GHANA WHOLESALE ELECTRICITY MARKET BULLETIN

MARKET WATCH

Monthly Market Data Analysis

ISSUE NO. 20: 1st August 2017 to 31st August 2017

This Bulletin covers major developments in the Wholesale Electricity Market (WEM) of Ghana from 1st August 2017 to 31st August 2017. It analyses the performance of the key WEM indicators against their benchmarks, and examines the likely implications of any discernable trends in the market. This edition of the Bulletin examines the financial sustainability of the power sector in the first quarter of 2017.

The Energy Commission (EC) would very much appreciate and welcome comments from readers on the Bulletin. Reasonable care has been taken to ensure that the information contained in this Bulletin is accurate at the time of publication, nevertheless, any errors, omissions or inaccuracies therein are regretted.

HIGHLIGHTS OF THE MONTH

Overview of the Month

Electricity supply from the hydro power plant continued to decline in August 2017. Generally, the hydro power plant generation dropped by 10.3% in August 2017 compared to July 2017. The Akosombo GS generation also dropped by 7.1% from 290.18 GWh per day in July 2017 to 269.49 GWh per day in August 2017 while Bui GS generation dropped by 45.9% from 28.52 GWh per day in July 2017 to 15.44 GWh in August 2017. Likewise, the Kpong GS electricity supply in August 2017 reduced by 9.2% from 61.04 GWh in July 2017 to 55.65 GWh in August 2017. There was also a significant improvement in the water level of both Akosombo GS and Bui GS in August 2017. The Akosombo Dam increase by 6.57 ft in August 2017 compared to 2.52 ft recorded in July 2017. Similarly, the Bui Dam rose by 4.95 ft in August 2017 compared to 2.39 ft in July 2017.

There was significant increase in the gas supply in August 2017 from both the WAGP and AGPP. Natural gas supply from the WAGP increased from 45.7 MMSCF per day in July 2017 to 61.6 MMSCF per day in August 2017. Likewise, natural gas supply from the AGPP increased from 76.4 MMSCF per day in July 2017 to 94.9 MMSCF per day in August 2017. This significant improvement in natural gas supply enabled the thermal power plants except Karpowership and AKSA to operate solely on natural gas in August 2017. Thermal power generation on the average increased by 3.9% from 23.84 GWh per day in July 2017 to 24.78 GWh per day in August 2017 due to the

Table 1 Projected and Actual Outturn of electricity demand and supply in August 2017

	August 2017		July 2017	
	Projected	Actual Outturn	Projected	Actual Outturn
Total Supply (GWh)	1,256.0	1,118.2	1,262.0	1,137.8
Source by Power Plants (GWh)				
AKOSOMBO	288.0	269.5	288.0	290.2
KPONG	57.0	55.6	57.0	61.0
BUI	71.0	15.4	71.0	28.5
Sunon Asogli	107.0	129.1	92.0	132.7
TAPCO	152.0	105.2	95.0	63.8
TICO	165.0	206.8	193.0	192.5
TT1PP	-	63.3	-	20.1
CENIT	-	-	-	-
TT2PP	-	-	-	0.5
MRP	-	-	-	-
Karpowership	155.0	107.5	155.0	159.6
AMERI	144.0	76.2	147.0	83.8
KTPP	-	-	-	-
Trojan Power	-	0.0	-	-
CENPOWER	-	-	-	-
AKSA	107.0	80.1	131.0	85.7
Total Generation (GWh)	1,246.0	1,108.8	1,229.0	1,118.4
Imports (GWh)	10.0	9.4	33.0	19.3
Total Supply (GWh)	1,256.0	1,118.2	1,262.0	1,137.8
Deficit (GWh)	-	(137.8)	-	(124.2)
Ghana Coincedent Peak Load (MW)	2,022.0	1,916.8	2,027.0	2,026.2
System Coincident Peak Load (MW)	2,195.0	1,929.8	2,200.0	2,042.2

increased generation from the TT1PP, TICO and TAPCO Power Plants. Despite the increase in generation by some thermal power plant, there were marginal reductions in others namely SAPP, AKSA, AMERI and Karpowership Power Plants.

There was a marginal reduction in electricity demand in August 2017 by 9.67 GWh from 1,118.45 GWh in July 2017 to 1,108.78 GWh in August 2017. Import also reduced by 51.5% from 19.34 GWh in July 2017 to 9.38 GWh in August 2017. Likewise, export reduced from 5.5 GWh in July 2017 to 4.51 GWh in August 2017.

The significant event worth noting in August 2017 is the arrival of the 470 MW Karpowership which is to replace the 225 MW Karpowership. The new 470 MW powership called 'Karadeniz Powership Osman Khan' docked on the 28th August 2017 at the Tema Fishing Habour and will provide twice the energy supplied by the former powership.

Electricity Demand and Supply

Electricity Demand

The System Peak Load (Ghana Peak Load plus Import) continues to decline since it reached its peak in April 2017 of 2,160.8 MW. The System Peak have decreased from 2,160.8 MW in April 2017 to 1,929.8 MW in August 2017, a decrease of about 11% (231 MW). Between July 2017 and August 2017, the System Peak Load has reduced by 5.5% (112.4) from 2,042.2 MW in July 2017 to 1,929.8 MW in August 2017. Similarly the Ghana Peak Load (Domestic Peak Load including VALCO minus Export) have decreased by about 10% (212.4 MW) from 2,108.8 MW in May 2017 to 1,916.8 MW in August 2017. Also between July 2017 and August 2017, the Ghana Peak Load reduced by 5.4% (109.4 MW) from 2,026.2 MW in July 2017 to 1,916.8 MW in August 2017. The System Peak Load in August 2017 was lower (12.1%) than the projected System Peak load of 2,195 MW under the 2017 ESP, while the Ghana Peak Load was marginally lower (5.2%) than the projected Ghana Peak Load of 2,022 MW for August 2017 under the 2017 ESP.

Electricity supply

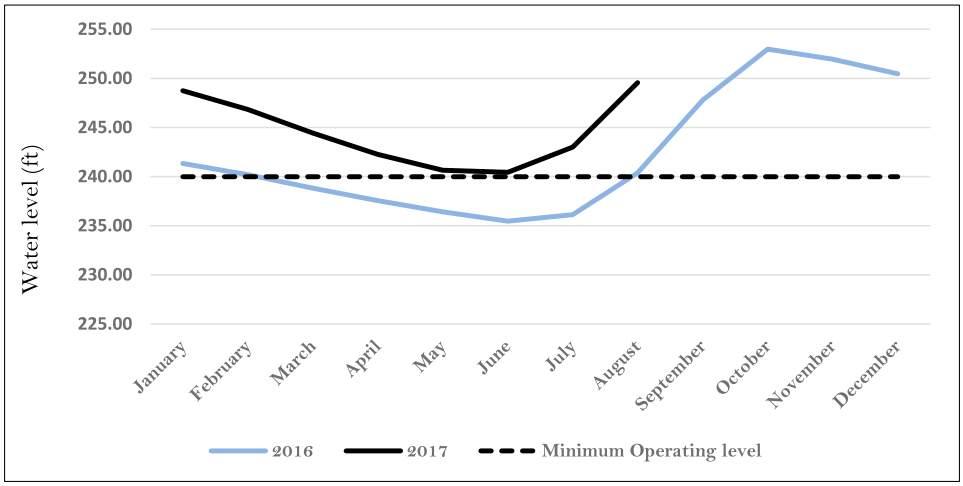
The average daily electricity supplied to meet Ghana's requirement decreased marginally to 36.07 GWh per day in August 2017 from 36.7 GWh per day recorded in July 2017. The total electricity supply in August 2017 was 1,118.16 GWh consisting of 1,108.78 GWh from domestic generation and 9.38 GWh of imports from La Cote D'Ivoire. The total supply of electricity in August 2017 was 140.84 GWh lower than the 1,259 GWh projected under the Electricity Supply Plan (ESP) developed for the year 2017. This represents an 11.1% deviation between the outturn and the projection. The deviation was due to the lower than expected demand due to the cold weather experienced in the raining season.

Hydro Dam Levels

Akosombo Dam Water Level continues to increase in August 2017

The rate of increase in the water level of the Akosombo dam increased from 0.081 feet per day in July 2017 to 0.212 feet per day in August 2017. The water level increased by 6.57 feet in August 2017 from 243 feet at the beginning of the month to 249.57 feet at the end of the month. The water level at the end of August 2017 was also higher than the level at the same time in August 2016 by about 9.19 feet and 9.57 feet above the minimum operating level of 240 feet. Figure 1 shows comparative end of month trajectory of the level of water in the Akosombo dam from January 2016 to August 2017.

Figure 1: Month-End Water Level for Akosombo Dam from January 2016 to August 2017

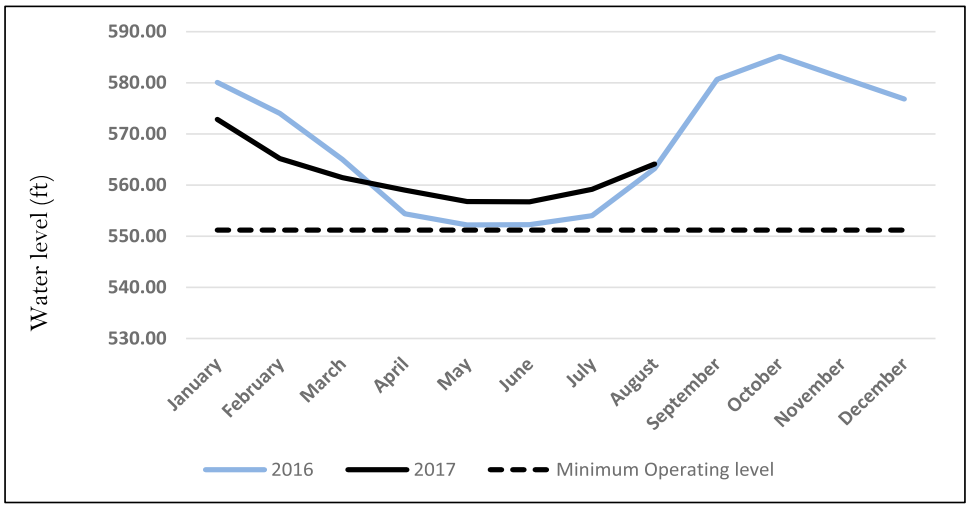


HIGHLIGHTS OF THE MONTH

Bui Dam Water Level continues to increase in August 2017

The Bui dam water level also witnessed a significant increase in the rate of increase in the water level in August 2017 from 0.077 feet per day in July 2017 to 0.16 feet per day in August 2017. The water level increased by 4.95 feet in August 2017 from 559.17 feet level at the beginning of the month to 564.13 feet at end of the month. The water level at the end of the month for Bui GS (564.13 feet) was above the level of the dam at the same period in August 2016 (563.21 feet) by 0.92 feet. Figure 2 shows comparative end of month trajectory of the level of water in the Bui dam from January 2016 to August 2017.

Figure 2: Month-End Water Level for Bui Dam from January 2016 to August 2017



Fuel Supply for Power Generation

Natural gas consumption continued for the second month running to dominate the fuel supply mix with its share increasing from 58% in July 2017 to 76% in August 2017 with liquid fuel accounting for the rest. There was no DFO and LCO consumption in August 2017. The share of HFO which was the only liquid fuel consumed in August 2017 reduced from 33% of the total fuel mix in July 2017 to 24% in August 2017. Shares of natural gas supply from the WAGPCo in the total fuel supply increased from 17% in July 2017 to 26% in August 2017. Similarly, natural gas supply from the AGPP increased from 41% in July 2017 to 50% in August 2017.

Figure 3a and Figure 3b shows the shares of sources of fuel and fuel type in the generation fuel mix for electricity generation respectively.

Figure 3a: Shares of sources of fuel in total fuel mix for power generation

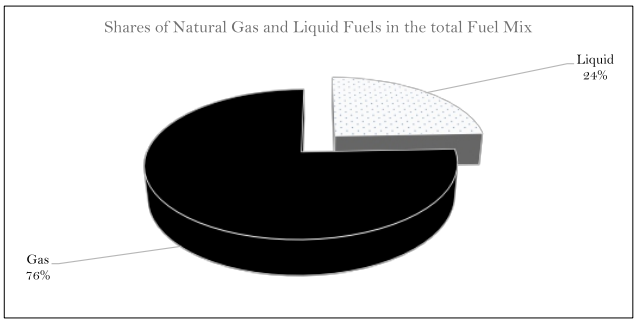
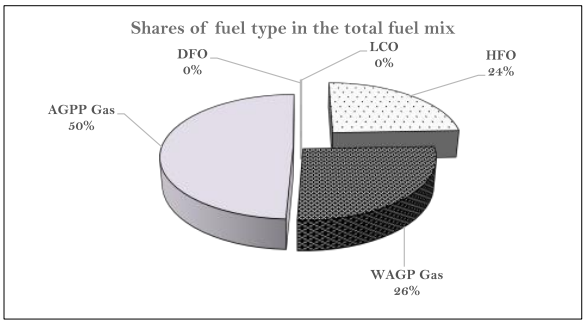


Figure 3b: Shares of fuel type in the generation fuel mix power generation



Natural gas supplies from WAGPCo increased marginally

Natural gas flow rate from Nigeria through the WAGP to Tema and Kpone increased to 53.33 MMSCF per day in August 2017 from the 32.96 MMSCF per day recorded in July 2017. Total supply increased to 1,608.22 MMSCF (35%) in August 2017 from 982.49 MMSCF (29%) in July 2017. The increase in natural gas supply ensured the continuous and consistent generation from the SAPP and the TT1PP in August 2017.

Natural gas supply from GNCC increased marginally

Natural gas flow rate from the AGPP to the Aboadze Power Enclave increased significantly from 76.39 MMSCF per day in July 2017 to 94.99 MMSCF per day in August 2017. Total gas supply from the Atuabo Gas Processing plant to the Aboadze Power Enclave of 2,878.83 MMSCF in August 2017 was 27.3% higher than the 2,261.94 MMSCF supplied in July 2017. Natural gas supply from the AGPP accounted for 65% of the total natural gas supply in August 2017. Of the total natural gas supplied in August 2017, 26.2% was used by the Ameri Power Plant for electricity generation, 51% was used by TICO Power Plant whiles the remaining 22.9% was used by the TAPCO Power plant.

Figure 4a: Contribution of Gas Supply by sources

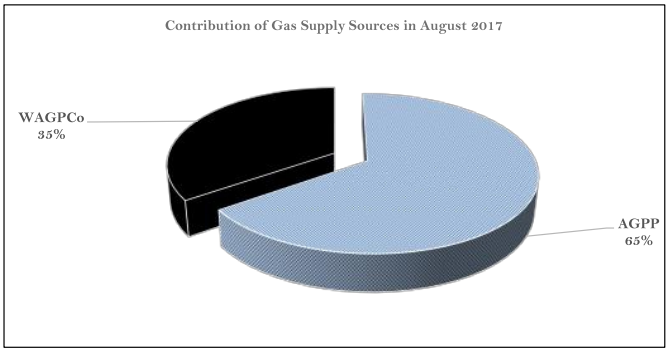
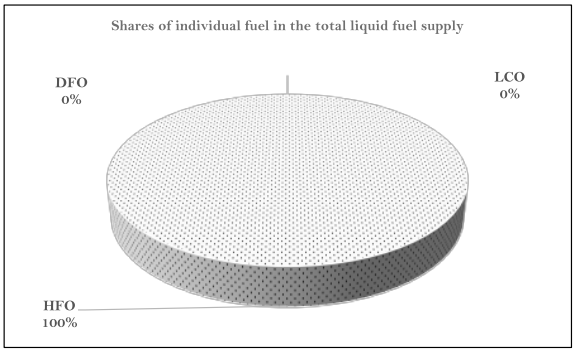


Figure 4b: Contribution of individual fuel in the liquid fuel supply



Liquid Fuel

A total of 257,364 barrels of liquid fuel was used by thermal power plants in August 2017. This total comprised of only HFO since LCO and DFO were not consumed in August 2017. The HFO supplied was used by the Karpowership and AKSA Power Plants only. The Karpowership consumed 56.02% of the total HFO supplied whiles the AKSA Power Plant consumed 43.98%.

Plant by Plant Highlights

Electricity Generation at the Akosombo Generation Station (GS) dropped significantly in August 2017

The Akosombo GS generated 269.49 GWh of electricity which was 20.69 GWh lower than it generated in July 2017 of 290.18 GWh. Average generation from the Akosombo GS decreased from 9.67 GWh per day in July 2017 to 8.69 GWh per day in August 2017 due to increased supply of electricity from thermal sources and lower demand. The Akosombo GS share of the total electricity supply continued to decline in August 2017 from 25.5% in July 2017 to 24.1% in August 2017. The low share of Akosombo GS in the total supply mix was also well anticipated in the 2017 Electricity Supply Plan (ESP) but the actual percentage outturn differed from the projection. The 2017 ESP projected supply from the Akosombo GS to be 22.8% in July 2017 and 22.9% in August 2017. The Akosombo GS generated 6% lower than the 288 GWh projected under the 2017 ESP. The Akosombo GS contributed 435 MW to meet both the System Peak Load and Ghana Peak Load in August 2017 which represent 22.5% and 22.7% of the System and Ghana Peak Loads respectively.

Electricity supply by Kpong Generation Station (GS) continued to decline

The Kpong GS generated a total of 55.65 GWh in August 2017 lower than the 61.04 GWh it generated in July 2017. The Kpong GS generated an average of 1.8 GWh a day in August 2017 which was 11.3% lower than in July 2017. Generation from the Kpong GS accounted for 5% of the total electricity supplied in August 2017. The generation from the Kpong GS was 2.4% higher than the 57 GWh projected for August 2017 under the 2017 ESP. The Kpong GS contributed 112 MW to meet both the System Peak Load and Ghana Peak Load in August 2017. This represented 5.8% and 5.84% of the System and Ghana Peak Loads respectively in August 2017.

Electricity supply by the Bui Generation Station (GS) continues to decline significantly

Electricity production from the Bui Power Plant decreased significantly in August 2017 to 15.44 GWh (0.498 GWh per day) from 28.52 GWh (0.92 GWh per day) in July 2017. This represents a decrease of 45.9% between August 2017 and July 2017, based on the daily average production of the months. The daily average generation suggests that the Bui GS operated largely with one units only at peak in August 2017. The Bui GS supplied 1.4% of the total electricity supplied in August 2017, lower than the 2.5% supplied in July 2017. The total electricity generated in August 2017 from the Bui Power Plant was about four folds lower than the 71 GWh projected to be generated in August under the 2017 Electricity Supply Plan (ESP). The Bui power plant contributed 100 MW to meet both the System Peak (1,929.8 MW) and Ghana Peak Loads (1,916.8 MW), which represents 5.2% for each.

Generation by the Sunon Asogli Power Plant (SAPP) dropped in August 2017

The continuous supply of natural gas enabled the Sunon Asogli Power Plant (SAPP) to operate for the whole month of August 2017, generating a total of 129.1 GWh of electricity (4.16 GWh per day), a drop from the 132.71 GWh (4.46 GWh per day) generated in July 2017. The Power Plant contributed 11.6% of the total electricity supplied in August 2017, a marginal drop from the 11.7% recorded in July 2017 and higher than the 8.5% projected under the 2017 ESP for August 2017. The SAPP contributed 182.1 MW to meet the System Peak Load (9.4%) and Ghana Peak Load (9.5%). The SAPP consumed a total of 891.95 MMSCF of natural gas at an estimated heat rate of 7,185.53 Btu/kWh, a significant increase in fuel efficiency as compared 7,540.8 Btu/KWh recorded in July 2017.

CENIT Power Plant continues to be offline in August 2017

The CENIT Power Plant was offline for the whole of August 2017 due to low levels of Light Crude Oil (LCO) stocks to power the plant and system demands. The Power Plant was also correctly projected to be offline in August 2017 under the 2017 ESP.

Ameri Energy Power Plant generation dropped in August 2017

Electricity generation from the Ameri Energy Power Plant declined from 2.79 GWh per day in July 2017 to 2.46 GWh per day in August 2017. The total electricity generation of 76.22 GWh was also lower than the 83.83 GWh supplied in July 2017. The lower supply from the Ameri Power Plant was due to grid demands. The Ameri Power Plant generated 47.1% lower than the 144 GWh projected under the 2017 ESP. The total of electricity generated by Ameri Power Plant in August 2017 represented 6.8% of total electricity supplied in the month which was lower than the 7.4% recorded in July 2017. The Ameri Power Plant consumed 658.99 MMSCF of natural gas to generate the 83.83 GWh of electricity at an estimated average heat rate of 10,037.88 Btu/kWh a marginal

improvement in fuel efficiency from the 10,059.38 Btu/kWh recorded in July 2017. The Ameri Power Plant contributed 197 MW to meet both the System Peak Load and Ghana Peak Load in August 2017.

Kpone Thermal Power Plant (KTPP) continues to be offline

The KTPP was offline for the whole of August 2017 due system demands. The Power Plant was also correctly projected to be offline in August 2017 under the 2017 ESP.

The New 470 MW Karpowership Power Plant arrives in Ghana

The 470 MW Karpowership docked on the 28th August 2017 and scheduled to commence commissioning in September 2017. It has 26 engines including 2 steam engines. The new power plant will provide over 20% of the total electricity supplied in the Country. The 225 MW karpowership operated for 28 days in August 2017 due to technical issues and generated 27.8% lower in August 2017 than in July 2017 from an average of 5.32 GWh per day to 3.84 GWh per day in August 2017. Total electricity supplied by Karpowership in August 2017 was 107.49 GWh, which was 32.6% lower than the 155 GWh projected under the 2017 ESP. The Power Plant contributed 9.6% of the total electricity supplied in August 2017, which is lower than its contribution of 14.02% in July 2017 and 12.3% projected under the 2017 ESP. The Karpowership also contributed 107.5 MW to meet both the System Peak Load (11.6%) and Ghana Peak Loads (11.7%) in August 2017. The Karpowership Power Plant consumed 144,180 barrels of Heavy Fuel oil (HFO) to generate the 107.49 GWh in August 2017 at an average heat rate of 8,101.85 Btu/kWh which is a marginal decline in fuel efficiency of 8,023.63 Btu/kWh recorded in July 2017.

AKSA Power Plant generation declined in August 2017

The AKSA increased its installed capacity from 160 MW to 250 MW in August 2017, that is, from 9 units to 16 units with the complete commissioning of 3 units. There was however no corresponding increase in generation due to low system demand in August 2017. The AKSA Power Plant generated 80.09 GWh in August 2017 5.65 GWh lower than it generated 85.74 GWh generated in July 2017 and significantly lower than the 107 GWh projected under the 2017 ESP. The Power Plant supplied 7.2% of the total electricity supplied in August 2017, which is marginally lower than the 7.5% supplied in July 2017. The Power Plant contributed 179.5 MW to meet both the System Peak Load (9.3%) and the Ghana Peak Load (9.4) in August 2017. A total of 113,184.71 barrels of HFO was consumed by the AKSA Power Plant at an average heat rate of 8,535.61 Btu/kWh a marginal reduction in improvement from the 8,522.66 Btu/kWh recorded in July 2017.

Takoradi International Company (TICO) increases its generation

The TICO Power plant operated for the entire month of August 2017 and generated a total of 206.79 GWh of electricity representing 18.5% of total electricity supplied in August 2017. The supply from the TICO Power Plant was 7.4% higher than the 192.52 GWh supplied in July 2017 and constituted 16.9% of the total supply in July 2017. The TICO Power Plant in August 2017 contributed 334 MW to meet both the System Peak Load and Ghana Peak Load in August 2017. The Power Plant operated on natural gas consuming about 658.99 MMSCF of natural gas to produce the 206.79 GWh of electricity at an estimated average heat rate of 7,616.89 Btu/kWh, a marginal reduction over the 7,567.83 Btu/kWh recorded in July 2017.

Takoradi Power Company (TAPCO) Plant continued to operate with half of its capacity

The TAPCO Power plant continued to operate at half of its capacity in August 2017 generating a total of 105.24 GWh, 65.1% higher than the 63.76 GWh it generated in July 2017. The power plant contributed 9.4% of the total electricity supplied in August 2017 and 5.6% in July 2017. The TAPCO Power Plant in August 2017 contributed 155 MW to meet both the System Peak Load (8%) and Ghana Peak Load (8.1%). The Power Plant operated on natural gas in August 2017 consuming about 753.04 MMSCF of natural gas to produce the 105.24 GWh of electricity at an estimated average heat rate of 7,684.02 Btu/kWh, an improvement in the fuel efficiency over the 8,287.91 Btu/kWh recorded in July 2017.

Tema Thermal 1 Power Plant (TT1PP) generation dropped significantly in August 2017

The TT1PP operated for 27 days in August 2017, generating a total of 63.29 GWh about 2.2 folds higher than the 20.06 GWh it generated in July 2017. The power plant contributed 5.7% of the total electricity supplied in August 2017, higher than the 1.8% supplied in July 2017. The power plant contributed 107 MW to both the System Peak Load (5.5%) and Ghana Peak Load (5.6%) in August 2017. A total of 716.28 MMSCF of natural gas was used to generate 63.29 GWh of electricity at an average heat rate of 11,769.99 Btu/kWh a significant improvement over the 12,284.02 Btu/kWh recorded in July 2017.

Trojan Power Plant continues to be offline in August 2017

The Trojan Power Plants in both Tema and Kumasi have been offline since July 2017 due to fuel supply challenges.

Electricity Exchange – Imports and export decreased whiles Ghana remained a net importer of electricity

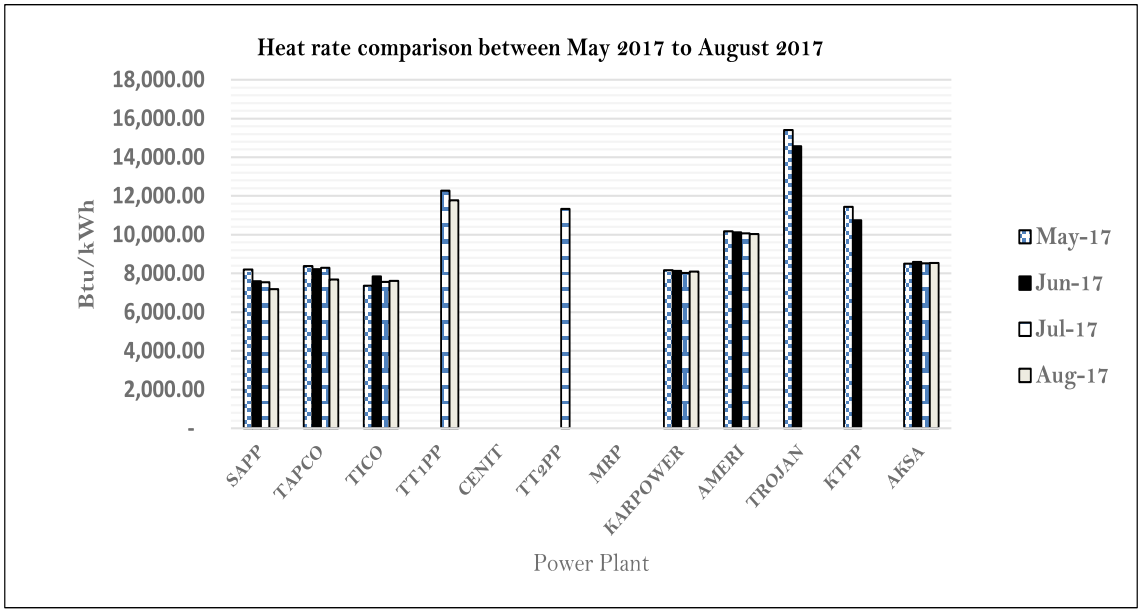
Electricity imports from La Cote D'Ivoire decreased significantly to 9.38 GWh in August 2017 from 19.34 GWh in July 2017. Total import in August 2017 was lower than the 10 GWh projected under the 2017 ESP. Electricity import contributed 0.84% of the total electricity supplied in August 2017. Daily peak import in August 2017 reached a maximum of 43 MW and did not contribute to both the System Peak Load and Ghana Peak Load.

Electricity export to CEB decreased marginally from 5.5 GWh in July 2017 to 4.51 GWh in August 2017 and was significantly lower than the 80 GWh projected under 2017 ESP. Ghana was a net importer of electricity in August 2017.

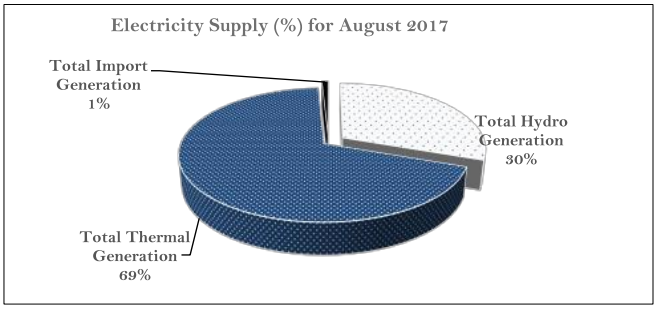
OPERATIONAL FACT SHEET

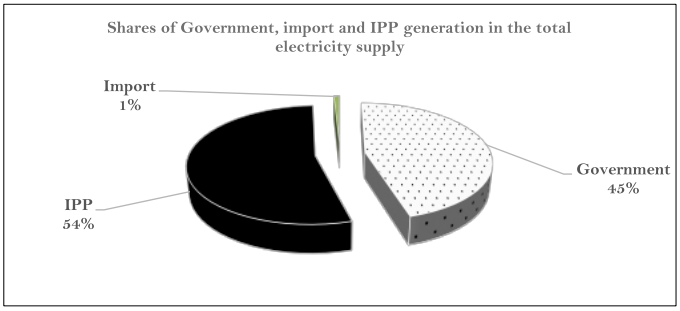
Peak Electricity Supply – August 2017			
Source of Supply	Generation at System Peak Load of August 2017 (MW)	Generation at Ghana Peak Load of August 2017 (MW)	Eleectricity Supply (GWh)
AKOSOMBO	435.00	435.00	269.49
KPONG	112.00	112.00	55.65
BUI	100.00	100.00	15.44
SAPP	182.10	182.10	129.10
TAPCO	155.00	155.00	105.24
TICO	334.00	334.00	206.79
TT1PP	107.00	107.00	63.29
CENIT	–	–	–
TT2PP	–	–	–
MRP	–	–	–
KARPOWER	224.10	224.10	107.49
AMERI	101.10	101.10	76.22
KTPP	–	–	–
Trojan Power	–	–	–
CENPOWER	–	–	–
AKSA	179.50	179.50	80.09
IMPORT	–	–	9.38
Export		13.00	4.51
System Coincident Peak Load	1,929.80	–	–
Ghana Coincedent Peak Load	–	1,916.80	–
Total Supply	–	–	1,118.16
Total Supply without export	–	–	1,113.66

Ghana Electricity Demand		
		Aug-17
Maximum System Peak Load	MW	1,929.8
Minimum System Peak Load	MW	1,735.0
Average Peak Generation	MW	1,932.2
System Base Load	MW	902.2
Total Electricity	GWh	1,118.2
Load Factor (LF)	%	77.9



OPERATIONAL FACT SHEET





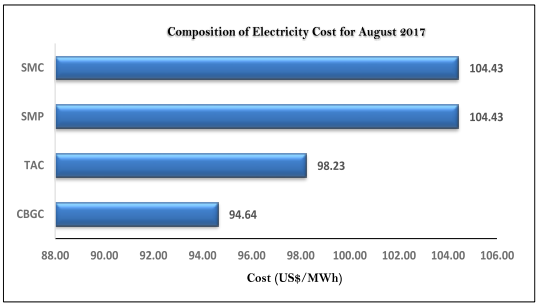
Power Plant Data for August 2017							
	Dependable Capacity (MW)	Plant Capacity Utilization (%)	Electricity Generation (GWh)	Gas Consumption (MMBtu)	LCO Consumption (MMBtu)	DFO Consumption (MMBtu)	HFO Consumption (MMBtu)
Akosombo	900.00	40.25	269.49	-	-	-	-
Kpong	140.00	53.43	55.65	-	-	-	-
Bui	340.00	6.10	15.44	-	-	-	-
SEAP	500.00	34.70	129.10	927,626.59	-	-	-
TAPCO	300.00	47.15	105.24	808,635.50	-	-	-
TICO	300.00	92.65	206.79	1,575,090.76	-	-	-
TT1PP	110.00	77.33	63.29	744,922.57	-	-	-
CENIT	110.00	-	-	-	-	-	-
TT2PP	45.00	-	-	-	-	-	-
MRP	70.00	-	-	-	-	-	-
KARPOWER	225.00	64.21	107.49	-	-	-	870,844.77
AMERI	230.00	44.54	76.22	765,037.00	-	-	-
TROJAN	56.00	-	-	-	-	-	-
KTPP	200.00	-	-	-	-	-	-
AKSA	160.00	67.28	80.09	-	-	-	683,635.62
Total	**3,686.00**	38.76	**1,028.69**	**4,821,312.42**	**-**		**870,844.77**

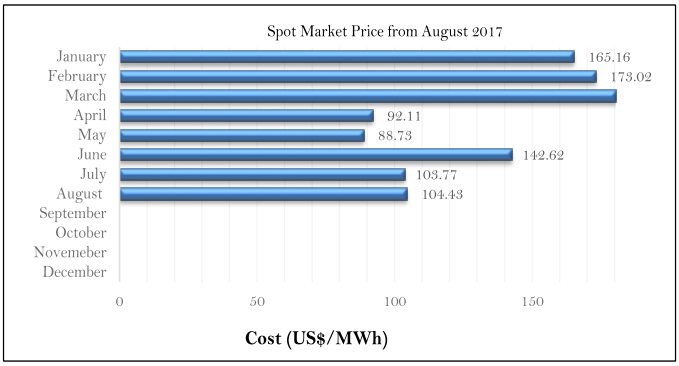
	Average Gas Flow (MMScfd) - August 2017				
Location	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Monthly Average**
Etoki	40.59	64.87	77.26	63.09	**61.61**
Tema	41.71	57.54	55.64	56.89	***53.33***
Aboadze	96.46	93.13	87.12	100.76	**94.99**

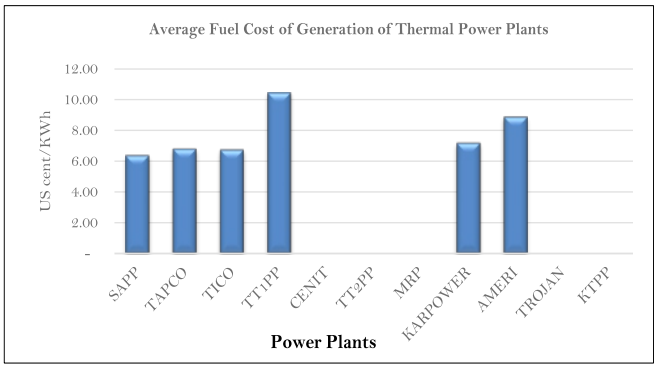
	Water Level (ft) - August 2017				Change in water level
Hydro Dam	**Week 1**	**Week 2**	**Week 3**	**Week 4**	(feet)
Akosombo	243.00	245.08	246.25	249.57	6.57
Bui	559.17	559.93	560.85	564.13	4.95

ECONOMIC FACT SHEET

		Aug-17	Jul-17	Change
Average Market Energy Cost	US$/MWh	80.95	77.76	3.20
Average Market Capacity Charge (AMCC)	US$/MWh	17.28	22.85	(5.57)
Total Average Market Cost (TAC)	US$/MWh	98.23	100.60	(2.37)
System Marginal Cost (SMC)	US$/MWh	104.43	108.96	(4.53)
System Marginal Capacity Charge (SMCC)	US$/MWh	-	-	-
Spot Market Price (SMP)	US$/MWh	104.43	108.96	(4.53)
Composite Bulk Generation Charge (CBGC)	US$/MWh	94.64	94.64	-
Deviation of TAC from CBGC	US$/MWh	(3.59)	(5.96)	2.37
Deviation of SMP from CBGC	US$/MWh	(9.79)	(14.32)	4.53

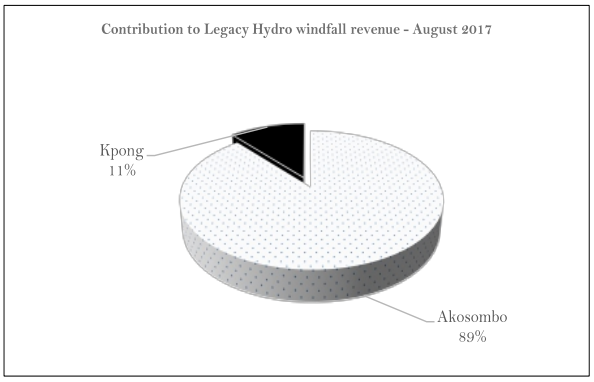






Aug-17				
	Average Cost	Average SMP	Difference	Windfall Revenue
Power Plant	US$/MWh	US$/MWh	US$/MWh	US$/MWh
Akosombo	33.10	104.43	71.33	19,222,226.90
Kpong	59.20	104.43	45.23	2,516,961.01
Total	92.30	-	-	21,739,187.91

Average Fuel Prices		
		Aug-17
Fuel Type	Unit	Delivered Cost
Natural Gas	US$/MMBtu	8.73
LCO	US$/BBL	63.00
HFO (Karpowership)	US$/Tonne	341.95
HFO (Tema)	US$/Tonne	361.80
DFO	US$/Tonne	575.95



1.0 Financial Sustainability of the Power Sector

1.1 Ability to Recover Cost

1.1.1 Electricity generation unit cost

The ability to recover the cost of the electricity generated (fixed cost and variable cost) is very important for the financial viability of the power sector. A vast majority of the electricity generated is sold in the regulated market that is, sold to the ECG, Enclave Power and NEDCo. In January 2017, 79.8% of the total electricity generated was sold in the regulated market, 81% in February 2017 and 81.6% in March 2017. It is therefore imperative for us to assess whether the Bulk Generation Tariff gazette by the PURC provide the appropriate cost recovery to the distribution utilities. An appropriate cost recovery tariff to the distribution utility will ensure that they are able to pay for the electricity purchased. Table 1.1.1 shows the comparison between the cost of generation of power plants from January 2017 to March 2017 with the approve BGT tariff by the PURC showing the effect of exchange rate variability on the ability to cover cost. Analysis A presents the BGT in terms of GHp which is the predominate currency for payment in the regulated market. Analysis B present the effect of exchange rate of the BGT.

Table 1.1.1 Comparison between cost of generation and PURC approve tariff from January 2017 to March 2017

	Jan-17	Feb-17	Mar-17
ANALYSIS A			
Cost of Generation (GHp/kWh)	38.34	35.88	39.29
PURC CBGT (GHp/kWh)	35.97	35.97	35.97
Difference (GHp/kWh)	-2.37	0.09	-3.32
ANALYSIS B			
Cost of Generation (USCent/kWh)	9.05	8.20	8.76
PURC CBGT (USCent/kWh)	9.48	9.48	9.48
Difference (USCent/kWh)	0.43	1.28	0.72
Average Monthly Exchange rate (GHS/US$)	4.24	4.37	4.48

In analysis A, obviously cost was not adequately covered in January 2017 and March 2017 but was covered in February 2017. The primary cause of this is due to the amount of hydro generation in the generation mix. In January 2017, hydro generation accounted for about 47.6% of the total supply, 60.7% in February 2017 and 51.9% in March 2017. The high share of hydro in February 2017 was due to supply shortfalls from the thermal sources due to fuel supply challenges. In the first quarter of 2017, cost of bulk electricity to the regulated markets was not adequately covered to the tune of GHp 2.37/kWh in January 2017 and GHp 3.32/kWh in March 2017. Cost were adequately recovered in February 2017 by over GHp 0.09/kWh.

The effect of exchange rate is visible in the analysis in table 1.1.1. Cost of generation fell below the gazetted tariff of UScent 9.48/kWh for all the three month in the first quarter of 2017. In the deregulated market, tariffs are collected from customer in Ghana Cedis but payment for bulk electricity are paid in US Dollars hence the effect of exchange rate volatility is very important to consider.

1.2 Ability to reliability meet demand

1.2.1 Ratio of installed capacity to Demand and Capacity Factor

The ratio of installed capacity to demand measure the extent to which our installed capacity adequately meet demand. Regionally, this ratio range from 2.2 for South Saharan Africa (SSA) and 2.6 for the world. Segregating by economic development, this ratio range from 2.3 for the OECD countries, 2.5 for high income non-OECD countries, 2.4 for upper middle income countries, 3.1 for lower middle income countries and 2.9 for low income countries. Ghana had a ratio of 1.78 for January 2017, 1.88 for February 2017 and 1.89 for March 2017 which was lower compared to the indicator from the other economies, Ghana is not performing well in this ratio.

The capacity factor of a power system measures the extent to which the supply system is being utilized. The capacity factor in January 2017 was 0.46, 0.4 in February 2017 and 0.46 for March 2017. This was lower than the average 0.5 for the OECD, South Saharan Africa (SSA), High income countries (non-OECD), Upper Middle Income and Lower Middle Income countries. It was however higher than the average for lower income countries of 0.4 except for February 2017. The Ghana electricity supply system was utilized below the average.

Table 1.2.1 Ratio of installed capacity to demand and capacity factor for the first quarter of 2017

	January 2017 indicator							
	Ghana	World	SSA	OECD	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Ratio Installed capacity to Demand	1.78	2.6	2.2	2.3	2.5	2.4	3.1	2.9
Capacity Factor	0.46	0.5	0.5	0.5	0.5	0.5	0.5	0.4

	February 2017 indicator							
	Ghana	World	SSA	OECD	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Ratio Installed capacity to Demand	1.88	2.6	2.2	2.3	2.5	2.4	3.1	2.9
Capacity Factor	0.40	0.5	0.5	0.5	0.5	0.5	0.5	0.4

	March 2017 indicator							
	Ghana	World	SSA	OECD	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Ratio Installed capacity to Demand	1.89	2.6	2.2	2.3	2.5	2.4	3.1	2.9
Capacity Factor	0.46	0.5	0.5	0.5	0.5	0.5	0.5	0.4

1.2.2 Reserve Margin

The reserve margin of supply system serves as an indicator in measuring the reliability of a power system. High reserve margin indicate a highly reliable sector, but a reserve margin which is too high could indicate an inefficient supply system. Two forms of this indicator was measured; constrained and unconstrained reserve margin. Constrained reserve margin takes into consideration planned maintenance, unplanned maintenance and fuel supply difficulties. That is, power plants that are technically available, have fuel available and could come up online when needed within the period under study. Ghana has over 3,900 MW of installed capacity in the first quarter of 2017. With demand hovering around 2,200 MW in the first quarter of 2017, it is expected that there would be enough capacity to meet this demand. The unconstrained reserve margin considers our installed capacity and is irrespective of fuel and technical unavailability of the power plant.

Table 1.2.2 Constrained and unconstrained reserve margin

	Jan-17	Feb-17	Mar-17
Constrained Reserve margin (%)	3.40	-1.18	6.57
Uncontrained reserve margin (%)	43.77	46.75	47.16

Despite the high installed capacity, technical and fuel supply challenges limited the number of power plants capable of generating in the first quarter of 2017. There were just enough capacity to meet demand in January and March 2017 with 3.4% and 6.57% reserve capacity respectively. These reserve margin fell below the 18% to 25% recommended by the International Energy Agency (IEA). There were significant import in February 2017 of 73 MW in order to make up for the shortfalls in generation capacity. There was however over 40% capacity not utilized due to technical and fuel supply challenges. This indicator reaffirms the below average capacity factor of the power system for the first quarter of 2017.

1.3 Ability to make investments

1.3.1 Capacity Annual Growth and Ratio of installed Capacity growth to demand growth

This indicator measures the annual growth in the installed capacity as a means of our ability to make investment in the power sector. There has been significant growth in the installed capacity of Ghana between 2016 and 2017. Installed capacity grew by 22.55% between January 2016 and January 2017, 18.71% between February 2016 and February 2017 and 23.57% between March 2016 and March 2017. This growth was higher than the indicators recorded for SSA, High income economies, Upper middle income economies, Lower middle income economies and low income economies as shown in table 1.4 below. That is, Ghana has made significant new investment in generation capacity than the others.

Table 1.3.1 Capacity annual growth and Ratio of installed capacity growth to demand growth

	January 2017 indicator					
	Ghana	SSA	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Capacity annaul growth (%)	22.55	3.1	3.1	2.7	3.9	3.4
Ratio of installed capacity growth to demand growth	4.46	0.2	0.6	0.7	0.3	0.02

	February 2017 indicator					
	Ghana	SSA	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Capacity annaul growth (%)	18.71	3.1	3.1	2.7	3.9	3.4
Ratio of installed capacity growth to demand growth	4.57	0.2	0.6	0.7	0.3	0.02

	March 2017 indicator					
	Ghana	SSA	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Capacity annaul growth (%)	23.57	3.1	3.1	2.7	3.9	3.4
Ratio of installed capacity growth to demand growth	3.26	0.2	0.6	0.7	0.3	0.02

The growth in capacity will not be important if it is not able to meet the growth in demand. The indicator that measures the ability of the growth in capacity to meet the growth in demand is the ratio of the growth installed capacity to growth in demand. Ghana's capacity growth to meet demand growth were significantly higher than the average recorded for SSA, High Income economies, Upper middle income economies, Lower middle income economies and low income economies as seen in table 1.3.3. This attest to the fact that the capacity additions were enough to meet our demand growth for the first quarter of 2017.

1.4 Ability to operate according to environmental and social norms

1.4.1 Emission factor and Fossil fuel dependency

The ability to make investments in the power sector to meet future demands and recoup these investments at reasonable returns should not override the need to operate in an environmentally sound manner. It is well known that a power system with large fossil fuel base has high rate of Carbon Dioxide (CO_2) emissions. That is, a high fuel dependent power system will have relatively higher emissions. To measure the dependency of a power system on fossil fuel, the fossil fuel dependency ratio is used.

Except in February 2017, fossil fuel accounted for over 47% of the total electricity supplied in January 2017 and March 2017. Natural gas supply challenges to the thermal plants limited the amount of electricity supplied from thermal sources in February 2017 which was 36% of the total supply. Ghana has a relatively lower fossil fuel dependency ratio than the average for the world (60.7%), high income economies

(84.4%), upper middle income economies (66.4%) and lower middle income economies (59.4%). The average is however higher than the average for SSA (45.3%) and lower income economies (40.6%). The fossil fuel dependency ratio however does not show the extent of the emissions (CO^2) from the thermal power plants.

To measure the extent of the emissions and the effect of the type of fuel used, the emission factor indicator would be used. The Emission factor measures the amount of CO^2 emitted for each unit of electricity produced from the thermal power plants. For every unit (kWh) of electricity produced from the thermal power plants in Ghana in the first quarter of 2017, about 0.6 kg of CO^2 was emitted. A high emission factor of 0.66 kg/kWh was witnessed in February 2017 due to high amount of LCO, DFO and HFO which constituted 84.5% of the total fuel used for electricity generation when there was natural gas supply challenges at the Aboadze Power Enclave. The CO^2 emissions in the first quarter faired favorably to the average emissions from the High Income economies (0.9 kg/kWh), Upper Middle Income economies (0.7 kg/kWh) and the United States (0.75 kg/kWh from data from the 100 largest power producers of the USA). The emissions from the thermal power plant in Ghana for first quarter of 2017 was higher than the world average (0.6 kg/kWh), SSA average (0.5 kg/kWh), Lower middle income economies (0.5 kg/kWh) and for Low income economies (0.3 kg/kWh). Comparing Ghana's emission with it peers (Lower Middle Income economies), Ghana is emitting about 1.4 kg for every unit (kWh) of electricity produced. Table 1.4.1 shows the compares the Ghana's emission factor and fossil fuel dependency with indicators from economies and region of the world.

Table 1.4.1 Emission Factor and Fossil fuel dependency

	January 2017 indicator						
	Ghana	World	SSA	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Emission Factor ($KgCO_2/kWh$)	0.65	0.6	0.5	0.9	0.7	0.5	0.3
Fossil fuel dependency (%)	49.9	60.7	45.3	84.4	66.4	59.4	40.6

	February 2017 indicator						
	Ghana	World	SSA	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Emission Factor ($KgCO_2/kWh$)	0.66	0.6	0.5	0.9	0.7	0.5	0.3
Fossil fuel dependency (%)	36.3	60.7	45.3	84.4	66.4	59.4	40.6

	March 2017 indicator						
	Ghana	World	SSA	High Income Non-OECD	Upper Middle Income	Lower Middle Income	Low Income
Emission Factor ($KgCO_2/kWh$)	0.62	0.6	0.5	0.9	0.7	0.5	0.3
Fossil fuel dependency (%)	47.5	60.7	45.3	84.4	66.4	59.4	40.6

1.4 Conclusions

A healthy power sector must be able to make investment to meet future demands and recover cost for the investments in a socially and environmentally sustainable manner. In assessing the financial sustainability of Ghana's power sector in the first quarter of 2017, four criteria were established; ability to make investments, ability to recover cost, ability to meet demand reliably and ability to operate according to environment and social norms. In assessing this criteria, some indicators were assessed. This included; Capacity annual growth, ratio of installed capacity to demand growth, electricity generation unit cost, ratio of installed capacity to demand, capacity factor, reserve margin, fossil fuel dependency and emission factor.

Ghana was able to make reasonable investment which was enough to meet demand. This investments, operationally, were not able to adequately and reliably meet the demand with below average capacity factor and unreliable reserve capacity due to fuel supply challenges. Fossil fuel dependency in the first quarter of 2017 was about 40% with over 50% of fuel used by thermal power plant obtained from liquid fuels (LCO, DFO and HFO) which emits higher amount of CO2 than natural gas. Emission factor for Ghana in the first quarter of 2017 was higher than it peers in the Lower middle income economies but lower than the emission factors for high income or rich economies.

Therefore, Ghana's power sector was not completely financially sustainable in the first quarter of 2017.

2.0 Performance Indicators of Power Plants

2.1 Capacity Utilization Factor (CUF)

The hydro power plants CUF decline in August 2017. Akosombo GS CUF declined marginally from 43.34% in July 2017 to 40.25% in August 2017, Kpong GS CUF declined from 58.6% in July 2017 to 53.43% in August 2017 and Bui GS had the highest decline among the hydro power plants from 11.27% in July 2017 to 6.1% in August 2017. This shows the declining share of hydro generation in the total electricity supply from 33.4% in July 2017 to 30.5% in August 2017.

With the thermal power plants, there was an increase in the CUF of TICO, TAPCO and TT1PP in August 2017 compared to July 2017. CUF for TICO increased from 86.26% in July 2017 to 92.65% in August 2017. Likewise, the CUF for TAPCO increased from 28.57% in July 2017 to 47.15% in August 2017. Some other thermal power plants CUF declined in August 2017 as compared to July 2017. These thermal power plant include SAPP, Karpowership, Ameri and AKSA. Karpowership had the highest decline in CUF from 95.32% in July 2017 to 64.21% in August 2017. The AKSA and Ameri power plants had reduced CUF in August 2017 largely due to grid demand.

The System Load Factor (LF) increased from 74.9% in July 2017 to 77.9% in August 2017.

Table 2.1.1: Power Plant Capacity Utilization, Average heat rate and Average Fuel Cost of Generation

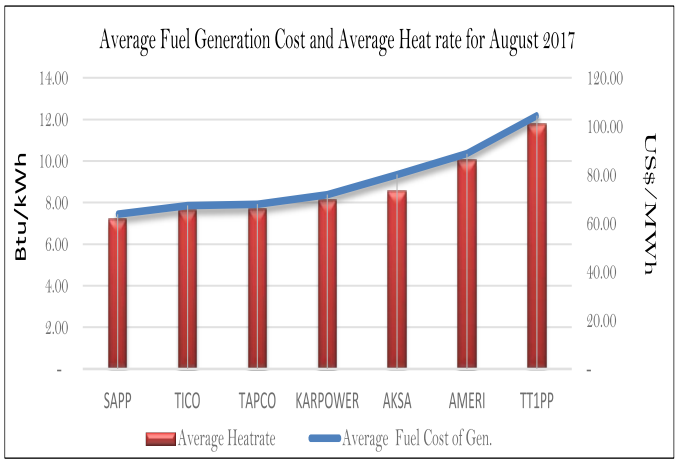
Power Plant	Capacity Utiliation (%)	Average Heatrate (Btu/KWh)	Average Fuel Cost of Generation (US$/MWh)
Akosombo	40.25	-	-
Kpong	53.43	-	-
Bui	6.10	-	-
SEAP	34.70	7,185.53	63.75
TAPCO	47.15	7,684.02	67.93
TICO	92.65	7,616.89	67.33
TT1PP	77.33	11,769.99	104.43
CENIT	-	-	-
TT2PP	-	-	-
MRP	-	-	-
KARPOWER	64.21	8,101.85	71.86
AMERI	44.54	10,037.88	88.73
TROJAN	-	-	-
KTPP	-	-	-
AKSA	67.28	8,535.61	80.10

2.2 Heat Rate (Fuel Efficiency)

There was a significant improvement in the heat rate of the SAPP in August 2017 compared to July 2017. The heat rate improved from 7,540.8 Btu/kWh in July 2017 to 7,185.5 Btu/kWh in August 2017 as it operated largely on the more efficient phase II. Similarly, the heat rate for TAPCO power plants improved from 8,287.9 Btu/kWh in July 2017 to 7,684 Btu/kWh in August 2017. There were marginal improvement in the heat rate of TT1PP and Ameri Power plants from 12,280.21 Btu/kWh and 10,059.4 Btu/kWh respectively in July 2017 to 11,769.99 Btu/kWh and 10,037.9 Btu/kWh in August 2017 respectively. The other thermal power plants such as TICO, Karpowership and AKSA Power plants had marginal reduction in their heat rate in August 2017 compared to July 2017. Fuel efficiency for TICO reduced from 7,567.8 Btu/kWh in July 2017 to 7,616.9 Btu/kWh in August 2017. Likewise, the fuel efficiency of Karpowership and AKSA Power plants reduced from 8,023.6 Btu/kWh and 8,522.7 Btu/kWh respectively in July 2017 to 8,101.9 Btu/kWh and 8,535.6 Btu/kWh in August 2017 respectively.

Figure 2.1 shows the ranking of the thermal power plants based on their efficiency levels with their corresponding fuel cost of electricity generation. The chart indicates the effect of fuel prices on the cost of generation of the thermal power plants.

Figure 2.1: Fuel efficiency ranking of thermal power plants with their respective fuel cost of generation.



2.3 Average Fuel Cost of Electricity Generation

There were generally improvement in the average fuel cost of generation for most of the power plants due to the improved supply of natural gas. All the thermal power plants except Karpowership and AKSA power plants which operated on HFO had improved fuel cost of generation in August 2017 compared to July 2017. The SAPP had the lowest average fuel cost of generation of US$63.75/MWh in August 2017. TAPCO, TICO, TT1PP and Ameri power plants all had improved cost of generation from US$83.23/MWh, US$67.54/MWh, US$108.96/MWh and US$88.92/MWh in July 2017 respectively to US$67.93/MWh, US$108.96.33/MWh, US$104.43/MWh and US$88.73/MWh in August 2017 respectively. Contrary to the gas fired power plant, the Karpowership and the AKSA power plants had an increased average fuel cost of generation in August 2017 compared to July 2017. The average fuel cost of generation for the Karpowership increased from US$69.01/MWh to US$71.86/MWh due to the increased cost of HFO from US$8.6/MMBtu in July 2017 to US$8.87/MMBtu in August 2017. Likewise, the AKSA power plant had an increased average cost of generation from US$77.72/MMBtu in July 2017 to US$80.1/MMBtu in August 2017 also due to the increased cost of HFO from US$9.12/MMBtu in July 2017 to US$9.38/MMBtu in August 2017.

Acronyms

AGPP = Atuabu Gas Processing Plant
Btu = British Thermal Units
CBGC = Composite Bulk Generation Charge
CUF = Capacity Utilization Factor
DFO = Distillate Fuel Oil
EC = Energy Commission
ECG = Electricity Company of Ghana
EMOP = Electricity Market Oversight Panel
ESP – Electricity Supply Plan
FPSO = Floating Production, Storage and Offloading
GHp = Ghana Pesewa
GNGC = Ghana National Gas Company
GWh = Giga-watt Hours
HFO = Heavy Fuel Oil
KTPP = Kpone Thermal Power Plant
kWh = Kilo-watt hours
MRP = Mine Reserve Plant
LEAP = Long-range Energy Alternative Planning
LCO = Light Crude Oil
LI = Legislative Instrument
LTA = Long Term Average
MW = Megawatt
MMscf = Million Standard Cubic Feet
MWh = Mega-watt hours
NITS = National Interconnected Transmission System
PV = Photovoltaic
SAPP = Sunon Asogli Power Plant
SMP = System Marginal Price
SNEP = Strategic National Energy Plan
TEN = Tweneboa, Enyenra, Ntomme
TT1PP = Tema Thermal 2 Power Plant
TT2PP = Tema Thermal 2 Power Plant
VRA = Volta River Authority
WAGPCo – West African Gas Pipeline Company
WAGP = West African Gas Pipeline
WEM = Wholesale Electricity Market

For any enquiries please contact the:
EMOP Administrator, EMOP Secretariat, Energy Commission, Accra.
Telephone: +233-302813756/7/9; Or email: marketoversightpanel@energycom.gov.gh