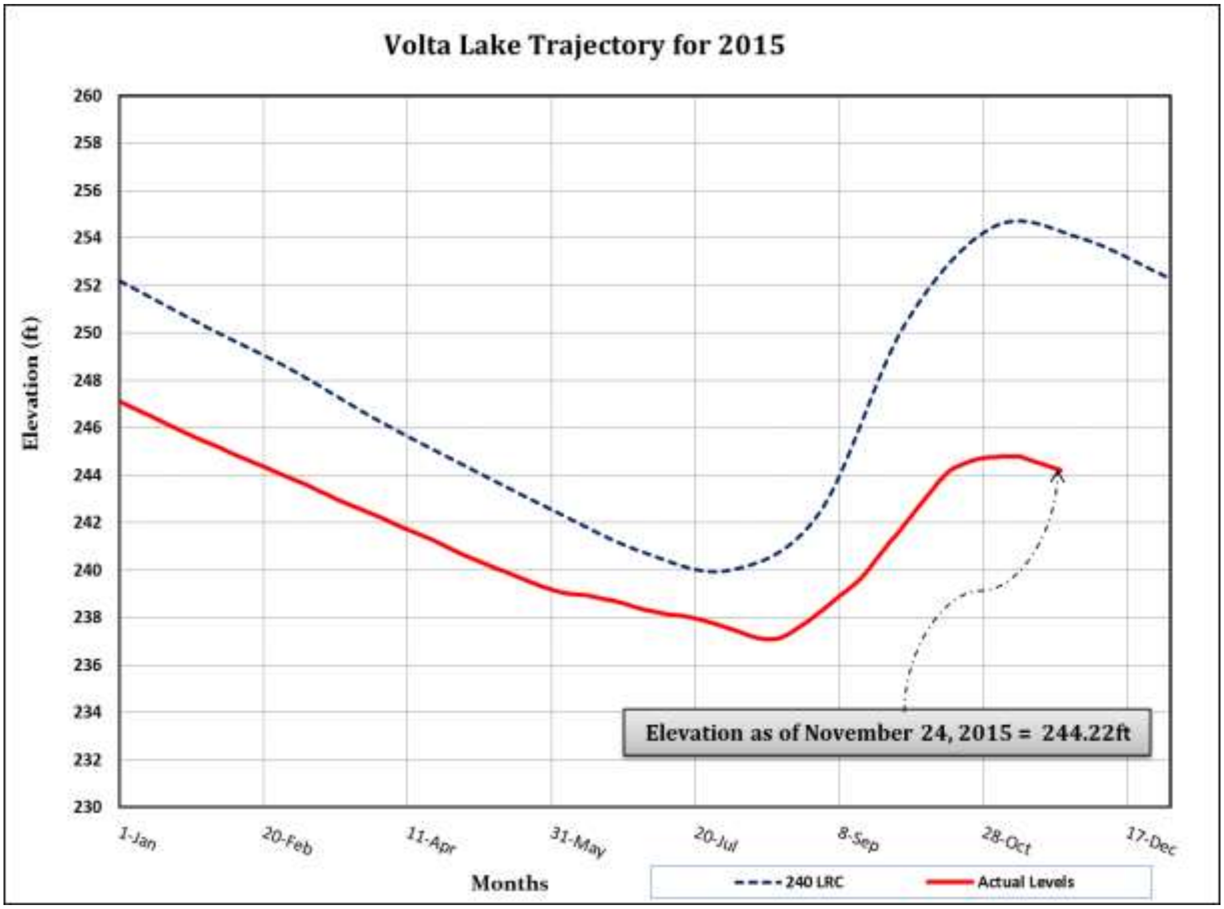

Figure 1: 2015 Akosombo Reservoir Trajectory

In the light of the poor inflows and with the relatively very low level of water in the reservoir, there is a limitation on the amount of power that can reliably and safely be generated from the Akosombo Generating Station. Based on an analysis conducted, the Akosombo reservoir can support only three (3) units operation which will lead to a minimum elevation of 235 ft. at the end of July 2016.

<u>Challenges with two Units Operation at Akosombo Generating Station</u>

It is very important that the number of units in operation Akosombo Generating Station (GS) be immediately limited to three (3) in order to avoid the situation where elevations lower than 235 ft. are recorded before the onset of the rains in 2016. Below elevation 235ft., the design of the penstock intake will only permit the operation of the two units (unit nos. 3 and 4) which have lower intake levels. Operating the Power System with only two (2) units running at Akosombo poses two key challenges as follows:

1. It is noteworthy that to date, Akosombo GS units are solely responsible for load following and real-time primary frequency control on the Ghana power system. In view of this it is of critical importance to note that two (2) units at Akosombo GS cannot alone effectively carry out the entire load-following burden on the Ghana power system, considering its present inertia. A minimum of three (3) units at Akosombo are required in operation at all times to effectively do this.
2. Secondly, the operation of two (2) units at Akosombo has implications on the power system stability such that it can easily experience system collapse with minimal disturbance in the power system.

It is therefore expedient that strict measures are put in place to manage the head water in the dam so that elevations lower than 235 ft. are not recorded before the onset of the rainy season in 2016.

At prevailing low elevations of the reservoir, the average reliable capacity of a unit at Akosombo is 125 MW. Hence operating three units at Akosombo would mean a capacity of 375 MW out of 900 MW would be available at Akosombo in 2016. Kpong Generating Station (GS) which is currently undergoing retrofit would have three (3) out of the four (4) units available. The total average capacity that would be available at Kpong GS would be 105 MW.

Three units operation at Akosombo GS through-out the year and operation of Kpong GS in tandem with Akosombo will lead to a projected annual generation from Akosombo GS and Kpong GS of 3,910 GWh.

The projected elevations for Akosombo Generating Station in 2016 based on three (3) units operation is shown in Figure 2. The projected minimum elevation at the end of the dry season in July 2016 is 235 ft. In the event that the rains delay in 2016 we risk going below elevation 235 ft. which will lead to the operation of 2 units.

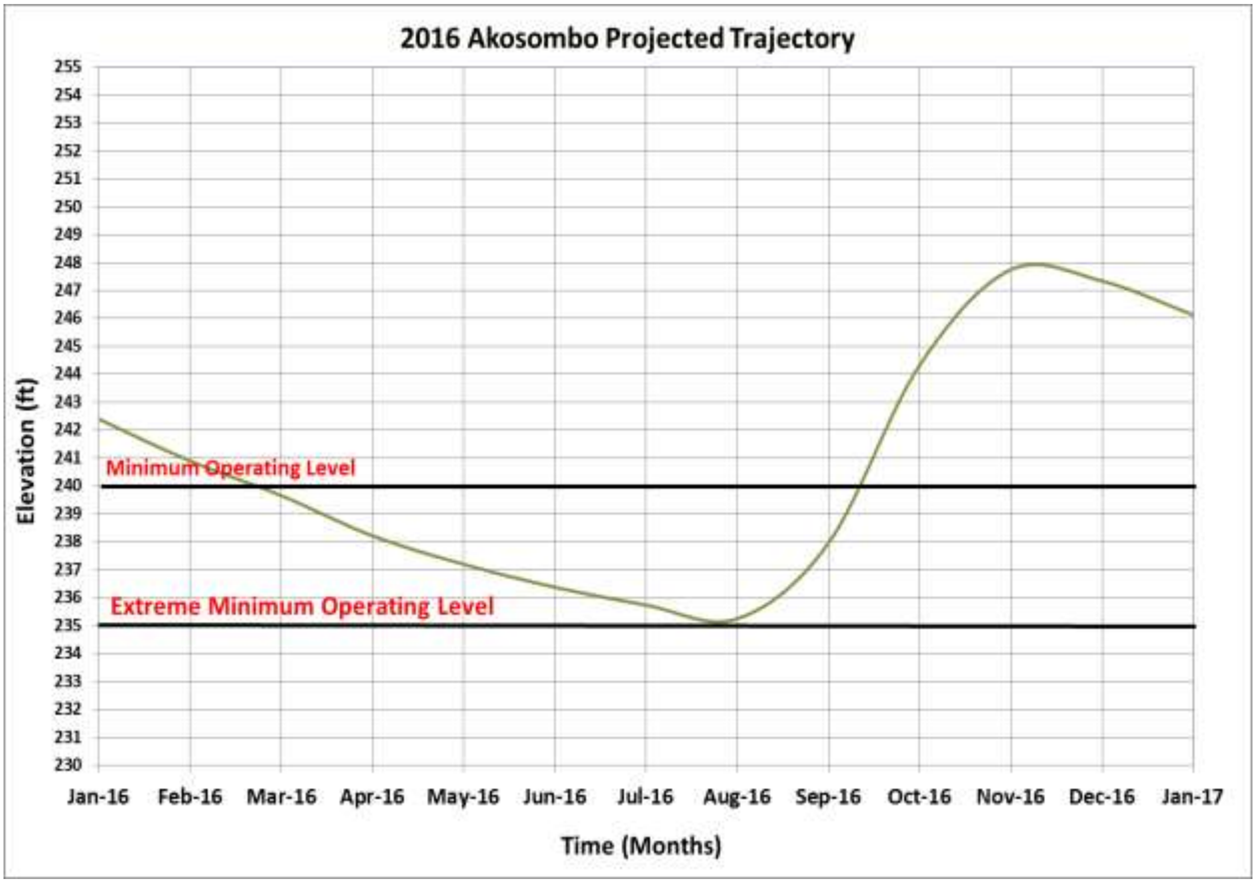

Figure 2: 2016 Akosombo Reservoir Projected Trajectory

Bui Hydro

In 2015, the Bui Generating Station (GS) operated two units during the peak period for a greater part of the year. However, during a greater part of the first quarter of 2015, Bui operated an additional unit during the off-peak period. At this mode of operation, Bui Generating Station produced about 870 GWh at the end 2015. Bui reservoir started 2015 at about elevation 177.3 metres (m). The reservoir's elevation in November 16, 2015 was 180.64 m. The maximum reservoir elevation is 183 m. The Bui reservoir trajectory for 2015 is shown in Figure 3.

In 2016, it is projected that Bui Generating Station would produce about 926 GWh of electricity. It is assumed that Bui GS would operate two (2) units during the peak period for 10 hours/day/unit from January to end of June 2016. For the second half of the year it is projected that Bui GS would operate two (2) units for 12 hours/day/unit from July to the end of December 2016. This mode of operation would result in the projected annual production of 926 GWh at the end of the year.

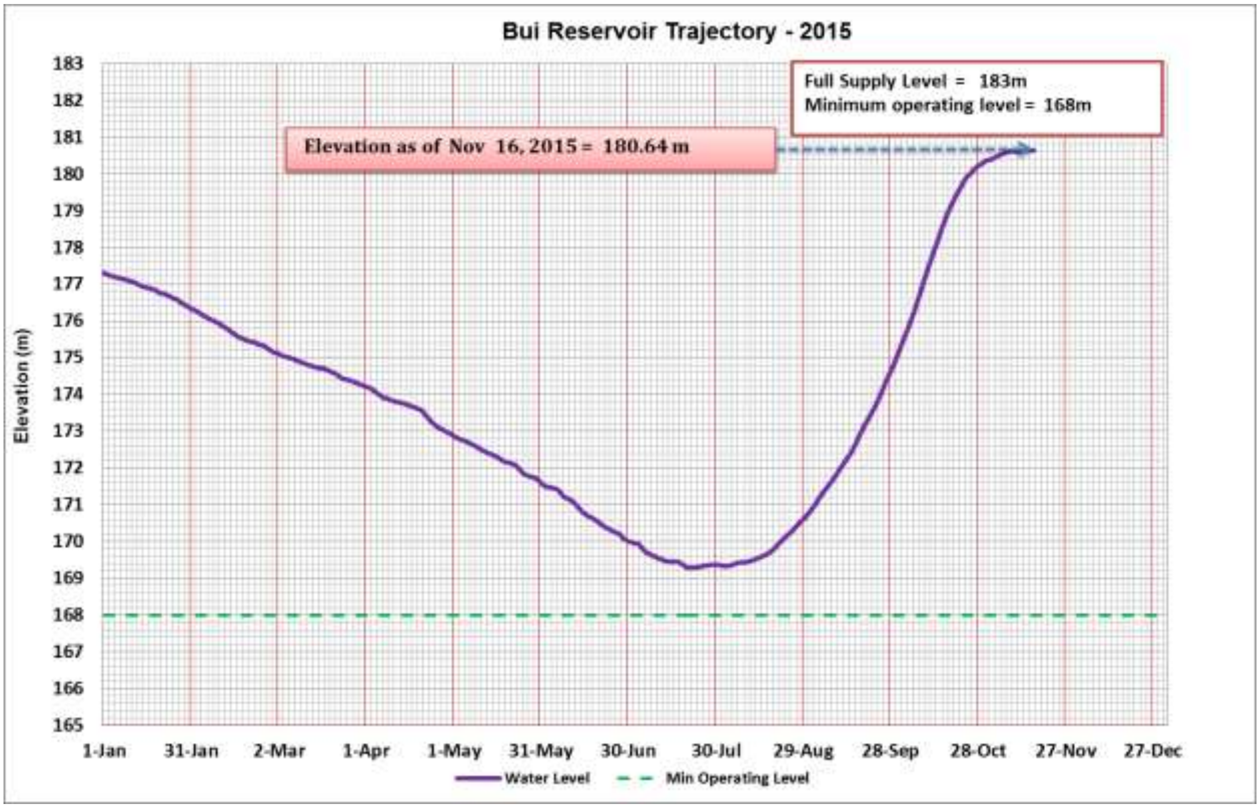

Figure 3: 2015 Bui Reservoir Trajectory

<u>Thermal</u>

The total installed thermal generating capacity by end of 2015 was 1,209.5 MW of which 1,115 MW was the dependable capacity. The available capacity of the thermal generating capacity reduced to 1,070 MW due to the drop in available capacities of the TT2PP and MRP plants to 30 MW and 40 MW respectively, from 45 MW and 70 MW respectively because of faults on the units.

It is assumed that in 2016, the same capacity of the thermal generation sources would be available.

The installed capacities, dependable capacities and available capacities of generation sources assumed for 2016 are shown in Table 5. From Table 5, the total installed capacity of the existing generation sources is 2,792 MW of which 2,515 MW is the dependable capacity. The total available capacity of the existing generation sources for 2016 is therefore 1,895 MW.

Table 5: Existing Generation Sources available for 2016.

PLANTS	Installed Capacity (MW)	Dependable Capacity (MW)	Available Capacity (MW)	Fuel Type	Availability Factor (%)
Akosombo GS	1,020	900	375	Water	100%
Kpong GS	160	140	105	Water	72%
TAPCO (T1)	330	300	300	LCO/Gas	85%
TICO (T2)	330	320	320	LCO/Gas	85%
TT1PP	110	100	100	LCO/Gas	88%
TT2PP	49.5	45	30	Gas	85%
MRP	80	70	40	Gas	80%
Trojan	20	18	18	Diesel/Gas	85%
VRA Solar Plant	2.5	0	0	Sunlight	18%
SAPP	200	180	180	Gas	92%
CENIT	110	100	100	LCO/Gas	92%
Bui GS	400	360	345	Water	85%
TOTAL	**2,812**	**2,533**	**1,895**		

Additional Generation Sources

The following power projects in progress last year are now operational except for the Takoradi T3:

- 110 MW installed capacity steam unit of the TICO Thermal power plant at Aboadze;
- 200 MW Kpone Thermal Power Plant;
- 180 MW Sunon-Asogli gas phase 2;
- 25 MW Trojan thermal plant; an imbedded generation.
- Retrofitting of the (Mines Reserve Plant) MRP from 40 MW to 76 MW; and
- 20 MW BXC solar power plant near Mankoadze in the Central Region. Also imbedded but unique because it is solar.

Based on efforts to bring on additional generation capacity to curb the on-going load shedding, a total installed generation capacity of 962 MW is expected to be online by end of first quarter of 2016. The dependable capacity of the expected generation sources is 868 MW. The installed and dependable capacities of the additional generation sources and their expected timelines are shown in Table 6.

Table 6: Expected Additional Generation Sources for 2016.

Plants	Installed Capacity (MW)	Dependable Capacity (MW)	Fuel Type	Availability Factor (%)	Remarks
KTPP	220	200	Gas/Diesel	85%	100 MW in January, full output from March 2016
VRA/AMERI	250	230	Gas	90%	Half capacity in February, full capacity in March
Karpower Barge	250	225	HFO/Gas	90%	Available from January, 2016
TT2PP-X	36	33	Gas	85%	Available from February 2016
SAPP (2)	186	180	Gas	85%	Gas turbine (120 MW) available from February, Full combined cycle (180 MW) available from March
Central Region Solar	20	0	Sunlight	15%	20 MW capacity available from January 2016 at a capacity factor of 15%.
TOTAL	**962**	**868**			

The **200 MW Kpone Thermal Power Plant** is diesel/gas powered. Until sufficient gas is available, the plant would be diesel fuelled and would only largely operate as a peaking plant due to the relatively high delivery cost of diesel.

The additional **180 MW** comprising **160 MW gas and 20-MW steam turbine** from **Sunon-Asogli plant** is fully operational by the end of first quarter. However, its full dependability would rest on availability of adequate gas.

Provisional licences issued for wholesale power supply from Renewables rose from 64 in early 2015 to over 80 by early 2016. However, only one solar project is completed and connected to the grid, i.e. the 20 MW solar photovoltaic grid inter-tied plant by BXC company at a location near Mankoadze in the Central Region. The 14 MW seawave energy plant near Ada in the Greater Accra Region could not be completed as planned. Three other Renewable Energy power plants have been issued with construction permits. They are the 150-MW Savannah Solar, 100 MW HEA Solar and the 225 MW Upwind Ayitekpa Wind. We do not however expect any of these three to be available this year.

The **132 MW Takoradi T3** thermal power plant that malfunctioned in 2013 is still not operational. It only ran for the months of January and February in 2015 and it is not expected to be available this year either[30].

Government is still talking to **AKSA Power from Turkey (370 MW)** and **General Electric/Early Power (300-1000 MW)**. These are projects which were supposed to have been available or commenced construction last this year.

To recall, the power contracts are not only needed to fix the current shortfall but provides these co-benefits:

- Providing the necessary cushioning to allow Akosombo and Bui hydrodams to recover to appreciable levels in the light of the less than expected precipitation in their catchment areas this year.
- Enabling the major thermal plants to undergo mandatory maintenance when due without the need for nationwide load-shedding;
- Allowing the necessary long term re-structuring of the existing power sector market to ensure long term sustainability to be implemented.
- Allowing construction of basic infrastructure for greenfield base-load plants such as LNG and or coal plants.

There are also major private licensed power initiatives that already operating at the imbedded generation level and supplying power to some industries. There is the **30 MW** Genser dual-**fuel coal** power plant supplying power directly to the Chirano Mines in the Western Region. It became operational early this year and currently using condensates from the Atuabo gas processing facility. There is also the Genser **5 MW LPG-fired** power plant located in Tema.

[30] The plant suffered a number of operational failures between 2013-2014 but the Canadian supplier has agreed to provide new turbines for the plant. However, search for funding is likely to delay its commercial operations this year.

Planned Maintenance

The key maintenance activities expected to be undertaken in 2016 on the various plants are shown in Table 7.

Table 7: Planned Maintenance for Power Plants in 2016.

PLANTS/ENERGY SOURCES	PLANNED MAINTENANCE
Akosombo GS	• Akosombo maintenance is not expected to impact on supply since only 3 units will be expected to be dispatched
Kpong GS	• Kpong major retrofit is on-going. Major unit inspection for 2 weeks will be carried out on 1 unit at a time in February and July 2016
TAPCO (T1)	• Fuel Nozzle Inspection on Unit 1 in March for 1 week • Major Inspection on Unit 2 (3rd April – 15th May) • Minor Inspection on Steam Turbine (19th June – 10th July)
TICO (T2)	• Hot Gas Path Inspection on Unit 1(5th November – 2nd December) • Warranty Inspection on Steam Turbine (5th November – 2nd December)
TT1PP	• Major Inspection in February (1 month) • Major Inspection (6th June – 24th July)
TT2PP	• Core Engine Swap and main gearbox overhaul on Unit 1 (1 – 14 August) • Core Engine Swap and main gearbox overhaul on unit 2 (4 – 17 July)
MRP	• Each of the 3 units will undergo maintenance for 4 days in March, June, September and December
The Solar Plants	• Maintenance not expected to impact on supply significantly
SAPP	• Hot Gas Path Inspection on 1 unit (20th February – 12th March) • Major Inspection on Steam turbine (28th March – 6th May) • Major Inspection on gas turbine (28th March – 28th April) • Combustion Inspection (17 – 27 April)
CENIT	• Combustion Inspection in March & July for 7 days each
Bui GS	• Maintenance will not impact on supply
Atuabo Gas supply	• Two weeks in March, two weeks in June/July.

Fuel Allocation, Requirements and Cost Implications

In 2016, natural gas, Light crude oil (LCO), diesel and Heavy fuel oil (HFO) are the types of fuel that would be required for firing thermal generating plants on the Ghana power system. HFO, LCO and diesel are procured from the open market but are largely to come from Nigeria to save freight cost.

Natural Gas

Natural gas would however come from two sources; WAGP carrying gas from Nigeria; and the Atuabo pipeline carrying indigenous gas from the Jubilee field. Gas from the Jubilee field is being processed at the Ghana National Gas Company's Gas Processing Plant at Atuabo. Further supply to the plant is also expected from the TEN fields but in 2017. The Sankofa Field being operated by the ENI is set to supply gas from its Floating Production Storage and Offloading (FPSO) vessel in 2018.

We estimate the average WAGP gas flow in 2016 to be 60 mmscfd, i.e. same as the previous year, whilst an average of 90 mmscfd (range of 80-100 mmscfd[31]) is expected from the Atuabo gas making a total average of 150 mmscf per day supply or 54,900 mmscf for the whole year[32]. Gas required for fuelling the thermal plants would thus range between 54,900 mmscf (54.9 bcf).

In the light of the projected limited quantities of natural gas supply, fuel allocation at Tema and Takoradi power enclaves thus projected as follows:

Tema:

- *Nigeria Gas allocated to existing and new Sunon-Asogli power plants.*
- *TT1PP/CENIT operates on light crude oil (LCO); KTPP operates on diesel; Karpower Barge operates on heavy fuel oil (HFO).*
- *MRP/TT2PP/TT2PP-X are on standby.*

Takoradi:

- *Ghana Gas allocated to VRA/Ameri power plant and partly to T2 power plant.*
- *T1 operates mainly on LCO with gas as supplement.*
- *T2 operates mainly on gas with LCO as supplement.*

Average delivery price of the WAGP gas in 2015 was $8.75/MMBtu ($9.1/mscf) and that of Atuabo gas was a uniform $8.84/MMBtu ($9/mscf). Assuming the Atuabo gas price of $8.84/MMBtu ($9/mscf) as the average delivery gas price for 2016, the total cost of gas required for **2016** would range from **$489-489.4 million**.

LCO

In 2015, Light crude was sold to Ghana at an average price of $46 per barrel. The average delivery price of the light crude (i.e. including transportation and treatment) for power

[31] 120 mmscfd high will be reached occasionally but not likely to be in most cases.
[32] Assumed 150x366 days.

generation was $60 per barrel. We expect the delivery price to remain about the same for 2016.

The total LCO requirement for 2016 is about 5.9 million barrels. Based on a cargo size of 405,000 barrels, a total of 14.5 cargoes of LCO would be required. The total cost involved would be **$354 million**.

<u>HFO</u>

HFO would be used mainly by the Karpower Barge. An estimated 2.8 million barrels would be required. This translates to 6.8 cargoes, assuming a cargo size of 405,000 barrels at an estimated delivery cost of **$201.6 million** at $72 per barrel[33].

<u>Diesel</u>

Diesel would be used mainly by the KTPP plant and for starting and shutting down all thermal plants. An estimated **1.4 million barrels** (3.4 cargoes for a cargo size of 405,000 barrels) would be required by KTPP for power generation. About **60,164 barrels** would be required for starting and stopping all VRA thermal power plants. Another **51,140 barrels** of diesel is estimated to be used by IPPs for starting and stopping of the plants. In all, about **1.51 million** barrels of diesel would be needed at a total delivery cost of **$136 million** at $90 per barrel[34].

In all, about **$1.18 billion** would be needed for **fuel** (*see Table 8*).

Table 8: Estimated Quantities of fuel needed for the Power Plants and cost involved.

fuel type	Unit delivery cost	Quantity	Total Cost (US$)
Gas	$9/mscf	54,900 mmscf	494,100,000
LCO	$60/bbl	5.9 million barrels	354,000,000
HFO	$72/bbl	2.8 million barrels	201,600,000
Diesel	$90/bbl	1.51 million barrels	135,900,000
		Grand Total	**1,185,600,000**

From the above analysis, we estimate that the **maximum grid electricity** available in **2016** would be about **16,401 GWh** with the corresponding installed and available capacities of about **3,737 MW** and **2,546 MW** respectively, provided the planned capacity additions for this year are timely completed and there is adequate financial resource to procure all the fuel needed to run the thermal power plants at the projected utilisation factors (*see Table 9*). This

[33] $72/bbl = 1.2 x LCO delivery cost.
[34] $90/bbl=1.5 x LCO delivery cost.

means that the existing generation capacity could supply about 40% more than last year which is equivalent to an increment of about **630 MW net** thermal power plant equivalent.

Table 9: Maximum Grid Power Generation Capacity estimated for 2016.

GENERATION PLANT	FUEL TYPE	CAPACITY (MW)				TOTAL GENERATION	
		Installed (name plate)	Average Dependable	Average Available	Utilization of available	GWh	% Share
Hydro Power Plants							
Akosombo	Hydro	1,020	900	375	0.99	3,285	
Bui	Hydro	400	345	230	0.46	926	
Kpong	Hydro	160	140	105	0.68	625	
	Sub-Total	*1,580*	***1,385***	***710***		***4,836***	***29.49***
Thermal Power Plants							
Takoradi Power Company (TAPCO)	Oil/NG	330	300	300	0.8	2,109	
Takoradi International Company (TICO)	Oil/NG	330	320	320	0.74	2,071	
Sunon–Asogli Power1 (SAPP1)	NG	200	180	180	0.78	1,275	
Sunon–Asogli Power2 (SAPP2)	NG	180	170	170	0.76	1,138	
Tema Thermal Plant1 (TT1P)	Oil/NG	110	100	100	0.54	472	
Tema Thermal Plant2 (TT2P)	Oil/NG	45	30	30	0.09	13	
TT2P-X	NG	49.5	45	30	0.04	10	
MRP	Diesel/gas	80	70	40	0	0	
CENIT Energy Ltd (CEL)	Oil/NG	110	100	100	0.8	694	
KTPP[#]	Oil	200	200	100	0.8	712	
AMERI	NG	230	230	230	0.8	1,592	
Karpower (power rental)	HFO	250	225	225	0.74	1,449	
	Sub – Total	***2,134.5***	***1,970***	***1,825***		***11,535***	***70.33***
Renewables *(excluding hydro)*							
VRA Solar	Solar	2.5	1.5	1.5	0.45	4	
BXC Solar	Solar	20	10	10	0.3	26	
	Sub – Total	*22.5*	11.5	11.5		***30***	***0.18***
Total		**3,737**	**3,366.5**	**2,546.5**		**16,401**	

But for the low-level of the Akosombo Dam, there would have been enough dependable capacity to eliminate the threat of load-shedding completely. Total dependable capacity would have reached about **3,400 MW**[35], about 200 MW more than the minimum threshold of 3,200 MW dependable capacity[36].

In the light of the electricity supply challenges, the Government is still considering more power rentals through independent power producers (IPPs) to mitigate the situation after bringing in **225 MW Karpower** Ship from Turkey and the **250 MW AMERI** (formerly APR from UAE) plant.

For Karpower, **450 MW** was envisioned originally and that target is still being pursued but requires addressing the transmission expansion offshore to evacuate the full capacity from whatever location along the shores of Ghana. From our estimation therefore, it is not likely to be available by the end of the year.

1.4.2 The 2016 Electricity Demand Outlook

We do not envisage major load-capacity expansion in existing industrial set-up. However, key spot loads identified for 2016 load demand growth are the following:

i. Western Diamond Cement (ECG) – 7 MW (Takoradi),

ii. Ghana Water Company Kpong – 25 MW,

iii. Enclave Power Authority 42 MW, Asanko Gold – 17 MW.

iv. Rice Factory at Nyankpala-2.5 MW,

v. GWCL in Wa- 3.5 MW,

vi. Aluminium Company in Tamale-1.5 MW etc.

The numerous rural electrification projects earmarked for commissioning in 2016, more so being an election year are anticipated to increase demand in both the ECG and NEDCO operational areas. Besides, on-going network expansion works and measures to improve the quality of distribution services by ECG and NEDCO would further allow the connection of new loads which would culminate in an increase in demand in the residential, commercial and industrial sectors.

Nevertheless, the available grid power supply of **16,401 GWh** means there would only be enough just to improve the economic growth to achieving the targeted 4-4.5% for 2016[37]. The estimated transmission grid system peak demand would be between **2,477-2,500 MW,** about 8.5% growth over what was projected for 2015.

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[35] Existing dependable capacity (2,533 MW from Table 5) + New/additional dependable capacity (868 MW from Table 6).

[36] See Page 7 of 2015 Energy Outlook for Ghana.

[37] See Level 1 on Pages 6 and 7.

Even though, significant improvement over 2015, it would still not eliminate the threat of load-shedding until the country is able to obtain significant imports from neighbouring Cote d'Ivoire to augment supply. This also means that VALCO would still have to be constrained at one-potline in 2016 just as in 2015 (*see Figure 4*).

It is worth noting that, due to the supply deficit in 2015, the generation capacity could not meet the projected peak demand for the year. The projected peak demand for 2016 is therefore a build-up on the projected peak demand for 2015.

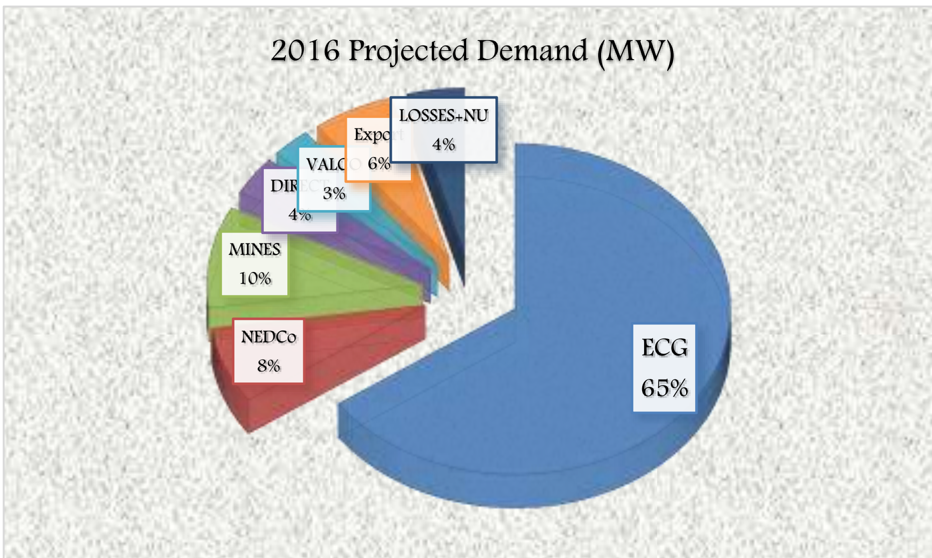

Figure 4: System Peak Demand by Major Customers for 2016

Figure 4 shows system peak demand for 2016 by customer, ECG demand constitute 64% of the total system peak followed by Mines 10%. VALCO at one potline represents 3%, NEDCO 8%, Exports to CEB and SONABEL 6%. Table 1 shows the composition of the demand.

Impact of Electricity Tariff on Demand

Prevailing electricity tariff moves Ghana from once among less expensive countries to very expensive grid tariff regimes in Africa[38]. This is likely to reduce grid power consumption particularly in commercial, services and industries which are the wealth creation sectors with consequential marginal growth of the economy from the expected **3.5-3.9% for 2015** to just around **4% for 2016**.

Most heavy industries including the mines would require on the average tariff less than 6 US cents per kWh to stay competitive with similar products imported. Light industries could go

[38] Low or less expensive tariff: 2-9 US cents/kWh; medium expensive tariff: 10-15 cents/kWh; High or very expensive 18-25 US cents. 26-35 US cents/kWh most expensive.

as high as 10 US cents per kWh to survive. Thus for current energy tariffs for industries ranging from 18 – 26 US cents per kWh, excluding service charges means they are on the very high-side.

For non-residential or Commerce/service customers, for a tariff range of 26-43 US cents per kWh for initial consumption of 300 kWh in a month, it would be cheaper running own diesel alternative if available, except for convenience. Running a back-up generator at the current retail diesel price in the country would produce electricity at an average cost of 27 US cents per kWh.

As if some service sector consumers have already realised it, they are switching to their back-up gensets during the last two weeks of the month.

Opportunity for Deployment of Solar PV for the Commerce/Services Sector

On the other hand, with solar electricity having feed-in tariff of **18.24 US cents per kWh** equivalent for systems without back-up storage and **20.14 US cents per kWh** equivalent for systems with back-up storage[39]) the prevailing high relatively electricity tariff *(see Tables 10 and 11)* make it cost competitive to encourage nationwide deployment of solar in all sectors of the economy. This also provides opportunity for increasing penetration of energy efficiency and demand-side management activities.

Table 10: Non-Residential Electricity Tariff for 2014, 2015 and 2016.

CONSUMPTION CLASS	**RATE**					
	Gp per kWh			**US cents per kWh**		
Year	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**
0-300	45.2	60.79	96.79	16.99	16.00	25.47
301-600	48.1	64.69	102.99	18.08	17.02	27.10
601+	75.9	102.08	162.51	28.53	26.86	42.77

US cent 1 = 2.66 Ghana pesewas average in March, 2014.
US cent 1 – 3.80 Ghana pesewas average in March, 2015
US cent 1 – 3.80 Ghana pesewas average in March, 2016

Rooftop Solar Programme

In the light of the power supply shortfall, the Energy Commission with its mandate to ensure the development and utilisation of the renewable resources has initiated the rooftop solar programme in an effort to contribute to mitigating the current power crisis.

[39] US cent 1 = 3.1986 Ghana pesewas average as at September 30, 2014 when the tariff were set.

The objective of the programme is to reduce the daily national peak load by 200 MW through self-generation using solar photovoltaic (PV) technology.

The programme is targeted at homes, offices, hospitality industry and small businesses.

Under the programme, a capital subsidy is given to beneficiaries in the form of rebate which would pay for part of the total cost of the solar system, specifically, the solar PV modules while the beneficiaries pay for the balance of system (BOS) components. Beneficiaries would also be given the option to take a special bank loan to offset the payment commitments.

Table 11: Selected Electricity Tariff Customer Classes for 2016.

CONSUMPTION CLASS	**RESIDENTIAL**		**NON-RESIDENTIAL**		**INDUSTRIES**	
	Gp per kWh	***US cents per kWh***	**Gp per kWh**	***US cents per kWh***	**Gp per kWh**	***US cents per kWh***
51-300	67.33	***17.72***	96.79	***25.47***		
301-600	87.38	***22.99***	102.99	***27.10***		
601+	97.09	***25.55***	162.51	***42.77***		
SLT – Low Voltage					100.88	***26.55***
SLT – Medium Voltage					78.09	***20.55***
SLT – High Voltage					71.76	***18.88***
SLT – High Voltage Mines					113.97	***29.99***

US cent 1 – 3.80 Ghana pesewas average in March, 2016

1.4.3 Summary of 2016 Power Forecast

The following conclusions are drawn in respect of the limited electricity supply for 2016:

i. Due to low elevations at Akosombo generation station, three (3) units would have to be operated throughout the year in order to prevent a situation where elevations below 235 ft. will be recorded prior to the onset of the rains.

ii. The Ghana power system would have low reserve margin in 2016 and therefore when units are out for maintenance the system will be prone to inadequate supply

iii. One crucial requirement for reliable power supply is the availability of the required quantities of fuel and funds to purchase the fuel in a timely manner.

Summary of forecast for the power sector for 2016 is as follows (see *Table 12)*:

Table 12: Summary of Power Sector forecast for 2016.

Optimum electricity requirement to eliminate the load-shedding (GWh) *(VALCO at 3-5 potlines in brackets)*	18,158-18,737 *(20,146-20,698)*
Expected dependable capacity (MW) *(Including spinning reserve margin)*	3,979-4,076 *(4,260-4,357)*
Corresponding installed capacity (MW) *(Including spinning/reserve margin)*	4,300-4,500 *(4,500-4,700)*
Likely available grid electricity supply (GWh)	16,400-16,402
Projected Available Capacity (MW) *(projected installed capacity)*	2,546-2,550 *(3,737)*
Likely shortfall in capacity *(dependable – Available)* (MW)	820
Total capacity required to cover existing shortfall and spinning/reserve margin (MW)	1,630-1,700
"Emergency" Power contracts planned to offset shortfall MW	895-1,595
Additional Power Capacity expected to be available this year *(excluding exports)* MW	868
Ghana System Peak/Maximum Demand (MW)[40]	2,325
GRIDCO Transmission System Peak/Max Demand (MW)	2,477
Projected volume of gas required (mmscf)	120,000-146,400
Estimated available gas supply (mmscf)	54,900-55,000
Expected Jubilee gas flow rate (mmscf**)*** MMBtu per day *(mmscf per day)*	29,280-36,600 80,000-100,000 *(80-100)*
Total Jubilee delivery gas price $ per mmBtu *($ per mscf)*	8.84 *(8.99)*
Expected WAGP gas flow rate (mmscf)* mmBtu per day *(mmscf per day)*	18,300-25,620 50,000-70,000 *(50-70)*
Average delivery WAGP gas price to VRA[41] $ per mmBtu *($ per mscf)*	8.7 *(8.9)*
Expected crude oil (LCO) requirement Million barrels	5.9 million
Projected delivery price for light crude oil (LCO) *dedicated for power production* $ per bbl *($ per mmBtu)(cif)*	60 *(14.6)*
Expected diesel requirement (barrels) *(Delivery price)*	**1.5 million** (*US$90/bbl*)
Expected HFO requirement (barrels) *(Delivery price)*	**2.8 million** (*US$72/bbl*)
**Low-side oil implies more gas available and high-side implies less gas available*	

[40] Domestic peak

[41] WAPCo delivers the gas at a lower price to VRA but the latter apparently adds administrative and other costs.

2.0 Petroleum Subsector: Oil

2.1 Overview of Petroleum Supply in 2015

Saltpond field

Total oil production from the Saltpond field fell from 97,301 barrels in 2014 to 46,630 barrels in 2015, a drop of about 48%. Production in 2013 was 98,289 barrels[42]. Mean daily and monthly productions were 128 and 3,885 barrels compared with 290 and 8,108 barrels respectively in 2014. Once again, as in the previous years, the production trend is an indication that the field has matured and consequently drying up (*see Figure 5*).

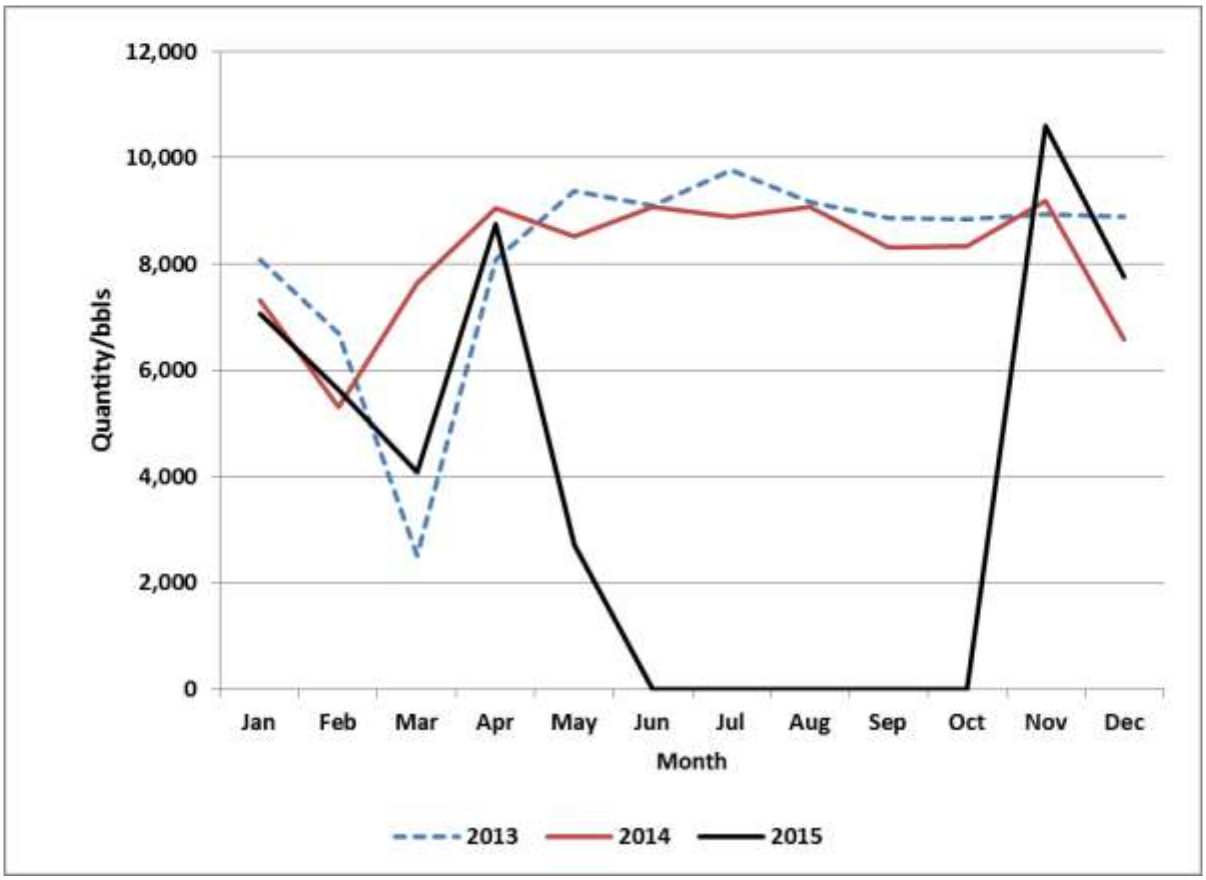

Figure 5: Comparison of Saltpond field oil production in 2013, 2014 and 2015

Jubilee field

Total oil production from the Jubilee field in 2015 on the other hand was around 38.8 million barrels compared with 38.7 million barrels in 2014 and 30.4 million barrels in 2013. Total

[42] Data provided by Saltpond Oil Fields Company.

production in 2012 was 27.4 million, meaning production is on the increase despite the fall in global oil prices.

Average daily oil production from the Jubilee field increased from about 91,000 barrels in 2013 to 105,935 barrels in 2014 and 106,938 in 2015 still though, unable to reach the target of 120,000 barrels per day as projected by the industry since 2012 (*see Figure 6*). Average daily production in 2012 was 81,000 barrels.

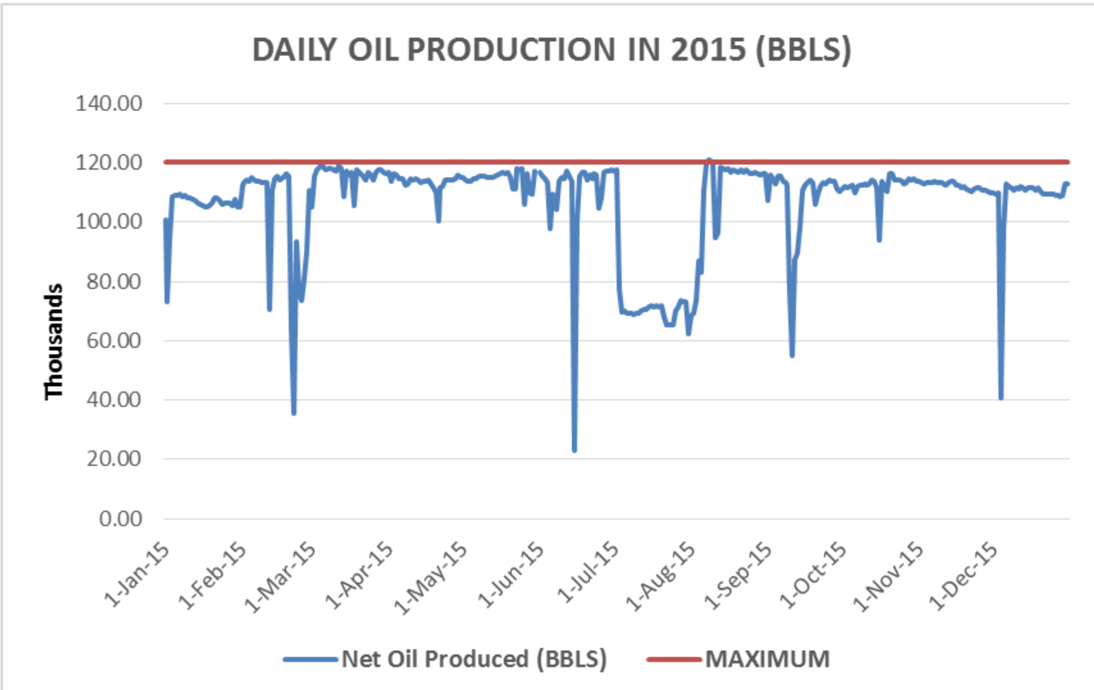

Figure 6: Jubilee field daily oil production in 2015

Mean daily production was fairly stable averaging 106,654 barrels throughout the year; peak average daily production was about 115,956 barrels occurring in March. It dropped to a monthly average of about 110,000 per barrel till reaching its lowest of 72,876 barrels in July before starting to edge up again.

Crude Prices

In 2015, crude oil from the Jubilee field was sold at a price range of $50-66 per barrel compared with $96-102 per barrel in 2014. Starting with an average price of $61 per barrel during the first quarter, it fell to an average of $54 in the second quarter, and then rose to an average of $64 before dropping below $50 per barrel during the last quarter. The annual average was about $56.6 per barrel.

Average price of crude oil sourced by Ghana in 2015 for the refinery was about $52 per barrel compared to $99 per barrel in 2014 (*see Table 13*). It was $65 per barrel in the first quarter before dropping to below $50 per barrel during the last quarter of the year.

The annual average for power generation however was relatively high, $59 per barrel *(fob)* and $60 per barrel *(cif)*.

Table 13 compares the Ghanaian sourced oil prices to those of West Texas Intermediate (WTI) representing the United States and the London Brent representing Europe.

Table 13: Average crude oil prices in Ghana, United States (Gulf Coast), and Europe (the North Sea).

Year	Ghana	WTI Gulf Coast/ United States	Brent Crude North Sea/ United Kingdom
	U.S dollars per barrel		
2010	80	79.4	70
2011	111	94.9	111
2012	113	93.3	112
2013	109	97.9	109
2014	99	93.3	99
2015	52 (60)*	48.7	52

**for power generation.*
Source: Bank of Ghana, LondonGasPrice.com, tradingnrg.com; www.statistica.com

Global Scan

The global economy growth has been on the downward trend since 2013. IMF projected the global economy to expand from 3.3% per annum in 2014 to 3.5% in 2015 but it rather dropped to 3.1% in the said year. The World Bank was even more conservative in its growth forecast; projected a lower growth of 2.6% growth in 2014 and 2.4% for 2015.

Average growth in advanced economies on the other hand expanded from 1.3% in 2013 to 1.8% in 2014 but saw a marginal increase to 1.9% in 2015. Growth is projected to remain unchanged or just marginal at 2.1% in 2016[43].

Economic growth in emerging market economies dropped from 4.3% in 2014 to 4% in 2015 and is projected to increase to 4.3 in 2016 due to moderate growth forecast for China (just around 7%).

Growth in Sub-Saharan Africa on the other hand dropped from 4.5-5% in 2014 to about 3.3-4% in 2015 and this is being attributed to the fall in oil prices and other primary

[43] IMF World Economic Outlook Update, January, 2016.

commodities[44]. The World Bank forecasts a 3.3% growth for the Sub-Saharan Africa in 2016.

With reference to the above discussion and from **Tables 14** and **15**, it is clear that economic growth is directly and strongly related to the injection of adequate energy for a developing economy like Ghana.

Table 14: Ghana's Oil Imports, costs and GDP growth compared.

Year	Crude oil (million tonnes)		Oil Products imported (1000 tonnes)	Petroleum imported in US$1000 (fob)	Average Crude oil price US$/bbl	Real GDP at 2006 constant prices Million GH Cedis	Average Exchange Rate GHs=$	Real GDP growth Rate
	Imported	Exported						
2010	1.66	0.01	1,590	2,134	80	24,101	1.45	8%
2011	1.53	3.53	2,109	3,159	111	27, 487	1.55	15%
2012	1.21	3.78	2,573	3,279	113	30,040	1.88	8.8%
2013	1.30	5.11	2,946	3,550	109	32,242	1.97	7.3%
2014	0.69	5.39	3,394	3,694	99	33,522	3.20	4%
2015	0.31	5.21	3.650	2,194*	60[45]	34,888**	3.68	3.9-4.1**

* *Estimated from different sources since final value not available from GSS and Bank of Ghana yet.*
***Provisional. Data source: Bank of Ghana, December 2015, Ghana Statistical Services, 2015*

Table 15: Ghana Economic Growth and Energy Consumption compared.

Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Real GDP in US$ equivalent	16,621	17,734	15,979	16,366	10,497	9,506
GDP Growth %	8	15	8.8	7.3	4.0	3.5-3.9
Final Energy consumed per GDP (TOE)	0.24	0.23	0.22	0.21	0.21	0.21
Primary Energy consumed per capita	0.28	0.30	0.32	0.32	0.34	0.34
Middle-income average minimum benchmark	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**
Final Energy consumed per capita (TOE)	0.23	0.24	0.25	0.26	0.26	0.26
projected	**0.40**	**0.42**	**0.42**	**0.43**	**0.43**	**0.43**
Middle-income average minimum benchmark	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**

[44] World Bank estimated 4.5% and 3.3% growth for 2014 and 2015 respectively whilst IMF estimated 5% and 4% for 2014 and 2015 respectively. IMF World Economic Outlook Update, January, 2016.
[45] Crude price was largely influenced by power generation accounting for 80% which averaged $59 per barrel (fob) but that for the refinery averaged $52 per barrel.

The consumption of both primary and final energy in Ghana still remain far below those of the average minimum exhibited by countries of lower middle income status as compiled by the International Energy Agency (IEA).

We projected under SNEP 1 that all things being equal[46], the country should have had energy injection of at least 0.40 tonnes of equivalent (TOE) by 2010 increasing to 0.43 TOE by 2015, i.e. thereby achieving the required energy supply and consumption to facilitate comfortable living standard of the populace and befitting a country of lower middle-income status.

Domestic consumption and stocks in 2015

Crude oil imported for domestic consumption further dropped from 693,000 tonnes (~4.85 million barrels) in 2014 to 310,000 tonnes in 2015, compared to 1.3 million tonnes (9 million barrels) in 2013; a decrease of a little over half the quantity from the previous year. Electricity production accounted for about 80% of the crude oil consumption whilst primary refinery operations accounted for the remaining 20%.

Total products supplied in 2015 however increased to over 3.5 million tonnes from almost 3.3 million tonnes, in 2014. The great product movers were LPG, diesel and gasoline. Kerosene, ATK and premix fuel supplied however dropped (*see Table 16*).

Table 16: Petroleum products supplied to the Economy for 2013-2015.

PETROLEUM PRODUCT	2013	2014	2015	*CHANGE*	
				b/n 2013 & 2014	***b/n 2014 & 2015***
	1000 tonnes			***Percentage***	
LPG	251.8	241.5	279	*-4.1*	*15.5*
Gasoline	1,080.6	1,102.3	1,163.2	*2.0*	*5.5*
Premix	53.4	56.2	47.2	*5.2*	*-16*
Kerosene	27.8	9.3	6.9	*-66.5*	*-25.8*
ATK	131.9	113.9	112	*-13.6*	*-1.7*
Gas oil/diesel	1,722.6	1,713	1,902.7	*-0.6*	*11.1*
RFO	39.3	26.8	13.4	*-31.8*	*-50.0*
Total	**3,307.40**	**3,263.1**	**3,524.4**	***-1.3***	***8***

Source: National Petroleum Authority, 2016.

[46] i.e. should the recommendations made in SNEP 1 had been followed. SNEP 1 is the same as SNEP (2006-2020) published by the Energy Commission in 2006. It is available at www.energycom.gov.gh/planning

Table 17: Petroleum products produced locally, imported and Exported from 2013-2015.

PETROLEUM PRODUCT	2013			2014			2015		
	1000 tonnes								
	Prod	**Imp**	**Exp**	**Prod**	**Imp**	**Exp**	**Prod**	**Imp**	**Exp**
LPG	25.3	203.9	0	3.3	236.4	0	2.0	197.7	0
Gasolines	167.3	1,017	36	40.4	1,254	10.2	31.8	1,182	9.9
Kerosene	14.6	0	0	4.5	0	0	0.2	0	0
ATK	59.8	41.4	122.3	9.4	112.4	105.6	18.2	109.1	101.9
Gas oil/diesel	113.3	1,639	51.8	27.8	1,742	10.8	28	2,161	10.3
RFO	43.5	44.3	3.7	43.7	48.6	0	8.9	0	0
Total	**424.2**	**2,946**	**213.8**	**129.2**	**3,394**	**126.6**	**89.1**	**3,650**	**122.1**

Prod refers to production at the local refinery, Tema Oil Refinery; **Imp** refers to imports while **Exp** refers to exports. NB: *Diesel export is largely sales to international bunkers. ATK export is sales to international aviation bunkers. Gasoline export was largely heavy gasoline.*
*Source: Tema Oil Refinery and National Petroleum Authority***.**

LPG supplied increased even though there were decreased in local production and imports. This could be due to commencement of operations of the Atuabo gas processing plant which is churning out more LPG as by-product of processing wet/rich associated gas to dry/lean gas for power production.

Significant rise in diesel supplied could be due to the increase in severity of the power load-shedding which demanded more diesel for private gensets.

Drastic drop in kerosene supplied was largely due to drop in demand for lighting caused by shift from use of kerosene to battery/cell dry and solar powered lamps for lighting. There has also been significant shift from kerosene to LPG for cooking anytime the latter is adequately available on the market as occurred in 2015. These trend changes were first noticed during the 2010 census. Drop in ATK in 2015 was attributed to relatively high cost of the fuel that year compared to the previous year. The airlines resorted to refuelling largely in low cost locations along their routes to avoid procurement in Ghana.

Products exported were largely marine gas oil (MGO) and heavy gasoline (naphtha), the former sold to foreign vessels.

2.2 2015 Forecast and Actuals

Average Brent price for refinery operations was $52 per barrel. LCO however for power operations was on the high side as usual, averaging $60 per barrel for the year. From average of $55 (*cif*) per barrel during the first quarter, it rose to an average of $70 (*cif*) by the end of the second quarter then fell to back to $55(*cif*) per barrel during the third quarter, thereafter falling below $50 per barrel during the last quarter (*see Table 18*).

Table 18: Yearly average crude oil prices for 2015: Forecast and Actuals.

	Ghana		WTI & NYMEX Gulf Coast/ United States		Brent Crude North Sea/ United Kingdom
	Brent	**LCOs***	**Brent**	**LCOs***	**Brent**
Forecast	60-65	55-60	60-61	54-55	63-65
Actual	52	60#	52	48.7	52

** Other light crudes / U.S refiner*
 # largely influenced by power generation requirements
Source: Bank of Ghana, U.S EIA Short Term Energy Outlook, 2015, 2016

Crude oil for refinery at Tema Oil Refinery (TOR) was just about 20% of the total crude oil imported in 2015. It has continuously dwindled since 2010 reaching its lowest of 61,800 tonnes in 2015 as compared to its refinery capacity of about 2 million tonnes per annum *(see Table 19).*

Table 19: Operating performance of Tema Oil Refinery with and without the RFCC[47].

	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

The Tema Oil Refinery (TOR) comprises a Crude Distillation Unit (CDU) with a production capacity of 45,000 barrels per day (bpd) and a 14,000 bpd Residual Fluid Catalytic Cracker

[47] RFCC is Residual Fuel Catalytic Cracker.

(RFCC) unit to process the Residual Fuel Oil (RFO), which is a by-product of crude oil processed by the CDU, into more diesel, gasoline and LPG *(see Table 19).*
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. All things being equal, it costs less to import crude oil for refining locally than importing the finished products.

A new crude oil furnace is currently being installed at the TOR, which is expected to increase the production capacity of the Crude Distillation Unit (CDU) to 60,000 barrels per stream day. The official commissioning of the crude furnace is set for some time this year, with an expected full operation in 2017.

The supply of all petroleum products with the exception of gasoline and diesel, LPG and ATK (including kerosene) was below the projections for 2015. The total product deficit was between 71 and 139 tonnes (*see Table 20*).

Table 20: Comparison of major petroleum products consumption in Ghana in 2014 and 2015[48].

PRODUCTS	2014 CONSUMPTION 1000 Tonnes			2015 CONSUMPTION 1000 Tonnes		
	Forecast	Actual	Net /shortfall*	Forecast	Actual	Net /shortfall*
Gasolines	1,150 -1,200	1,158.5	8-41.5	1,150-1,200	1,210.4	10.4
Diesel	1,760 - 1,850	1,713.3	46.7-136.7	1,760- 1,850	1,902.7	52.7
Kerosene /ATK	240 – 250	123.2	116.8-126.8	240 - 250	118.9	121.1-131.1
LPG	300 – 350	241.5	58.5-108.5	300 - 350	279	21-71
Total	***3,450 3,650***	***3,263.5***	***198-405.5***	***3,450 3,650***	***3,511***	***71-139***

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
** Low-side implies high efficient fuel consumption.*

Drop in ATK supply for 2015 was attributed to its relatively high cost in the country. ATK supply shortfall in the country in 2013 compelled a number of foreign airlines to make alternative refuelling arrangements with neighbouring countries before landing or taking off in the country. The shortfall in kerosene was largely due to the shifts from its usage for lighting and cooking to better options.

There was significant improvement in LPG supply though still below forecast. This was largely due to the operations of the Atuabo Gas Processing Plant which is producing LPG as by-product from processing the wet associated gas from the Jubilee Field to dry gas for power generation.

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

There is now a deliberate government policy to make the LPG produced available for local consumption as against export. Also, subsidies on LPG has largely been removed.

National LPG penetration share of households increased from 6% in 2000 to 18% in 2010 and 22.3% in 2013[49]. Government is targeting 50% penetration by end of 2020 but it is not likely to be achieved if the existing limited distribution outlets nationwide remain the same.

For instance, to achieve a 50% nationwide penetration of LPG, the consumption would require an LPG supply of at least 450,000 tonnes by 2020 based on an estimated population of 31-32 million by the end of the decade.

Increasing refinery capacity and revamping of TOR would also increase its production of LPG.

The total national LPG storage capacity coverage is however a challenge, since the distributions are largely found in southern Ghana, from Kumasi, Koforidua and along the coast. The limited storage capacity nationwide would thus continue to constrain the local distribution and access.

Government measures put in place to support and accelerate the supply and use of LPG include:

- Re-capitalising the Ghana Cylinder Manufacturing Company (GCMC) to expand production capacity and focus on the production of small sized cylinders that would be portable and affordable to households in rural communities.
- Constructing LPG storage and supply infrastructure in all regional and district capitals in the long term

[49] 2010 Population Census, Ghana Statistical Services. 2013 data is from GLSS 6, 2014, Ghana Statistical Services.

2.3 Forecast for 2016

Average oil production from the Jubilee field decreased from 110,000 barrels per day in 2014 to 106,939 barrels per day in 2015. Thus fell below the 115,000-120,000 barrels per day projected for 2015.

For 2016, we project the average oil production to remain about the same or drop marginally to **100,000-105,000** barrels per day due to the prevailing low average oil prices.

Further, we forecast that average Brent crude oil that Ghana buys would lie within **$45-50** per barrel and **$40-45** per barrel for other light crudes for refinery operations (*see Table 21*). Average delivery price of light crudes for power production would be **$55-60** per barrel.

Table 21: Forecast for average light crude oil prices for 2016.

FUEL BRAND	Ghana	United States (WTI and NYMEX)	Europe[50] (UK & Holland)
	US dollars per barrel		
Brent crude	45-50	34	37
Other light crudes/ U.S refiner	40-45	34	36-37

Jubilee field oil was exported at an average price of $56.6 per barrel in 2015. We project the average price in 2016 to drop to **$45-50** due to the global price slump.

For the year **2016**, the total petroleum product requirement would as usual depend upon the performance of the economy and it is projected as follows (*see Table 22*):

For 2016, 3.7-3.9 million tonnes, equivalent to 70,000-75,000 barrels per stream day refinery capacity would be required to enable the country meet at least, its projected economic growth of 4-4.5%. A higher economic growth would however demand about 4.5-4.8 million tonnes equivalent to 85,000-90,000 barrels per stream day refinery capacity (*see Table 22*).

The requirement for diesel (gas oil) include demand by the mining and the petroleum upstream industries. Limited grid power supply would also put pressure on the total requirement due to increasing demand for back-up generation.

A third of the total LPG requirement could come from TOR, if operating averagely at over 90% capacity during the year (*see Table 19*).

[50] London and Rotterdam trading for Brent averaged $36 for 2016. www.tradingeconomics.com World Bank forecasts $37 per barrel for 2016.

Table 22: Forecast for petroleum product requirement for 2016.

PRODUCT	National supply requirement 1000 Tonnes	
	For marginal economic growth 4-4.5%	**For economic growth >4.5%**
Total Gasolines	1,300 -1,400	1,700-1,800
Total Diesel	2,0 00 - 2,100	2,300-2,400
Kerosene	5-6	8-10
ATK	120-130	200 – 220
LPG	290 – 300	300 – 350
Total	***3,715-3,936***	***4,508-4,780***
Equivalent refinery capacity	***70-75 per day***	***85-90 per day***

Additional LPG supplies would come from the Atuabo gas facility processing the wet associated gas from the Jubilee field. For instance, processing 80 mmscfd of the wet gas would yield about 500 tonnes of LPG a day, which would be enough to meet the country's projected short to medium term demand of **300,000-350,000** tonnes per annum up to 2020[51]. Ability to meeting this supply requirement would translate into achieving the country's target of **50% penetration** within **2015-2020.**

Evacuation of the LPG to the storage some distance away for now is being done by road since the originally planned LPG pipeline has not been built. Plans are however advanced to begin construction.

Overland pipelines are generally found to have lower cost per unit and higher capacity compared to shipment by rail or road and for that matter the most economical way to transport large quantities of fluids[52] over land. Overland pipeline transportation and distribution have therefore been the dominant mode for terrestrial oil and products transport. It is also said to be safer.[53]

Refinery capacity

The Tema Oil Refinery (TOR) was supposed to refine all the crude oil needs of the country with the exception of the consignments meant for power generation. The country's annual

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[51] Assuming short term is 1-2 years; 2015-2016 and medium term; 2015-2020.

[52] Also natural gas and crude oil.

[53] Advances in Natural Gas Technology, INTECH publication, April, 2012, edited by Hamid A. Al-Megren, www.intechopen.com/books.

petroleum requirement has however exceeded the capacity of TOR by more than 50% assuming TOR is operating even at 90% capacity utilisation.

Capacity utilisation at TOR however worsened from about 5% in 2013 to just around 3.1% in 2015. Based on international standards however, at least 90% capacity utilization is required for refineries to achieve economic viability.

On the other hand, the prevailing low global oil price regime is an incentive for the refinery to make profit perhaps for the first time in many years; all things being equal and in a de-regulated market, the lower the input (crude oil) price the higher the profit margins on the outputs (products).

Thus, providing at least **1.5 million tonne (about 11 million barrels**) for the refinery, *(i.e. at least 70% equivalent to about 30,000 barrels per stream day*) during the year could help break-even for TOR operations, depending upon the production configuration. Profit could start showing up as the capacity utilisation increases.

Strategic reserves

Fuel supply security and the erratic prices of fuel have advised countries to set up strategic stocks for both crude oil and refined products. Most developed countries, for instance, the OECD[54] members have agreed on a minimum of six months of strategic stocks. However, with the prevailing low global oil prices, many of them had taken the opportunity to expand their crude oil reserves beyond the minimum to years.

Ghana decided on a similar measure in the 1990s and is supposed to maintain three weeks of strategic stocks of refined products on the average. However, most gasoline formulas when bought from open market are cracked petroleum products, meaning coming from the cracker units of refinery instead of straight-runs. Cracked gasoline and products have relatively short lifespan, usually not more than three months compared to straight-run products. This also means such cracked products must be used within three months of their storage to avoid gum formation. Straight-run gasoline and products last longer but more expensive, even then just a couple of years. Crude oil storage however, has the comparative advantage of far longer lifespan and could even be indefinite depending upon the blend and state. Among the long term strategy recommended under the SNEP 2006-2020 therefore was to expand the strategic stock to include crude oil.

Just as with the OECD countries, the global low oil price regime is an opportunity for BOST to implement and include crude oil in its existing strategic stock for the country.

[54] OECD is Organisation for Economic Cooperation and Development.

3.0 Petroleum Subsector: Natural Gas

3.1 Overview of Natural Gas Supply in 2015

Total gas flow in 2015 was 46,911,854 mmBtu (46,912 mmscf) almost twice that of 2014[55]; about 44% (95.4% in 2014) coming from Nigeria via the WAGP and the remaining 56% (4.6% in 2014) coming from the Atuabo gas processing plant.

About 51% of the total gas was supplied to the Sunon-Asogli thermal plant in Tema and the remaining 49% to the VRA thermal plant at Takoradi. All the indigenous gas i.e. the Jubilee field gas however went to the Takoradi thermal plant.

3.2 2015 Forecast and Actuals

Average gas flow in 2015 was about 64 mmscfd. Average gas flow from the WAGP and Jubilee fields were 56 mmscfd and 72 mmscfd respectively, which was within the forecast for the year.

The WAGP delivery gas price averaged $8.99/mmBtu ($9.16/mscf) for foundation customers and $9.14/mmBtu ($9.31/mscf) for standard customers for the first half of the year but dropped to $8.31/mmBtu ($8.45/mscf) for standard customers during the second half of 2015 due to its indexation to the falling oil price *(see Table 23).*

Table 23: Pricing Components for WAGP Delivered Gas for foundation customers in 2015.

Details	Customer Price		
	2014	**Jan-Jun 2015**	**July-Dec 2015**
	$/mmBtu		
Gas Purchase	2.4688-2.4776	2.2901	1.6171
ELPS Transport	1.2745	1.2959	1.2959
WAGP Transport	4.3465	5.0265	5.0265
WAGP Credit Support Charge	0.1299	0.1299	0.1299
WAGPA Charge	0.0600	0.0600	0.0600
Pipeline Protection Zone charge	0.0300	0.0250	0.0250
Shipper Fee	0.1000	0.1000	0.1000
Fuel charge	0.0749-0.0750	0.0717	0.0583
Delivered Gas Price ($/mmBtu)[56]	**8.3708-8.3798**	**8.9991**	**8.3127**

Source: Adapted from WAPCo, 2016

[55] Total gas flow in 2014 was 23,633,724 mmBtu (23,631 mmscf).
[56] Delivered gas price is not necessary an absolute sum of the listed charges.

The Jubilee gas delivered price was however uniform at $8.842/mmBtu ($9.01/mscf) throughout the year *(see Table 24).*

Table 24. Jubilee-Atuabo Delivered Gas Price in 2015.

Details	Customer Price for 2015
Gas commodity price	2.9
Gathering, Processing & transportation	5.28
PURC levy	0.66
Delivered Gas Price ($/mmBtu)[57]	**8.84**

Energy Commission, 2015.

Comparatively, average spot (Henry Hub) price in the United States in 2015 fell below the projected $3.85-$3.88 per mmBtu ($3.92-$3.95 per mscf) to $3/mmBtu ($3.06/mscf) [58].

Average gas price in the European Union (EU) however fell from about $10/mmBtu ($10.2/mscf) in 2014 to $7.26/mmBtu ($7.39/mscf) in 2015[59]. The EU Natural Gas Import Price dropped from $5.35/mmBtu ($5.45/mscf) beginning of this year to around $4.20/mmBtu ($4.28/mscf), early March, down from $8.27/mmBtu ($8.42/mscf) first quarter of 2014[60].

3.3 Forecast for 2016 and beyond

For **2016**, we project a further drop in WAGP delivery price to VRA from $8.31/mmBtu ($8.45/mscf) to between **$8.25-8.30/mmBtu ($8.40-8.45/mscf)** during the first half of the year but increase to **$8.50-8.55/mmBtu ($8.66-8.71/mscf)** during the second half**.** Annual average price would drop slightly from **8.75/mmBtu** to **8.7/mmBtu**[61]**.**

The delivery price of the Jubilee gas is on the other hand expected to remain at **$8.84/MMBtu (($9.01/mscf)** throughout the year.

However since we project the bulk of the gas to come largely from the Jubilee, we estimate a total average delivery price of $8.87/mmBtu ($9/mscf).

[57] Delivered gas price is not necessary an absolute sum of the listed charges.
[58] Spot prices usually do not include transportation cost.
[59] Projected price for 2015 was $7.80-8.10/mmBtu.
[60] https://ycharts.com/indicators/europe_natural_gas_price, March,2016.
[61] WAPCo delivers the gas at a lower price to VRA but the latter apparently adds administrative and other costs.

The average US spot price for gas is projected to drop further to $2.25/mmBtu ($2.75/mscf) for 2016.[62] Comparatively, the EU gas import price would range between $3.5-4.3/mmBtu and largely coming from Russia *(see Table 25).*

The market is nevertheless projecting US exports of LNG to Europe in 2016 but the average delivery price is estimated at $7-8/mmBtu and this is unlikely to withstand any potential price war with Gasprom of Russia which is capable of coming down to as low as $3.5/mmBtu to price out any potential trans-Atlantic trade.

Table 25: Average delivery gas prices in Ghana (WAGP), United States (Henry Hub), and Europe (the North Sea); 2011-2016.

Year	**WAGP+Jubilee/ Ghana**	**Henry Hub/ United States**	**Northsea Europe/**
	U.S dollars per mmBtu		
2011	6.56	3.59	8.70
2012	8.19	2.75	8.90
2013	8.27-8.38	3.71	10.63-10.72
2014	8.49	4.52	10.05
2015	8.80	3.00[63]	7.26
2016*	**8.87**	**2.25**	**3.5-4.2 *(4.5-8)*****

**forecast ;*
*** LNG forecast price range in bracket. Price range is an indication of where it is coming from.*
Source: Bank of Ghana, LondonGasPrice.com, tradingnrg.com

3.3.1 Gas Supply Challenges

A sustainable and relatively cost-competitive fuel supply to produce affordable power has been the weakest link in the electricity supply value chain. On the thermal side, gas on the average has been cheaper than oil. The key challenges however that have been experienced in the reliability of gas supply include:

i. Inadequate supply;
ii. planned and unplanned supply interruptions; and
iii. finance - domestic and international payment deficits.
iv.

Inadequate gas supply

With the number of thermal power plants currently installed and expected to be in operation by 2016, the supply requirement by the end of the year including potential demand by the

[62] US EIA Short Term Energy Outlook, March, 2016.
[63] Estimates from US EIA Short Term Energy Outlook, 2016

power rentals is expected to be between **328-400 mmscfd**. However only about 150 mmscfd would be available and provided the projected required amount of fuels are supplied. This translates into a deficit of **178-250** mmscfd.

Indigenous gas and LNG to the rescue

Even though, the country can boast of about five (5)) trillion standard cubic feet per day (tscf) of proven gas reserves, exploitation would depend on the demand and the delivery cost to the market.

Besides the associated gas from the Jubilee field, more gas is expected from other neighbouring fields in the short to medium term, the most prominent being the TEN (Tweneboa-Enyenra-Ntomme) fields. The development of the TEN fields commenced in 2013 and is expected to produce an average gas supply of 63-70 mmscfd and between 30,000-50,000 barrels of oil a day. First oil is expected by end of 2017, but the arrival of the FPSO[64] Professor Atta-Mills has raised the hope of seeing first oil from the field by the end of this year. Of course, this would also depend on the rate of development of the field[65].

The FPSO Professor Atta-Mills which would produce and store the oil from the TEN fields arrived in Ghana waters in the first week of March, 2016, after setting off from Singapore on 23rd January, 2016 where it was constructed. In Ghana waters, it would move to installation phase, followed by hook-up of sub-sea facilities via flow-lines, risers, and control umbilicals. The integrated infrastructure is billed to undergo final commission and testing during the second quarter before the first oil[66]. TEN is expected to yield an average of 90 mmscfd of gas for over 20 year operational lifetime.

The US$7.9 billion project - Sankofa and Sankofa East fields, another neighbouring fields to the Jubilee field presents the most significant proven non-associated gas discovery in recent times. Estimated yield is about twice the projected average yield from Jubilee; about 185 mmscfd. Deepwater 'non-associated' however means it would cost more to develop the field. Wellhead price is estimated to be $6-9 per mmBtu[67].

First oil from Sankofa and Sankofa East fields estimated at 30,000 barrels per day is expected by end third quarter of 2017 whilst the gas phase is expected to be completed during the first quarter of 2018 with the first gas being delivered by the end of that quarter.

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[64] Floating Production Storage and Off-loading vessel.

[65] Otherwise, we had earlier projected its first oil to be likely available in 2018 rather than in 2017 considering that the original project economics was based on $80 per barrel as against the current low price of oil which averages below $50 per barrel. From the World Bank report*: Energizing Economic Growth in Ghana: Making Power and Petroleum Sectors Rise to the Challenge, June, 2013. Energy Group, African Region.*

[66] Orient Energy Review, Vol.5 No.02/03 Feb-March, 2016.

[67] Natural Gas Pricing Policy for Ghana, Final Report, World Bank, May 2012, consultant- R. Garcia Consultores S.A

Production from these new fields would make available an average total of 300-500 mmscfd by 2020 if developments of the fields are carried out as planned [68].

Total gas supply however is not likely to exceed **500 mmscfd** though demand for power generation could go past **800 mmscfd** by 2020**.**

Thus, establishing the fact that the indigenous gas would still not be adequate to meet the gas requirements for the medium-to-long term requirements of the country, Ghana is therefore looking at supplementing the gas supply with LNG imports.

<u>LNG Option</u>

An estimated deficit of about **300 mmscfd** by 2020 is within the breakeven point for a typical 200-250 mmscfd LNG re-gasification facility.

LNG had been cheaper than crude oil in the past but the latter could be cheaper this year except that oil prices had generally been erratic and for that matter there is no guarantee for the existing relatively low prices to remain so in the medium to long term.

LNG supply option (*see Annex 3*) however would be relatively expensive compared to local or the WAGP gas. Nonetheless, it has the potential to be cost-competitive and perhaps cheaper this time for possible shipments coming from the United States which for the first time and in this year 2016, it would begin to allow shipment of LNG from its shores. Even though average base price of gas could average $2/mmBtu *(see Table 25),* refrigeration into LNG averages $5/mmBtu and shipment could range between $1-3/mmBtu depending upon shipment location and the volumes involved.

Potential LNG supplies are also likely to come from cargos plying between Western African (Nigeria and Angola) and the European markets. LNG cargoes from Nigeria accounted for 3% of United States' LNG supply in the past but there was no shipment in 2014, prompting shippers to look for alternative markets such as the growing Asian market.

Ownership and financing arrangement would also have a significant impact on the cost of the delivered gas. Ownership can be Joint Venture - shared cost between a Ghanaian and foreign partners; Public or State Private Partnership (PPP); or facility wholly owned by a foreigner investor.

PPP through state participation by providing sovereign guarantee is likely to reduce cost further due to potential decrease in risk cost.

Table 21 presents a qualitative analysis of the likely cost range for the country if an LNG regas facility is built in the country.

[68] World Bank\ Energy Group report, June, 2013.

Table 26: Estimated LNG cost range for potential cargo shipments to Ghana.

<table>
<tr><th rowspan="2">LNG Cargo Destination</th><th colspan="4">Ownership/Financing Arrangement in US dollars per MMBtu*</th></tr>
<tr><th>PPP</th><th>Joint Venture/ Shared Cost</th><th>Operator wholly owned</th><th>Add Construction of off-loading/regas berth</th></tr>
<tr><td>Potential cargos from USA</td><td>6-7</td><td>7-8</td><td>8-9</td><td rowspan="5">1.0-2.0</td></tr>
<tr><td>Nigerian cargo originally destined to USA</td><td>6-7</td><td>8-9</td><td>9-10</td></tr>
<tr><td>From Nigeria en-route to Europe</td><td>7-8</td><td>9-10</td><td>11-12</td></tr>
<tr><td>Angolan cargo originally destined to USA</td><td>7-8</td><td>9-10</td><td>10-11</td></tr>
<tr><td>From Angola en-route to Europe</td><td>8-9</td><td>11-12</td><td>13-14</td></tr>
</table>

**Assuming operating life time of 5-10 years and minimum delivery volume of 200 mmscfd*

As mentioned previously, although most of the gas would be used for power generation, there would still be gas demand for industrial purposes such as heating and as feedstock but would also depend upon quantities available and the base price of the gas delivered. The resulting scenarios would thus likely be as follows

- Industrial use of gas is not likely to be realised until after 2020 and beyond.
- that a typical urea-fertilizer plant with a minimum capacity of 800,000 tonnes per year would require about 50 mmscfd but would not be available until after 2020, if construction is even to start in 2018. Also, it would require a delivered gas price of not more than $3/mmBtu on the average.
- that a typical methanol plant with a minimum capacity of 800,000 tonnes per year would require about 70 mmscfd but would not be available until after 2020, if construction is even to commence in 2018. Such a plant would require a delivered gas price of not more than $5/mmBtu on the average.

<u>Progress of Planned LNG projects</u>

The Ghana National Petroleum Corporation (GNPC)[69] early this year signed an agreement with a private company, Quantum Power for the latter to construct and operate a 500 mmscfd[70] floating LNG storage, regasification and delivery facility moored offshore Tema. The US$550 million facility is said to be on BOOT[71] basis with the assets said to be transferred to GNPC after 20 years of operation. The project is likely to be operation in 2017

[69] The National Oil Company (NOC)
[70] 3.4 million tonnes of LPG per year.
[71] Build Own Operate Transfer

and it would allow GNPC, the national gas aggregator to supply contracted 250 mmscfd gas request from the local market.

Interruptions both planned and unplanned

There had been some interruptions due to planned servicing and unplanned shutdown. Shutdowns at Jubilee fields would require back-up supply from WAGP gas Nigeria which currently is already inadequate and power imports from neighbouring la Cote d'Voire if available.

Shut downs at the Atuabo gas processing plant would require the two mentioned external reinforcements but also alternative supply arrangement when the Jubilee gas is available.

Plans are thus underway to install a spare overhead compression system in the course of the year, in order to minimise the downtime and to guarantee continuous plant operation. These would contribute to ensuring an uninterrupted supply of sales gas to the downstream consumers (*see Chapter 5.2*).

Finance – domestic and international payment deficits

Inadequate gas supply from Nigeria through the WAGP could not only be due to capacity challenges in Nigeria but finance as well *(see Annex 3).* Persistent untimely payment of gas delivered and the huge debt burdens of the off-takers most of the public entities are the bane or the weakest link along the electricity supply-distribution value chain. For instance, the Volta River Authority (VRA) has been indebted to N-Gas of Nigeria for gas supplied exceeding three months and over $100 million as at the end of 2015. Besides, debt accrued by beginning this year till early March, 2016 is over $100 million. Ghana also owed neighbouring Ivory Coast for power imports as at the end of 2015.

On the domestic side, VRA owes Ghana Gas Company for gas supplied from Atuabo, also in the tune exceeding $100 million as at the end of 2015. Ghana Gas in turn could not pay GNPC, the current national gas aggregator, because of the debt chain, considering that the aggregator is also currently experiencing revenue shortfalls due to the prevailing low prices of crude exports.

On the distribution or retail end, the Electricity Company of Ghana (ECG) is unable to settle its debts to the generation and the supply utilities because of untimely payments by mostly government and its agencies leading to legacy debts that have the potential of collapsing Ghana's power sub-sector. ECG itself by operation is also able to collect less than 70% of its revenue annually and consequently making the distribution subsector the weakest link in the electricity supply and distribution cycle or value chain. Notwithstanding, the ECG has signed a number of PPAs (Power Purchasing Agreements) with a number of Independent Power

Producers (IPPs) with apparently not much due diligence to the price of the electricity to be supplied in terms of cost-competitiveness.

Whilst a mature, strong and transparent regulatory environment would generally offset the need for such guarantees especially for commercial risks, this is hardly the case in Ghana. For this reason, most of the incoming independent power producers (IPPs) have been demanding the government to guarantee ECG's payments through Government Consent and Support Agreement (GCSA) before proceeding to the construction stages of their capital investments. These GCSAs normally indemnify the investors against all manner of commercial as well as political risks.

However, owing to the current fiscal challenges facing the economy as well as to forestall the financial sustainability of the electricity supply-distribution value chain, the government is intervening with among many measures the, the following:

- In a major policy shift, either a Partial Risk Guarantee (PRG) or Put/Call Option Agreement (PCOA) is issued as a credit enhancement instrument in place of the GCSA[72]. Under a PCOA, the buyer, which in this case is the ECG and the government shall have a 'call option' over all the shares upon early termination of a PPA while the seller and its shareholders have a 'put option' over the shares upon early termination due to a breach of the PPA as may be duly specified in the agreement.
- ECG has been made to suspend signing new PPAs without authorisation from the sector Minister. A ceiling has also been imposed on the size of the power plant particularly with renewable power plant with all PPAs and/or quotations being subjected to tender to select the least cost and most favourable bidder. Millennium Development Authority (MiDA) is also providing support at looking into partial privatization of electricity distribution and retailing by inviting the private sector to participate in the operations and management of ECG.
- In 2015, the government introduced the Energy Sector Levy, which has resulted in the rapid increase in petroleum prices and electricity tariffs. Although the government has been severely criticized for introducing such a heavy levy, it keeps defending its stance that such was needed to protect the collapse of the power industry, by clearing the legacy debts and to cover the fuel bill for 2016.
- To safeguard the financial operations and assets of the Ghana Gas Company, the government ordered the GNPC to entirely takeover its management and operations. The process however still lingers on, with reasons being attributed to administrative and legal challenges. To move the process further, the government has formed a new board for the Ghana Gas Company.

[72] Well illustrated in the February, 2016 edition of the Ghana Wholesale Electricity Market Bulletin - Market Watch, p7-8. Available at Energy Commission's website www.energycom.gov.gh/datacenter

4.0 Woodfuel Subsector: Charcoal demand and prices

Average prices of charcoal in the country rose from about GH¢17 per mini bag and GH¢25 per maxi bag in 2014 to GH¢20 and GH¢31 in 2015 respectively; increases of about 21% for mini-bag and 24% for the maxi-bag over the previous year.

As usual, the high-price areas were the coastal and the Upper East Region. The low-price regions were also usual the transitional regions of Brong Ahafo and Northern followed by the forest regions of Ashanti, Eastern and Western. Except for the Ashanti, Western and Upper East, all the regions experienced very high price increment for the year 2015 *(see Tables 27 and 28).*

Table 27. Average price per bag of charcoal in the ten regions for 2014 and 2015[73].

Region	Mean Price per Mini bag in Ghana Cedi (GH¢)			Mean Price per Maxi bag in Ghana Cedi (GH¢)			*Percentage change in mean prices 2013/2014*	
	2014	**2015**	***% change***	**2014**	**2015**	***% change***	***Mini***	***Maxi***
Ashanti	12.71	15.12	***19.00***	19.32	22.91	***18.54***	***38.91***	***16.25***
Brong Ahafo	9.22	12.15	***31.80***	15.81	20.27	***28.20***	***29.68***	***25.68***
Central	23.53	31.00	***31.72***	31.09	39.03	***39.03***	***18.66***	***17.37***
Eastern	16.62	21.51	***29.46***	22.21	30.55	***25.54***	***23.66***	***16.71***
Gt. Accra	22.42	26.61	***26.61***	30.26	37.10	***22.62***	***28.63***	***27.79***
Volta	20.67	28.28	***36.83***	36.43	49.50	***35.90***	***24.07***	***13.77***
Western	18.20	21.68	***19.15***	28.58	32.96	***15.32***	***18.95***	***10.82***
Northern	12.88	15.79	***22.56***	22.15	25.32	***14.33***	***41.54***	***21.04***
Upper East	20.35	23.00	***13.02***	30.65	34.45	***12.38***	***37.50***	***22.94***
Upper West	11.86	15.47	***30.43***	18.25	23.00	***26.05***	***25.90***	***17.29***
National	***16.66***	***20.14***	***20.88***	***25.11***	***31.35***	***24.03***	***26.02***	***18.50***

[73] The price survey was conducted in the district capitals and computed as average for each region.

In terms of price per unit weight of the charcoal[74], the Upper East and the coastal regions were the high-price regions with Volta being the highest, followed by Central, Greater Accra, Western in 2015 (*see Tables 28 and 29*).

Table 28: Average price per kilogramme of bag of charcoal in the regions for 2014 and 2015.

Region	2014			2015			*Percentage change in mean prices*	
	Mean Price per kg in Ghana Cedi			Mean Price per kg in Ghana Cedi				
	Mini Bag	**Maxi Bag**	**Mean**	**Mini Bag**	**Maxi Bag**	**Mean**	***2013 /2014***	***2014 /2015***
Ashanti	0.49	0.37	***0.43***	0.58	0.45	***0.52***	*26.5*	*19.77*
Brong Ahafo	0.30	0.27	***0.29***	0.36	0.33	***0.35***	*23.9*	*18.97*
Central	0.75	0.52	***0.64***	0.95	0.67	***0.81***	*17.6*	*26.56*
Eastern	0.64	0.42	***0.53***	0.75	0.58	***0.67***	*20.5*	*25.47*
Gt. Accra	0.71	0.50	***0.61***	0.81	0.67	***0.74***	*40.7*	*21.31*
Volta	0.79	0.69	***0.74***	0.91	0.87	***0.89***	*17.5*	*20.27*
Western	0.70	0.54	***0.62***	0.83	0.64	***0.74***	*14.8*	*18.55*
Northern	0.42	0.39	***0.41***	0.51	0.44	***0.48***	*30.6*	*15.85*
Upper East	0.66	0.53	***0.60***	0.74	0.60	***0.67***	*29.3*	*11.67*
Upper West	0.38	0.32	***0.35***	0.50	0.41	***0.46***	*20.7*	*30.00*

[74] In terms of the charcoal weight:

- Significant quantities of charcoal production in Ashanti and Eastern Regions come from wood off-cut and sawmill residues. The average mini (fertilizer) bag of charcoal weighs from 21-22 kg and the maxi bags weigh from 44-45 kg.
- For most parts of coastal Central Region and for some parts of Greater Accra, particularly, the Ashaiman suburban, there is significant charcoal production from Acacia plantations. The weight range of mini bag acacia-based charcoal is 31-32 kg and for the maxi bag, the range is 57-63 kg.
- For all other regions, particularly, from the Brong Ahafo upwards to the Upper regions, the average mini bag charcoal weighs around 26 kg and the average maxi bag weighs about 52 kg.

Table 29: Charcoal Prices by Ecological Zones in 2015.

Ecological Zones	Mini Bag				Maxi Bag			
	Price per bag (GH¢)		Price per kg (GH¢/kg)		Price per bag (GH¢)		Price per kg (GH¢/kg)	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
Coastal	26.39	24.00	0.84	0.76	39.63	37.00	0.66	0.62
Forest	20.11	15.00	0.77	0.58	30.63	29.00	0.58	0.55
Transition	12.53	13.00	0.40	0.42	20.76	21.00	0.36	0.37
Savannah	17.74	17.00	0.57	0.55	28.55	26.50	0.50	0.46
Country Average	***20.14***	***20.00***	***0.65***	***0.58***	***31.15***	***32.00***	***0.53***	***0.50***

5.0 The Regulatory Regime

5.1 The Electricity Supply Industry

5.1.1 Licensing and Permitting

The Energy Commission in 2006 established a licensing framework for issuing licences to electricity service providers. The Licensing Manual for service providers in the Electricity Supply Industry was revised and published in 2012, setting the requirements and guidelines for entities desiring to acquire licences to operate in the electricity supply industry.

Under the Licensing framework, provisional and full licences have been issued to entities engaged in the various segments of electricity supply. Besides adding generating capacity to the existing capacity and enhancing service delivery to customers, the licensing regime enhances the Commission's authority to hold the licensees to the terms and conditions stipulated in the licence.

Licences and permits issued by the Commission so far are as follows:

i. In 2015, construction Permit was issued to Amandi Energy for the construction of 203 MW Combined Cycle at Aboadze in the Western Region. The Company had earlier been issued with a siting permit during the third quarter of 2013.

ii. Construction works on the 300 MW Cenpower Generation Plant is on-going but not expected to be completed this year.

iii. The following companies were also granted construction permits;
    a. Sunon Asorgli Power (Ghana. Ltd) Expansion of 360 MW Combined Cycle at Kpone in the Greater Accra Region;
    b. Marinus Energy Limited 80 MW Simple Cycle at Anochie near Atuabo in the Western Region. The company first received a siting permit in August, 2013; and
    c. Ameri Power Limited 250 MW emergency power plant also at Aboadze in the Western Region; were all issued in 2015.
    d. Rotan Power Limited 660 MW Combined Cycle at Aboadze in the Western Region was issued in 2016.

iv. The following companies were issued with wholesale supply license:
    a. Two Electricity Embedded Generation Licences were issued to Genser Power Limited, an IPP to distribute electricity to specific consumers in the distribution network, ie. 5 MW at Tema and 30 MW at Chirano in the Western Region.
    b. Siting Permits issued to potential IPPs increased from 10 in 2015 to 14 at beginning of 2016 and expected to result in **5,863MW** from 4,325 MW last year.

v. Provisional Wholesale Electricity Supply licences issued to potential IPPs, as well as Government-owned VRA, increased to 43 from 31 in the beginning of 2015. These total about 13,578 MW of power
vi. Sage Power Limited was issued with Electricity Brokerage License as well as Electricity Export Licence.
vii. Enclave Power Company was issued with distribution and sale licence to distribute and sell electricity to customers in Dawa Power Enclave (yet to be constructed) besides its existing operations at Tema.
viii. Bulk Customers of electricity operating in the deregulated Wholesale Electricity Market increased from 33 in early 2015 to 36 early 2016.

5.1.2 Codes of Practices and Regulations

The Commission developed and launched the ***National Electricity Grid Code*** in 2010 to govern the operation of the National Interconnected Transmission System (NITS). The Grid Code specifies in detail the technical operational rules, codes and procedures as well as obligations and liabilities of all players in the market. Complementary to the National Electricity Grid Code, the Energy Commission has completed the drafting of the ***National Electricity Distribution Code*** that sets in detail, the minimum acceptable technical standards for the development of the electricity distribution networks, provides guidelines and technical requirements for interconnection and evacuation of embedded generation and other relevant issues related to the safe and reliable management and operation of the Electricity Distribution Network. The draft is currently on hold awaiting the adoption and inclusion of certain standards by the Ghana Standards Authority.

The Commission has developed the Electrical Wiring Regulation 2011, L.I. 2008 to regulate electrical wiring in the country.

Pursuant to the above, a certification guideline has been developed. Furthermore, a curriculum for the certification examination has also been developed in conjunction with the Technical/Vocational Education Directorate of the Ghana Education Service.

With regard to the regulations and codes, all stakeholders have been met to discuss the implementation of the corresponding provisions.

In 2013, The Energy Commission in collaboration with the Technical Examinations Unit, of the Ghana Education Service conducted the first certification examination for potential and practicing electrician for certification as Certified Electrical Wiring Professionals (CEWPs). Subsequently, examinations were conducted in 2014 and 2015 and by early March this year, about 3,000 electricians had been certified as CEWPs and 42 as Certified Electrical Wiring Inspectors, representing about 50% increase from 2014. The Commission also carried out public sensitization activities to create awareness in the general public on the provisions of the Regulations. In addition, the Commission has conducted training programmes in all the regional capitals for the CEWPs.

As part of its implementation, monitoring exercises are being carried out. CEWPs who were suspected to have violated provisions in the wiring regulations were first giving hearing by a Disciplinary Committee and those found culpable were penalized.

5.1.3 Establishment of Wholesale Electricity Market

The Electricity Regulation 2008 provides for the establishment of a competitive wholesale electricity market to facilitate wholesale electricity trading and the provision of ancillary services in the National Interconnected Transmission System (NITS). The Wholesale Electricity Market (WEM) in Ghana, the Electricity Transmission Utility (ETU) shall ensure the procurement and dispatch of electricity from any facility of a wholesale supplier to a bulk customer and distribution utility in a fair, transparent and non-discriminatory manner.

The Wholesale Electricity Market would allow for choice and competition in the wholesale supply of electricity and subsequently create an enabling environment to attract Independent Power Producers (IPPs) into the country.

Further incentive for private sector investment in the Wholesale Supply of electricity is Ghana's interconnection with some neighbouring West African countries, through which the market for electricity in those countries will be opened up to the IPP's in Ghana.

Such a market, in principle, requires to be guided by rules and regulations (backed by legislation) that should essentially reflect the government's broad policy objectives regarding the structure and administrative management and operation of the market.

The Market Oversight Panel (MOP) was thus set up in 2015 and members of the panel had been nominated by the appropriate institutions and had since been approved by the Ministry. The Commission is in communication with the sector Ministry for the inauguration of the MOP. Whilst awaiting the official inauguration, MOP has been publishing a monthly bulletin which is available on the Commission's website[75].

5.2 The Natural Gas Supply Industry

Electricity supply is heavily dependent on the availability of fuel to power the thermal plants. So far, natural gas supply from Nigeria through the West African Gas Pipeline (WAGP) has

[75] http://www.energycom.gov.gh/index.php/planning/ghana-wholesale-electricity-market-watch-monthly-bulletin

proven very limited and unreliable. The arrival of the gas from the Jubilee field is therefore mitigating the supply situation. Gas from the Jubilee field is processed at the Ghana National Gas Company's Gas Processing Plant at Atuabo, which has been experiencing shutdowns due to routine maintenance and servicing. Thus, during such times, there is no gas supply for power generation, hence leading to load shedding if alternative options are not available. To ensure continuous flow of gas, plans are therefore underway to install an Overhead Compression Unit at the Atuabo processing plant *(see Annex 4).*

5.2.1 Licensing and Permitting

A Licensing Manual for Natural Gas Supply Industry was developed by the Energy Commission in 2008 to serve as a guide for prospective natural gas service providers with regard to licensing requirements as well as assisting in ensuring compliance with codes and standards governing quality, health and safety in the industry as stipulated in the Energy Commission Act, 1997 (Act 541). The manual was reviewed in 2012 to facilitate the accelerated development of the natural gas industry. BOST has been formally licensed as the Natural Gas Transmission Utility Licence to operate the Natural Gas Interconnected Transmission System (NGITS).

The Energy Commission has thus further issued the following licences to players in the Natural Gas industry.

i. In 2013 a Provisional Liquefied Natural Gas (LNG) facility Licence was also issued to Quantum Power Ghana Gas Limited also for an LNG facility to be sited at Tema in the Greater Accra Region. Quantum power was granted a Siting Permit for the LNG facility after a presentation and site appraisal from the Energy Commission siting committee. Construction permit has not been issued yet.

ii. Earlier in 2012 a Provisional Wholesale Supply Licence was issued to Rotan Gas Limited for an LNG facility to be sited at Aboadze in the Western Region. The Rotan facility is to feed into a 660 MW power barge owned by Rotan.

iii. Provisional LNG facility licence was issued to Newstar Terminals at Atuabo. The company intends to regasify LNG supplied by Sage Petroleum. No further licence has been issued since.

5.2.2 Codes of Practices and Regulations

Since the natural gas industry is still new in Ghana and like any other energy infrastructure, it is important that developers satisfy some basic requirements and comply with established regulation before the construction of facilities takes place. It is in this respect that the Energy Commission has developed the ***Natural Gas Pipeline Safety Regulation*** with adopted Ghanaian Standards and which has been approved by Parliament in 2012.

A ***Natural Gas Transmission Access Code*** to establish conditions for Natural Gas Service Providers to have fair, transparent and safe access to the Natural Gas Transmission Network in Ghana has also been developed in accordance with Sections 24, 27 and 28 of the Energy Commission Act, 1997 (Act 541). The Commission however is still developing an ***Occupational Health and Safety Regulation*** with adopted Ghanaian Standards.

5.3 Renewable Energy Update

As at early March, 2016, 82 Provisional Wholesale Electricity Supply Licences had been issued to potential Independent Power Producers (IPPs) proposing to develop a total of about 5,547 MW of electricity from various renewable energy sources.55 of the licences issued are for solar photovoltaic (PV) generation with a total capacity of about 2,749 MW. As at end of 2015, 44 licences were issued a total capacity of 2,472 MW compared with 29 with total capacity of 2,155 MW in 2014.

25 licensees have moved to the Siting Permit stage of the licensing process of which 20 are for solar PV. However, only two companies have been issued with Construction Permit to develop a solar PV project. A Construction Permit has also been issued for a 225MW wind project. Details of the Provisional Licences and Permits issued are shown in *Table 30.*

Table 30: Provisional Licences issued for Renewable Energy Electricity as of March, 2016.

Category	**Number of Wholesale Electricity Supply Licences Issued**			**Total Proposed Capacity (MW)**
	Provisional Licences	**Siting Permits**	**Construction Permits**	
Solar	55	20	2	2,748.5
Wind	9	2	1	951
Hydro	5	-	-	208.62
Biomass	2	-	-	68
Waste-to Energy	10	2	1	570.81
Wave	1	1	1	1,000[76]
Total	**82**	**25**	**5**	**5,546.93**

The Sector Ministry, through the Energy Commission, has begun the implementation of a Rooftop Solar Photovoltaic (PV) Programme in the country. The primary objective of the programme is to provide 200 MW peak load relief on the national grid through solar PV technology in the medium term.

[76] Applicant requested for 1,000MW, but 20MW Construction Permit has been issued.

To kick-start the actual implementation of the programme, the Energy Commission is facilitating the installation of 20,000 rooftop solar PV systems in residential facilities (homes) under a Capital Subsidy Scheme in 2016, where solar panels up to a maximum of 500 peak Watts (Wp) shall be given to prospective residential applicants. The beneficiary should be willing to purchase and install the requisite and certified Balance of System (BoS) components such as inverter, batteries, charge controllers, etc. using a licensed solar vendor[77]; and change all lamps in their facility to LED lamps as a prerequisite. So far, 112 applications had been received and being processed.

Also, the Energy Commission in collaboration with the Electricity Company of Ghana (ECG) is piloting 33 net-meters equipped with automatic reading mechanism at various residential and commercial facilities. Monitoring of the net-metered solar PV systems by ECG is currently on-going. Implementation of the net-metering Scheme is planned to begin by June 2016.

The Government of Ghana in November 2015 published an invitation for pre-qualification for the procurement of 20 MWp solar PV power. During the first stage of the tender process, 18 bids were shortlisted to subsequently submit proposals. The proposals would be evaluated and ranked for award primarily based on least cost quotation. The award of contract is expected to be issued by August 2016.

The Public Utility and Regulatory Commission (PURC) and the Energy Commission are yet to issue the Renewable Energy Purchase Obligations (REPO) to Distribution Utilities and Bulk Customers. PURC apparently is still working on the Renewable Energy Purchase Obligations (REPO).

[77]Solar vendor licensed by the Energy Commission

Annex1 – 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 A).

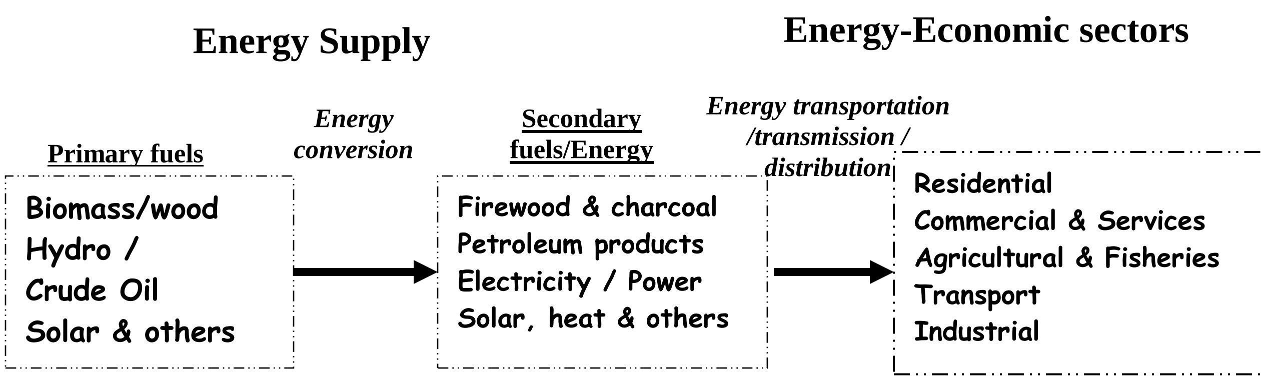

Figure Annex A1. Energy supply continuum

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

Figure A2. Energy supply continuum

Annex 2 – Liquefied Natural Gas Regas Terminal Technologies

LNG could be delivered through the following terminal technologies:

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

Energy Bridge Regasification Vessels

Energy Bridge Regasification Vessels, or EBRVs™, are purpose-built floating storage re-gasification units (FSRU) LNG tankers that incorporate on-board equipment for the vapourisation of LNG and delivery of high pressure natural gas. It is the technology that can be delivered in the shortest possible time; i.e. **within a year**. 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.

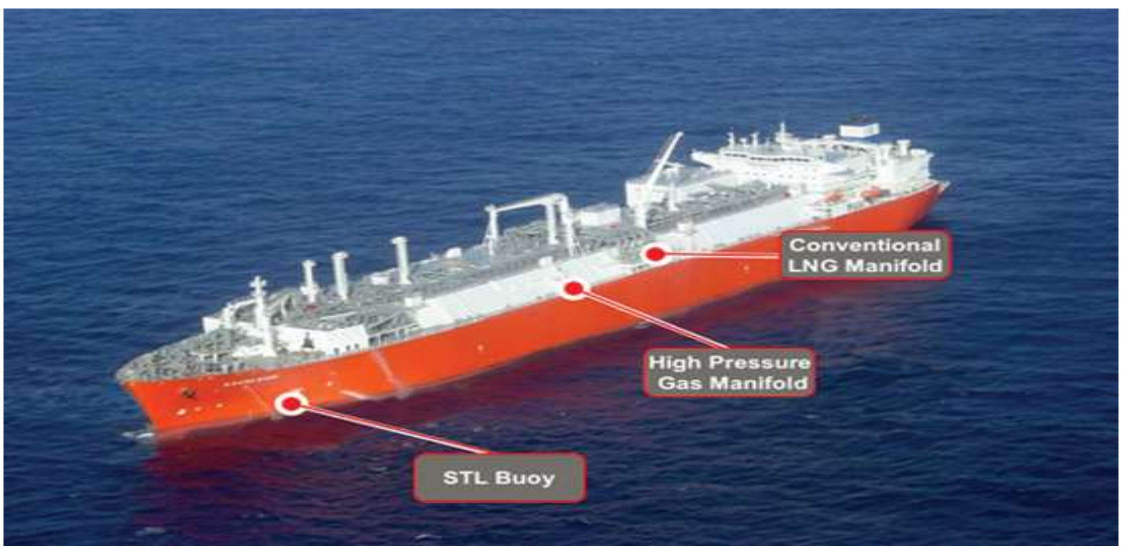

Figure A3.

LNG Floating, Storage and 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 storage LNG re-gasification unit or facility (FSRU). Typical LNG ship has capacity of 120,000-125,000 liquid cubic metres (lm^3). The larger the containment the greater the application for floating storage and regasification applications[78]. Some 59 ships built worldwide before 1983 with containment between 122,000-133,000 liquid cubic metres are due for retirement. 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.

Floating Regas facility would take between **one and half-to-two years** to build if a project is approved and money is readily available today, otherwise **up to two and half years** to allow for initial paper work.

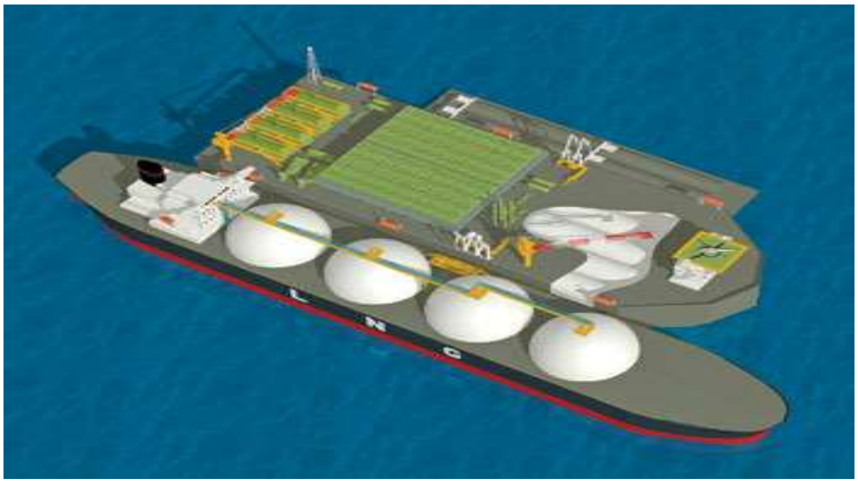

Figure A4.

<u>Permanent LNG discharge/re-gasification terminal</u>

Contrary to FSRU, this is permanently fixed as the name implies and it is usually a specialised or dedicated harbour. Development of permanent LNG re-gasification plant of say 100-200 mmscfd capacity would require at least **3-4** years even if a project is approved and money is available today.

Figure A5.

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

Annex 3 – Nigeria Gas Supply Challenges

Ghana has been expecting much of its natural gas to come from Nigeria. However, there are over 23 grid-connected generating plants in operation in the Nigerian Electricity Supply Industry (NESI), with a total installed capacity of almost 11,000 MW and available capacity of about 6,200 MW. Most generation is thermal based, with an installed capacity of about 8,600 MW (81% of the total) and an available capacity of about 5,000 MW (83% of the total) as of 2015[79].

Nigeria had projected to expand its installed capacity to about 13,000 MW by 2016 and 15,000 MW by 2020 against an estimated demand of 26,651 MW by the end of the decade[80]. However, the nation could only achieve an available capacity of 5,500 MW by ending of 2015[81].

This ambition puts a greater strain on the existing gas supply situation as the country struggles to achieve its domestic gas supply and export plans. Supply requirement totals about **5 billion cubic feet per day (bcfd)** for domestic consumption, LNG contractual shipments and WAGP commitments. Despite, the country is currently only able to produce about **4 bcfd,** of which about **2.8-3.0 bcfd** is for the production of the **22 million tonnes of LNG** the county exports annually. Existing power plants require at **least 1.5 bcfd,** which translates into very little or no gas for pipeline export to WAGP partner. The supply to the WAGP partner however ramps up only when a local power plant trips or is offline for maintenance. The country thus needs to develop new fields to meet the projected demand but industry experts estimate that to happen within 2017 - 2018, provided the existing schedule is executed as planned.

The current policy of the Nigerian government somehow seems to be to meet local gas demand first before considering exports to neighbouring countries. For this reason, there is a policy in place compelling all major gas shippers including N-Gas that ship gas to Ghana through the West African Gas Pipeline (WAGP) to meet local supply quota first before export. As at the end of 2013, most shippers were finding it difficult to meet the local quota obligation. Besides, the sabotaging of oil and gas facilities in the Delta region still remains a challenge[82]. These are contributing to the relatively low average supplies to the WAGP, aside untimely payments by off-takers particularly in Ghana for gas supplied.

For N-Gas of Nigeria to limit gas supply to WAGP at the contracted volume of 123 mmscfd instead of the full capacity of 440 mmscfd as originally agreed in the supply contract is of concern but not hopeless[83]. The supply balance of 312 mmscfd reinforces the opportunity for the development of a viable alternative supply option such as an LNG terminal along Ghana's coast.

[79] http://www.nipptransactions.com, 2015
[80] Power Generation: Status and Outlook, a presentation by Presidential Task Force on Power, at Electric Power Investors ' Forum by Bureau of Public Enterprises,
[81] Energy Commission of Nigeria, website news update, 1st Quarter, 2016.
[82] Orient Energy Review, Vol.5 No. 02/03 Feb-March, 2016.
[83] Energy Commission source.

Annex 4 – Provision of Overhead Compression in the Atuabo Gas Processing Plant

The Gas Processing Plant (GPP) at Atuabo commenced commercial operations after the Energy Commission issued an Operating Licence to the Ghana National Gas Company on the 31st of April 2015. The GPP is composed of the following modules:

- Inlet Separation
- Inlet Filtration
- Fuel Gas Conditioning
- Gas Chilling and Deethanization
- Deethanizer Overhead Compression
- Fractionation
- Glycol Regeneration
- Heat Medium System
- Flare & Closed Drain System

Raw gas is received at the Inlet Separation at about 130–140 barg. After processing, pipeline pressure generally rides on the exit or operating set pressure of the Low Temperature Separator (LTS) which is usually set at 51 barg.

The first phase of the Western Corridor Gas Infrastructure Project involves the use of a Joule-Thomson valve for inlet separation at the LTS. This means that complete separation of lean gas at the LTS is not possible. Residual gas separation takes place at the Deethanizer at about 33.5 barg. Residual gas separated at the Deethanizer has to be compressed to about 51 barg to meet sales gas pressure.

The above description depicts the Deethanizer Overhead Compression a vital module of the GPP. The overhead compressor is a reciprocating caterpillar engine with a mandatory maintenance of 4,000 man-hours, meaning that anytime it has to undergo mandatory maintenance, the entire GPP has to be shut down. The installation of a spare overhead compression system is therefore critical to minimizing downtime and guaranteeing continuous plant operations to ensure an uninterrupted supply of sales gas to downstream consumers.

The installation of a spare overhead compression system is therefore critical to minimize downtime, and to guarantee continuous plant operation to ensure an uninterrupted supply of sales gas to downstream consumers.