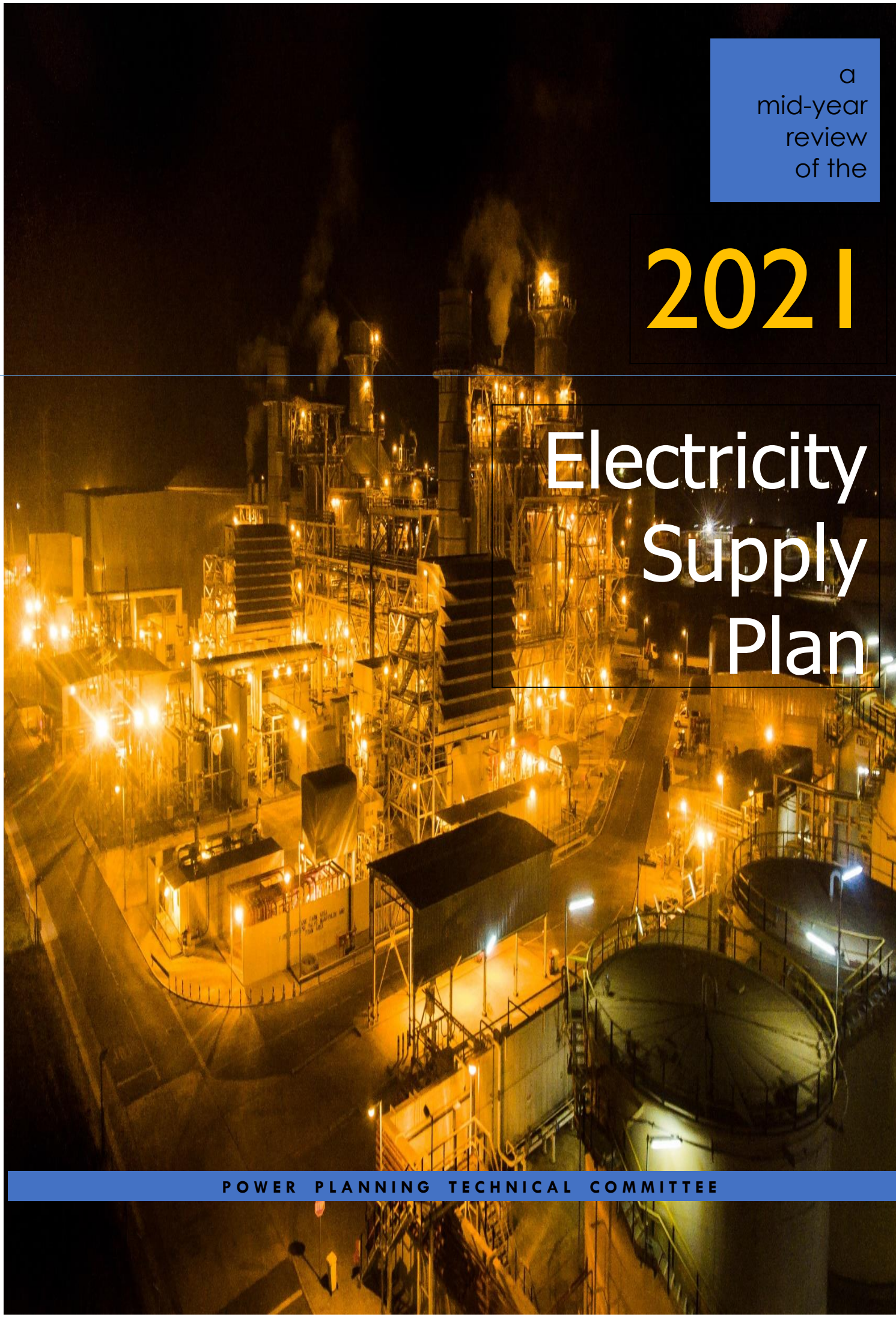

a mid-year review of the

2021

Electricity Supply Plan

POWER PLANNING TECHNICAL COMMITTEE

ACKNOWLEDGEMENT

The Power Planning Technical Committee (PPTC) which was inaugurated in 2020 by the Hon. Minister of Energy to among others develop planning reports for the Ghana Power System worked to develop the 2021 Supply Plan Mid-Year Review as per the requirement in Section-7 of the National Electricity Grid Code and Section 2 (2)(c) of the Energy Commission Act 1997 (ACT 541).

The Committee is made up of technical experts as follows:

Chairpersons:

Ing. Frank A. Otchere (Chairman)	–	Ghana Grid Company Limited
Salifu Addo (Co-Chairman)	–	Energy Commission

Other Members:

Ing. Frederick Okang	–	Ghana Grid Company Limited
Ing. Kassim Abubakar	–	Ghana Grid Company Limited
Ing. Sheila Bortey-Kharis (Mrs.)	–	Ghana Grid Company Limited
Monica Debrah (Mrs.)	–	Ghana Grid Company Limited
Simpson Attieku	–	Energy Commission
Eric Kyem	–	Energy Commission
Joseph Banuro	–	Energy Commission
Adolf Nii Ashong	–	Energy Commission
Ing. Frederick N. A. Oblitey	–	Public Utilities Regulatory Commission
Ing. Hanson Monney	–	Ministry of Energy
Ing. Abdul N. Wahab	–	Volta River Authority
Ing. Justice Barnor Kyere	–	Bui Power Authority
Ebenezer Baiden	–	Electricity Company of Ghana
Ing. Mohammed T. Tampuri	–	Northern Electricity Company Limited
Hamis Ussif	–	Ghana National Petroleum Corporation
Benjamin Buabeng-Acheampong	–	Ghana National Gas Company

We hereby wish to acknowledge all Wholesale Suppliers, Bulk Customers and other key stakeholders who provided relevant information to conduct demand forecasts, determine sources of supply, firm up maintenance programmes, potential new projects and other information required for developing the 2021 ESP.

We also acknowledge Mrs. Laura Zordeh (Energy Commission) who provided administrative support to the PPTC during the development of the report.

EXECUTIVE SUMMARY

The mid-year review of the 2021 ESP presents a review of the Ghana power system performance in the first half of the year (January to June), demand projections and the power supply outlook for the second half of the year (July to December 2021).

It assesses available hydro generation capacities, taking into consideration reservoir elevations at Akosombo and Bui at the beginning of the year and hydro allocation by the EMOP. Additionally, it presents fuel requirements for thermal generation and associated costs required to supply the projected electricity demand for the remaining half of the year, making and evaluating the associated evacuation requirements to ensure reliable power supply.

The half year review further highlights potential challenges to electricity service delivery in Ghana in the second half of the year and makes recommendations for actions necessary to be taken to mitigate the potential challenges and ensure reliable power supply.

Review of Performance for January to June 2021

Peak and Energy Demand

The projected peak load for the first half of 2021 was 3,283.4 MW. The system however, recorded a maximum coincident load of 3,206.0 MW on April 7, 2021.

The peak domestic load recorded within the period was 2,893 MW which occurred on January 20, 2021. This represents a 9.58% (253 MW) growth over the 2020 domestic peak load of 2,640 MW over the same period.

The total energy consumed, including losses, was 10,847.70 GWh as against the projected total energy consumption of 10,667.3 GWh. The actual energy consumed was higher than the projected by 178.40 GWh (16.72%).

Energy Supply

A total of 10,845.70 GWh was generated from hydro (3,392.2 GWh), thermal (7,432.5 GWh) and import (21.01 GWh) in the first half of 2021. Hydro, thermal and import contributed 31.28%, 68.53% and 0.19% respectively. A total of 300.93 GWh and 446.81 GWh were exported to CEB and Burkina Faso respectively during the period. A net of 115.4 GWh was also exchanged between Ghana and Cote d'Ivoire. This was made up of 20.77 GWh imports and 94.63 GWh exports.

Transmission Losses

The total system transmission loss recorded in the first half of 2021 was 589.01 GWh which is 5.51% of total energy transmitted (10,845.70 GWh) representing a 1.15% increase over the projected transmission loss of 582.29 GWh.

Transmission Lines and Feeder Availability

The System Average Availability (SAA) for the NITS was 99.10% whereas the System Average Availability (SAA) for the same period in 2020 was 99.08%.

Demand Outlook for 2021

The Projected Coincident Peak demand for Ghana has been reviewed downwards to 3,354.36 MW from an initial projection of 3,303.74 MW (2020 ESP).

The projected energy consumption has also been reviewed upwards to 21,654.53 GWh, from 21,265.52 GWh.

2021 Reviewed Supply Outlook

Hydro Power Generation for 2021

The total projected hydro generation for 2021 is 7,252.08 GWh. This is made up of 5,605.8 GWh, 894.2 GWh and 752.3 GWh from Akosombo, Kpong and Bui Generating Stations respectively. The micro hydro Tsatsadu plant will also operate at 40 kW during the period.

Akosombo Hydro Elevation

The lake elevation at the end of the first half of the year was 259.80 feet, which is 3.29 feet higher than the level at the same time in 2020 (257.49 feet). It is expected to have adequate headwater for operating the plant for the next half year.

Bui Hydro Elevation

With a year-start elevation of 172.16 MASL in 2020, Bui Hydro elevation ended the first half of the year at 166.74 m. It lowest elevation over the period was 166.70 m, which is 1.30 m below the Minimum Operating Level. This is the lowest elevation ever recorded.

Thermal Power Generation for 2021

The Projected Dependable Thermal Capacity for the 2nd half-year is 6,819.86 MW. The reviewed projected total thermal energy generation for 2021 is 14,242.57 GWh.

Renewable Energy (RE) Generation for 2021

Solar PV generation commenced on April 14, 2021 with the synchronization of the first

25MWp. An additional 25MWp was synchronized to the grid on April 25, 2021, increasing the installed capacity to 50MWp. Total generation from the Solar PV Plant for the first half of the year was 14.6042 GWh, against a projected generation of 31 GWh.

The lower than projected generation was because of the COVID-19 restrictions which affected project schedule. The peak load for the period was 44.358MW and was recorded on June 24, 2021 at 11:32hrs.

Imports

No import is programmed for the second half of the year.

Plants	Installed Capacity (MW)	Dependable Capacity (MW)	Fuel Type
Akosombo GS	1020	900	Hydro
Kpong GS	160	140	Hydro
TAPCO (T1)	330	300	LCO/Gas
TICO (T2)	340	320	LCO/Gas
TT1PP	110	100	LCO/Gas
TT2PP	80	70	Gas
KTPP	220	200	Gas/ Diesel
VRA Solar Plants	22	0	Solar
AMERI	250	230	Gas
T3	132	120	Gas
Bui GS	404	360	Hydro
Tsatsadu Hydro	0.045	0.045	Mini Hydro
CENIT	110	100	Gas
SAPP 161	200	180	Gas
SAPP 330	360	340	LCO/Gas
KAR Power	470	450	Gas
AKSA	370	350	HFO
BXC Solar	20	0	Solar
Meinergy Solar	20	0	Solar
Trojan	44	39.6	Diesel/Gas
Genser	22	18	Gas
CEN Power	360	340	LCO/Gas
Twin City	194	190	LCO/Gas
TOTAL	**5,238.05**	**4,747.65**	

Existing and Committed generation capacity for 2021

Fuel Availabilities

Two main supplies of natural gas were considered as follows:

Nigeria Gas – Average supply of 50 mmscf/day is assumed from July to December 2021,

Ghana Gas – Average daily supply in the second half of 2021 is shown below:

- ✓ Jubilee and TEN Fields- an average of 125 mmscf/day in 2021;
- ✓ OCTP/Sankofa Fields –an average of 210 mmscf/day in 2021;

The average daily quantity of gas expected for the rest of the year 2021 is therefore projected at **355 MMscfd** from July to September and 415MMscfd in November and December when LNG commissioning starts in the third quarter of 2021**.** The Tema LNG is expected to add intermittent flows of between 60MMscfd and 180MMscfd.

Fuel Volumes and Cost

Based on the projected generation, the total projected natural gas consumption for the period July to December 2021 is 59.68 Million MMbtu.

There would be no significant requirement for LCO for the rest of the year 2021. This is due to anticipated high volumes of gas from Sankofa, Jubilee and TEN fields and adequate stocks of LCO at Takoradi to date.

The total estimated fuel cost is therefore US$ 376.60 million. This translates into an approximate monthly average of US$ 62.77 million.

National Interconnected Transmission System

The total circuit length of National Interconnected Transmission System (NITS) from the beginning of 2021 is 6,185.3 km with a total transformation capacity of 8,901.8 MVA with some 65 Bulk Supply Points.

The NITS is capable of evacuating all the power that is projected to be generated from all generating enclaves to the major load centres. However, a study conducted revealed low voltages especially in the Southern parts of the country and some congestion in some transmission corridor.

Nevertheless, further studies show that upon completion of the ongoing transmission projects (ie., the new 330 kV Kumasi – Kintampo line, 161 kV Volta – Achimota - Mallam upgrade and the Kasoa BSP) congestion is removed, thereby reducing losses significantly by 37.3%.

Distribution Outlook in 2021

ECG Network

ECG successfully commissioned the following projects and works within the Southern Electricity Distribution Zone (SEDZ) to help augment its ability to deliver quality electricity services to its customers:

- ✓ Pokuase Bulk Supply Point (BSP) with four (4No.) 120/145MVA Power Transformers.
- ✓ Construction of a 2x40MVA DCTLfrom GRIDCo Aflao BSP to ECG Denu Substation.
- ✓ Construction of 33kV switching station at Peki.
- ✓ Construction of 33kV Quadruple and Double Circuit Tower Lines from the Graphic road BSP to connect the Korle-Bu and Awudome Substations.

Electricity distribution losses for the quarter was 36.50%, about 5.6% higher than the regulatory benchmark of 23.4%. Technical loss was about 10.5% whilst commercial loss was 25.0%.

CONCLUSION

Demand and Supply Outlook

a) The Projected Coincident Peak demand for Ghana has been reviewed upwards to 3,354.36 MW from an initial projection of 3,303.76 MW.

b) The projected energy consumption has also been reviewed upwards to 21,601.26 GWh, from 21,265.52 GWh.

c) The Supply Outlook is as follows:

- ✓ Hydro supply will be 7,042.28 GWh representing 32.5% of the total energy supply;
- ✓ Thermal supply will be 14,466.51 GWh representing 66.8% of total energy supply; and
- ✓ Renewables supply will be 146.94 GWh representing 0.7% of total energy supply

d) Total projected energy exports are 1,573.13 GWh for 2021.

e) VALCO is expected to continue operating on one pot-line with a projected total consumption of 763.34 GWh.

f) In terms of fuel, the following quantities of the various fuel types are required for the 2nd half of the year:

2. Natural Gas - 59.68 million MMBtu
3. HFO - 97 barrels

g) Annual total fuel cost of **USD 376.60** million is required, averaging a monthly total of some **USD 62.77** million.

Requirements for Grid Reinforcement

a) The transmission system has some constraints. This situation sometimes results in low voltages, overloading of lines and increased overall transmission system losses.

b) Losses will be reduced upon:

- ✓ Completion of 161kV Anwomaso-Kintampo, 161kV Volta-Achimota-Mallam, 161kV and the Kasoa Bulk Supply Point.
- ✓ Repair and restoration of the capacitor banks will reduce overall system losses.

In absolute terms completing the ongoing transmission projects and restoration of capacitor banks will save 62.0 MW losses at peak.

c) For radial lines and single transformer stations, significant percentage of network loads could be islanded in the event of outage of such lines and transformers.

d) A fair East-West balance in generation provides better system stability and minimal overall transmission system losses.

Distribution Systems

a) In a bid to to deliver quality electricity services to its customers, ECG has successfully commissioned several works and projects within the Southern Electricity Distribution Zone (SEDZ).

b) Electricity distribution losses for the quarter was 36.5%, about 5.6% higher than the regulatory benchmark of 23.4%. Technical loss was about 10.5% whilst commercial loss was 25.0%.

RECOMMENDATIONS

Based on the above conclusions, the following recommendations are made:

a) Fuel supply security and adequacy remains the single most important risk to power supply reliability in Ghana. In this vein, it is strongly recommended that all the relevant sector agencies and stakeholders work conscientiously together to ensure that fuel supply is adequate, secure and at low cost at all times.

b) The following are ongoing transmission expansion projects:

- ✓ Volta – Achimota – Mallam Transmission Line Upgrade Project
- ✓ Kumasi – Kintampo 330 kV transmission line Project;

should be expedited and completed in the second half of 2021 to ensure adequacy of evacuation capacity.

c) In order to meet the transmission reliability benchmarks, the following are the critical transmissions additions and upgrades required in the medium term:
    - ✓ Upgrade of 161kV Aboadze – Takoradi – Tarkwa – Prestea circuit;
    - ✓ Construction of a second 330 kV Prestea – Dunkwa – Kumasi circuit;
    - ✓ Upgrade of 161kV Aboadze – Mallam transmission lines;
    - ✓ 161 kV Mallam – A4BSP transmission line;
    - ✓ Construction of a second 330 kV Aboadze – A4 BSP circuit
    - ✓ Construction of a double circuit 330 kV line from A4BSP to Kumasi
    - ✓ Break-into the 330 kV Takoradi Thermal – Anwomaso line at Dunkwa with a link to the existing 161 kV substation.

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ABBREVIATIONS

BSP	Bulk Supply Points
CEB	Communauté Electrique du Bénin
CIE	Compagnie Ivoirienne d' Electricité
COVID-19	Corona Virus Disease
ECG	Electricity Company of Ghana
EDM	Énergie du Mali
EMOP	Electricity Market Oversight Panel
EPC	Enclave Power Company
ESP	Electricity Supply Plan
FPSO	Floating Production Storage Offloading
GDP	Gross Domestic Product
GNGC	Ghana National Gas Company
GNPC	Ghana National Petroleum Company
GPP	Gas Processing Plant
GRIDCo	Ghana Grid Company
GS	Generation Station
GWh	Gigawatthour
HFO	Heavy Fuel Oil
HV	High Voltage
IMF	International Monetary Fund
IPPs	Independent Power Plants
KTPP	Kpone Thermal Power Plant
kV	Kilovolt
LCO	Light Crude Oil
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LV	Low Voltage
MMBtu	Million British Thermal Unit
MMscfd	Million standard cubic feet day

MVA	Megavolt ampere
MVAr	Megavolt ampere of reactive power
MW	Megawatt
MWp	Megawatt peak
NEDCo	Northern Electricity Company
NG	Natural Gas
NITS	National Interconnected Transmission System
OCTP	Offshore Cape Three Point
PURC	Public Utility Regulatory Commission
SAPP	Sunon Asogli Power Plant
SVC	Static VAR Compensator
TAPCO	Takoradi Thermal Power Company
TEN	Tweneboa, Enyenra, Ntomme fields
TICO	Takoradi International Company
TT1PP	Tema Thermal Power Plant 1
TT2PP	Tema Thermal Power Plant 2
TTIP	Takoradi-Tema Interconnected Project
TUF	Transformer Utilization Factor
USD	United State Dollars
VALCO	Volta Aluminum Company Limited
VRA	Volta River Authority
WAGP	West African Gas Pipeline
WAGPCO	West African Gas Pipeline Company

1 INTRODUCTION

The 2021 Electricity Supply Plan (ESP) released at the beginning of the year presented an outlook of electricity demand and supply on the Ghana power system for the year 2021, basing on assumptions for demand, projected available generation resources and transmission infrastructure.

In accordance with prudent practice, we present per this report a mid-year review of the 2021 Electricity Supply Plan. It presents an assessment of the power system performance in the first half of the year including an analysis of the year-to-date hydrology at the Akosombo and Bui dams. It also considers thermal generation and fuel usage.

It then makes projections for the rest of 2021 making adjustments to assumptions in the 2021 ESP where necessary. Projections for system demand and the generation outlook are accordingly reviewed.

Additionally, the Supply Plan takes a look at the NITS analysing its resilience and ability to supply the projected Ghana demand in 2021.

2 SYSTEM PERFORMANCE REVIEW FOR THE FIRST HALF OF 2021

2.1 Objective

In this chapter, we begin the mid-year review of the 2021 Electricity Supply Plan with an analysis of the Ghana Power System Performance in the first half of the year 2021, that is the period January 1 – June 30, 2021. The peak demand, energy consumption and power plant generation data is compared against projections per the 2021 Electricity Supply Plan. The system performance with respect to voltages and transmission system losses are also analysed.

2.2 Peak Load

The actual peak load realised in the first half of 2021 was 3,206.0 MW. This peak load was recorded on April 07, 2021 and is 77.4 MW (2.4%) lower than the projected peak load (3,283.4MW) for the period per the 2021 ESP. The deviation from the projected peak load could be attributed to the load shedding which was being carried out at the time when some customer loads in Kumasi (55MW) and Asawinso (22MW) had been curtailed to control network voltage in and around Kumasi.

The peak load recorded also represents an 8.4% (249.0 MW) growth over the 2020 peak load of 2,957.0 MW. The summary of projected and actual peak load as recorded over the period is shown in Table 2.1:

Table 2.1 System Peak Demand for 1st half of 2021 and Projection

Load Type	System Peak (MW)		Difference (MW)
	Actual - 1st half 2021	Projected - 1st half 2021	(Projection - Actual)
Domestic Peak	2,893.0	2,858.4	-34.6
Export (CEB+ SONABEL)	230.0	310.0	80.0
VALCO	83.0	115.0	32.0
System Peak (coincident)	3,206.0	3,283	77.4

Table 2.2 compares the actuals against the projected monthly peak load for the first half 2021.

Table 2.2: Comparison of Monthly Peak Load for 1st half of 2021(Actual against Projected)

Month	Projected Demand (MW)	Actual Demand (MW)		Difference
		System	Domestic	(Projected - System)
Jan-21	3,264.0	3,070.0	2,904.0	194.00
Feb-21	3,191.1	3,088.0	2,893.0	103.12
Mar-21	3,256.4	3,172.0	2,818.0	84.39
Apr-21	3,283.4	3,206.0	2,893.0	77.42

May-21	3,258.6	3,073.0	2,884.0	185.60
Jun-21	3,054.0	3,097.0	2,997.0	-43.0

2.3 Domestic Peak Load

Domestic peak load here refers to the maximum amount of power consumed within Ghana off the NITS. This includes supplies to residential, commercial, industrial and mining loads in Ghana excluding VALCO.

The peak domestic load recorded within the period was 2,893.0 MW which occurred on January 20, 2021. This represents a 9.58% (253 MW) growth over the 2020 domestic peak load of 2,640 MW over the same period.

Table 2.3: System Peak Demand for 1st half 2021 & 2020

Type of Peak	Domestic Peak (MW)		% Growth
	1st half 2021	1st half 2020	
Domestic Peak	2,893.0	2,640.0	9.58%

2.4 Energy Consumption

A summary of 2020 and 2021 first half year energy consumption data is shown in Table 2.4 and Figure 2.1.

Table 2.4: Summary of Energy Consumption for 1st half 2021: actual vrs. projected

Customer	Projection (GWh) 1st half 2021	Actual (GWh) 1st half 2021	Actual (GWh) 1st half 2020	% Growth (2021-2020)
ECG	6,847.97	7,169.05	6,321.25	13.41%
NEDCo	795.62	900.73	781.37	15.28%
Mines	900.27	698.37	737.43	-5.30%
VALCO	481.01	375.45	341.46	9.95%
EPC	140.27	118.48	117.7	0.67%
Export	790.17	825.40	1,022.20	-19.25%
Direct Cust.	124.39	163.95	137.27	19.44%
Losses	582.29	589.01	455.63	29.27%
Network Usage	5.28	5.26	4.83	8.85%
Total Energy Transmitted	10,667.26	10,845.70	9,919.14	9.34%

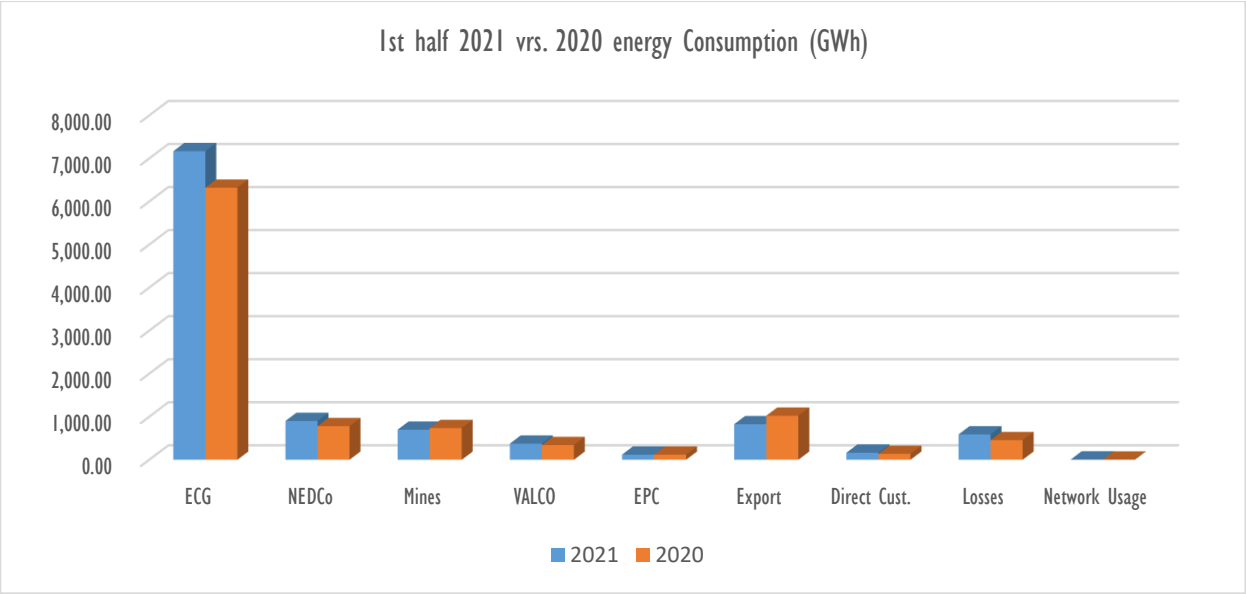

Figure 2.1: Energy Consumption for 1st half of 2021 compared with 2020

The data shows high growth in ECG and NEDCo consumption. This is a sign of growth in the Ghana Economy. Losses on the other hand grew tremendously compared to the same period in 2020 which is attributable to congestion in NITS due to:

1. Delayed completion of projects,
2. Lack of generation in the northern parts of the NITS due to limited dispatch of Bui as a result of poor headwater levels from the beginning of the season.

VALCO load has also grown appreciably. On the contrary, export reduced significantly when export to SONABEL had to be limited to control voltage decay in the middle to northern parts of the NITS due to limited generation from the Bui plant.

2.5 Exports

A total of 300.93 GWh and 446.81 GWh were exported to Togo/Benin and Burkina respectively during the period. Power exchange between Ghana and Cote d'Ivoire was made up of 94.63 GWh exports and 20.77 GWh imports (a net Exchange of 115.4 GWh).

2.6 Energy Generation

Actual monthly energy generation recorded in the first half of 2021.

Table 2.5: Projected versus Actual Energy generation for 1st half of 2021

Months	Projected (GWh)					Actual (GWh)			
	Total Hydro (GWh)	Total Thermal (GWh)	Total Solar (GWh)	Import (GWh)	Total (GWh)	Hydro (GWh)	Thermal (GWh)	Import (GWh)	Total (GWh)
January	583.07	1,217.9	6.90	0	1,807.84	566.80	1,276.14	1.11	1,844.06
February	526.65	1,162.0	6.23	0	1,694.85	550.23	1,156.47	1.98	1,708.68
March	583.07	1,239.8	6.90	0	1,829.77	534.85	1,310.68	4.87	1,850.40
April	531.52	1,242.8	8.47	0	1,782.80	531.52	1,313.06	3.06	1,847.64
May	633.60	1,216.1	8.75	0	1,858.40	633.60	1,227.27	4.60	1,865.46
June	638.37	1,111.5	8.47	0	1,758.37	575.19	1,148.88	5.38	1,729.45

The hydro/thermal proportions for the 1st half of 2021 is presented graphically in Figure 2.2.

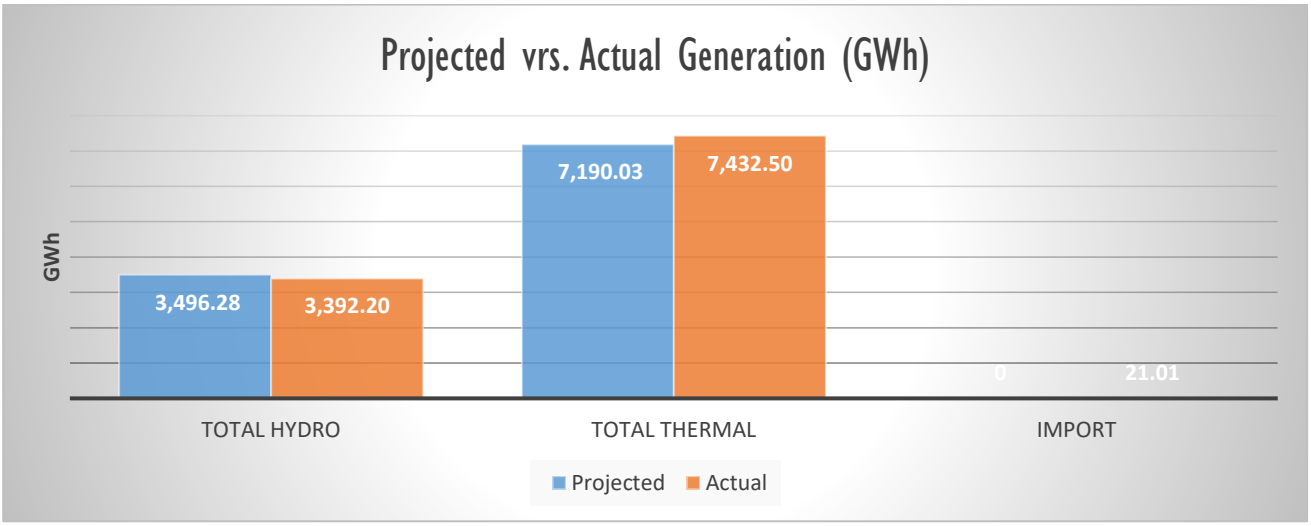

Figure 2.2: Projected versus Actual Energy Generation for 1st half of 2021

Table 2.6 gives a monthly generation breakdown of the individual plants.

The variation between the projected and actual energy for thermal generation is due to the increase in export as compared to the projected for the period

Table 2.6: Comparison of projected and actual monthly energy generation (GWh)

Plant/Months	Projection 2021 (GWh)						Actuals 2021 (GWh)						
	Jan	Feb	Mar	Apr	May	Jun	Jan	Feb	Mar	Apr	May	Jun	Actual
Akosombo	479.86	433.42	479.86	464.38	479.86	464.38	396.41	404.89	418.42	434.00	517.75	464.21	98.33
Kpong	72.19	65.21	72.19	69.86	72.19	69.86	71.59	69.07	74.43	75.92	90.09	83.83	96.76
Bui	31.02	28.02	31.02	30.02	31.02	30.02	98.81	76.28	42.00	21.60	25.76	27.15	97.95
TAPCO	172.42	155.74	172.42	166.86	172.42	166.86	194.07	156.81	130.65	154.66	187.39	220.27	92.25
TICO	195.23	176.33	195.23	188.93	195.23	188.93	26.86	87.62	227.59	218.77	215.39	217.35	92.36
TT1PP	59.52	0.00	59.52	0.00	59.52	0.00	77.20	1.32	48.41	11.33	20.59	68.74	93.41
CENIT	47.74	47.74	47.74	47.74	47.74	47.74	58.39	39.45	56.96	70.30	77.05	22.52	98.73
Karpower	267.84	241.92	267.84	259.20	267.84	239.20	264.22	250.17	281.39	265.52	166.23	145.82	99.21
TT2PP	9.49	8.57	9.49	9.18	9.49	9.18	6.26	8.54	12.23	17.19	15.44	17.25	98.41
SAPP	187.49	169.34	187.49	181.44	187.49	162.47	346.07	284.81	353.77	291.08	219.64	257.99	97.71
AMERI	91.44	80.92	57.10	69.32	58.09	25.15	66.07	0.00	0.00	0.75	0.00	0.00	82.88
KTPP	0.00	57.12	0.00	61.20	0.00	61.20	0.00	61.11	33.99	71.12	73.96	5.84	98.77

AKSA	9.49	8.57	9.49	9.18	9.49	9.18	19.55	27.64	21.51	30.89	33.36	25.80	99.21
CENPOWER	107.51	97.10	107.51	104.04	107.51	104.04	134.20	115.25	116.55	123.27	128.19	130.34	97.8
AMANDI	69.71	118.63	125.99	130.06	86.01	83.23	81.25	122.78	23.59	56.62	89.13	33.53	-
Early Power	-	-	-	15.7	15.2	14.4	2.01	0.97	4.03	1.57	0.89	3.45	-

The total energy generated over the period was 10,845.70 GWh; this was made up of 3,392.2 GWh (31.28%) from hydro generation, 7,432.50 GWh (68.53%) from thermal generation and 21.01 GWh (0.19%) from Imports.

Figure 2.3 shows a graphical illustration of the actual generation mix for the first half of 2021.

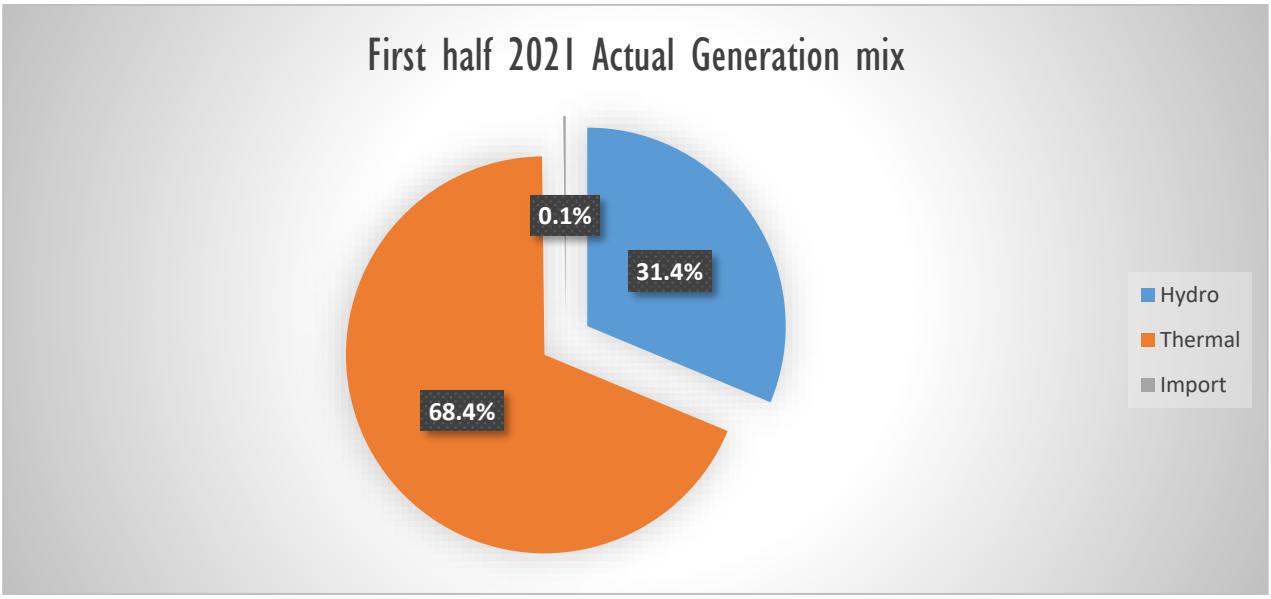

Figure 2.3: Generation Mix for 1st half of 2021

2.6.1 Hydro Reservoir Performance

The Akosombo and Bui reservoir performances as at the end of June 2021 are shown in Table 2.7. The head water trajectories for Akosombo and Bui for the period are also shown in Figures 2.7 and 2.8 respectively.

Table 2.7: Akosombo and Bui Reservoir Elevations for 1st half-year

Level	*Akosombo Height (ft.)*	*Bui Height (m)*
Maximum design elevation	278.00 (84.73 m)	183.00
Elevation at January 01, 2021	267.70 (81.59 m)	172.16
Elevation at the end of June, 2021	259.80 (79.19 m)	166.74

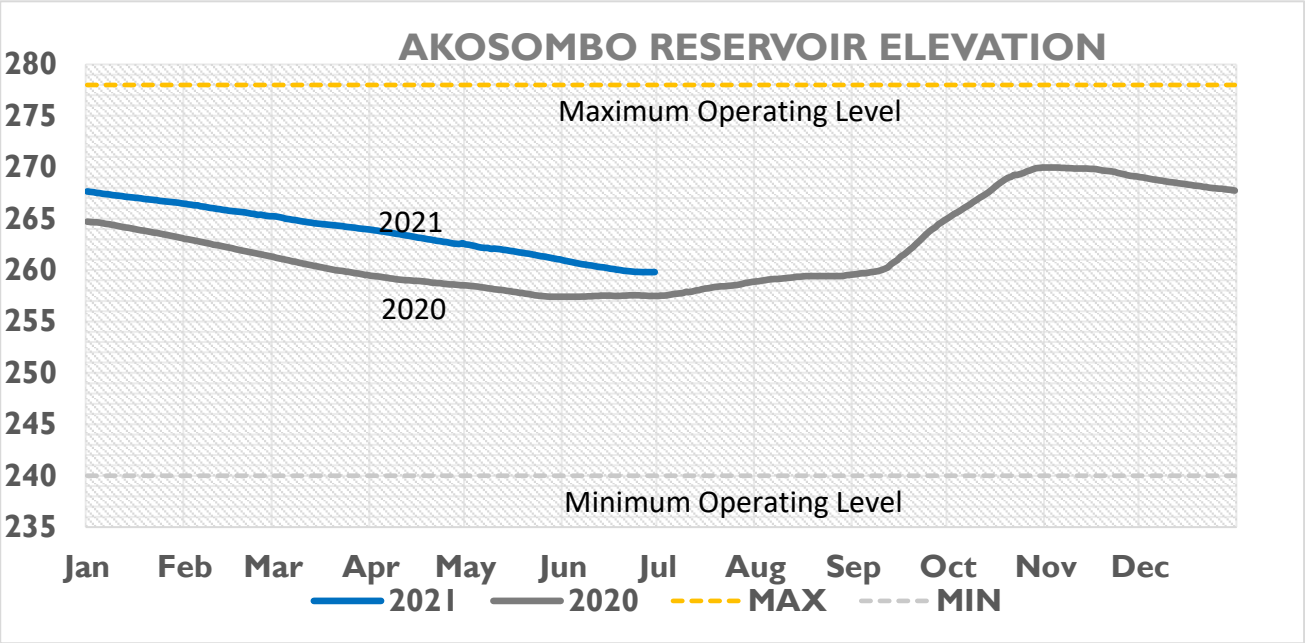

Figure 2.4: Akosombo Reservoir Trajectory

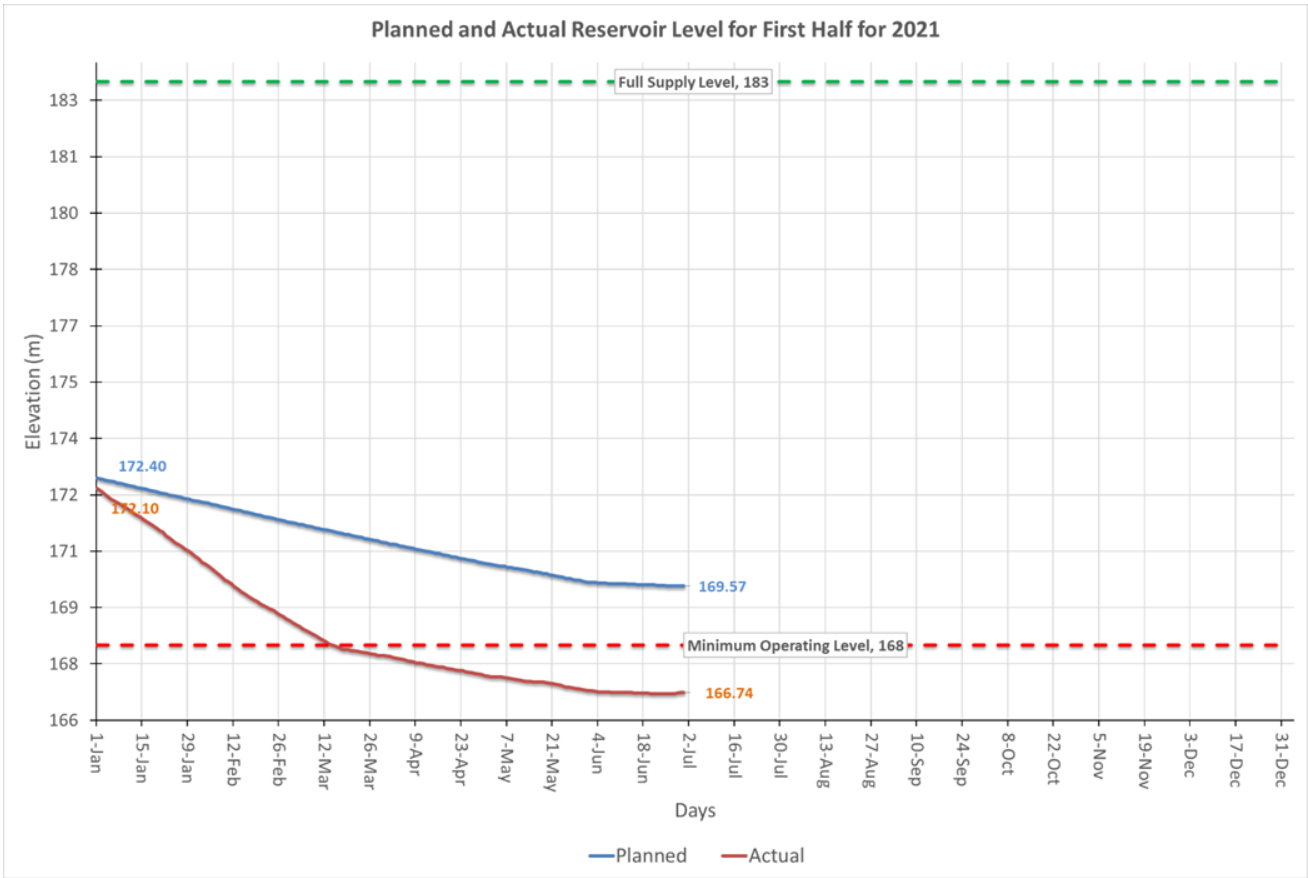

Figure 2.5: Bui Reservoir Trajectory

a. Bui Hydro

The Bui Reservoir elevation at the beginning of 2021 was 172.16 MASL, dropping by 5.40m to a minimum of 166.76 MASL (below the minimum operating level of 168 MASL) at the end of June 2021. The end of mid-year level was 2.81 meters below the projected of 169.57 MASL. This required a conservative dispatch of the Bui GS to manage the limited head water. The dispatch will continue in a conservative mode whiles the inflows in the upcoming inflow season are monitored and analysed critically to determine when there would be a need to revise the dispatch of the plant

The total hydro generation from Bui Generating Station (GS) in the first half of 2021 was 277 GWh. This was 96 GWh over the conservative projection of 181 GWh for the reporting period. The huge deviation from the projected generation was due to higher dispatch during the period.

Additionally, the Bui Hydro Plant operated a total of 2,727.33hrs in Synchronous Condenser Mode to supply reactive power for grid voltage stability during the period.

2.7 Fuel Supply

The fuel supply security as well as the fuel consumed by the thermal plants for the first half-year is highlighted below:

2.7.1 Fuel Usage

2.7.1.1 Natural Gas Usage

Gas supply data from the three domestic sources in the first half of 2021 is shown below:

Table 2.8: Quantities of Natural Gas Supplied for the 1st half of 2021

MONTH	JUBILEE + TEN		Sankofa/ OCTP	
	Monthly Total (MMscf)	Daily Average (MMscfd)	Monthly Total (MMscf)	Daily Average (MMscfd)
21-Jan	3,517	113	5,905	190
21-Feb	3,088	110	5,573	199
21-Mar	3,544	114	5,484	177
21-Apr	3,416	114	5,985	199
21-May	3,445	111	5,428	175
21-Jun	2,832	94	5,169	172
TOTAL	**19,866**	**110**	**33,543**	**186**

Gas utilization by power producers amounted to a total of 53,409.0 MMscfd.

2.7.1.2 Natural Gas Supply Security

In January and February 2021, GNPC took enough gas from Sankofa to achieve the 45day high flow test required to end the Run-in Period (ended on 22nd February 2021) under the Sankofa/OCTP GSA. This helped to reduce GNPC's monthly offtake obligation and liability. Jubilee, together with GNGC, also successfully conducted a 12-hour high gas flow test during the first half of the year. This test was conducted to assess the maximum export capacity of the Jubilee offshore facilities and Atuabo Gas Processing Plant (GPP) and improve reliability of the facilities along that gas supply corridor.

There was a number of challenges across the value chain, including outages offshore, shutdowns at the GPP as well as downstream challenges with the national electricity grid, which affected gas supply during the period. Table … shows the gas supply from the domestic sources.

2.8 Renewables

In the first half of 2021 Bui Solar PV farm was on April 14, 2021 as the first non-embedded RE generating facility in Ghana. At commissioning, the initial capacity was 25MWp. An additional 25MWp was commissioned on April 25, 2021, increasing the capacity to 50MWp. Total energy generation by the Solar PV farm in the first half of the year was 14.604 GWh. The peak generation realised for the period was 44.358 MW and was recorded on June 24, 2021. at 11:32hrs.

2.9 System Disturbances - 1st Half of 2021

The Ghana Power System experienced a number of disturbances in the first half of 2021 caused mostly by transmission line faults and gas supply related trips, leading to supply interruptions to various consumers on the power system. Below is a list of disturbances triggered by Transmission System faults and their causes.

i. January 5, 2021: At 20:55 h, the Kumasi-Konongo line tripped on fault resulting in cascaded trips to the Anwomaso-Kumasi, Kumasi – New Obuasi, Nkawkaw – Anwomaso, Obuasi - Kenyasi and all lines serving the northern part of the grid. By 22:06 h, all lines in addition to customer loads were restored.

ii. January 19, 2021: At 06:18 h, a system disturbance occurred when transmission trips initiated by faults on Techiman-Kintampo and the Anwomaso – Kumasi lines resulted in cascaded trips

to all lines serving the northern portion of the grid. All lines and customers which were affected were restored by 07:53 h.

iii. February 3, 2021: At 00:49 h a snapped conductor on Tarkwa – Takoradi line resulted in cascaded trips to Aboadze – Tarkwa, Prestea – Obuasi, Dunkwa – Bogosu and Bui – Techiman lines and all lines serving the northern portion of the grid. The grid was fully restored by 01:40 h.

iv. March 07, 2021: At 14:04 h The Prestea-Obuasi transmission line tripped on a fault while Bui was not generating active power into the grid. This resulted in increased loading on the Aboadze-Anwomaso 330 kV transmission line (TT8AW) causing overloading on the Anwomaso 330/161 kV transformers. The transformers tripped together with the TT8AW line and caused a severe surge on the NITS. This led to cascaded trips on other transmission lines and generating units in service, leading to a total system collapse. Restoration started immediately and by 18:30 h, supply had been restored to all bulk supply points.

v. March 19, 2021: At 14:14 h, system disturbance initiated by fault on Kumasi–Techiman line resulted in trip to all lines serving the Techiman substation and subsequently resulting in outage to the northern portion of the NITS. The system was however fully restored by 15:04 h.

vi. March 28, 2021: At 12:02 h, trip on the Kumasi – Techiman and the Aboadze – Anwomaso lines resulted in cascaded trips to all lines serving the northern portion of the NITS including the Prestea – Bingerville, Konongo – Kumasi and the Dunkwa – Bogosu lines. Supply was fully restored by 14:32 h when the Prestea – Bingerville line was brought back into service.

vii. April 3, 2021: At 23:06 h, the Volta–Accra East line no. 1 tripped when a conductor on the line fell near the Accra East substation. This resulted in trips on all lines within the Volta – Achimota Corridor and subsequently customers served within the corridor. Generating plants in service at Aboadze also tripped. All lines except the faulted line and feeders which were taken out of service due to low voltages being recorded were fully restored by 14:01 h on April 4, 2021.

viii. April 12, 2021: At 13:36 h the Takoradi Thermal-Anwomaso 330 kV transmission line tripped, triggering cascaded trips on some other transmission lines and all generating units in service at Aboadze. Automatic frequency relays operated to take some customer loads during the

disturbance. Restoration started promptly and by 14:05 h, all transmission lines which tripped had been restored.

ix. April 29, 2021: At 06:41 h the 330/161 kV auto transformers (2T1 and 2T2) at Volta tripped due to a fire outbreak on 2T1 transformer. This resulted in cascaded trips on Aboadze-Volta-Asogli-Dawa-Davie 330 kV transmission lines and some generating units in service at Aboadze and Tema. Automatic frequency relays operated to take some customer loads during the disturbance. By 09:21 h, all transmission lines which tripped and supply to all affected bulk supply points had been restored.

x. April 30, 2021: At 09:34 the Prestea-New Tarkwa line tripped and led to cascaded trips on some other transmission lines and all generating units in service at Aboadze. Automatic frequency relays operated to take some customer loads during the disturbance. Restoration started promptly and by 11:37 h, all transmission lines which tripped had been restored, and supply had also been restored to all affected bulk supply points.

xi. May 23, 2021: At 11:27 h on Sunday May 23, 2021 the Volta 330/161 kV auto transformer no. 2 (2T2) tripped on overload and led to cascaded trips on some other transmission lines and generating units in service at Tema and Takoradi. Automatic frequency relays operated to take some customer loads during the disturbance. Restoration started promptly and by 15:33 h, all transmission lines which tripped had been restored, and supply had also been restored to all affected bulk supply points except Kumasi. Supply to Kumasi was eventually restored at 18:27 h.

xii. May 30, 2021: At 13:48 h the Akosombo-Tafo 161 kV transmission lines tripped due to an earlier tripping of the Tafo-Nkawkaw line, while the Cape Coast – Mallam, Winneba – Mallam and the Akosombo-Nkawkaw lines were out of service for planned work. This led to power swings resulting in cascaded trips on some other transmission lines and generating units in service at Tema, Kpong GS and Takoradi. Automatic frequency relays operated to trip some customer loads during the disturbance. Restoration started promptly and by 18:26 h, all transmission lines which tripped had been restored, and supply had also been restored to all affected customers.

- Gas/Fuel Related Disturbances

i. Compressor trip at ENI ORF on February 27, 2021

At 18:24 h on February 27, 2021, a compressor at the ENI Sankofa Onshore Receiving Facility (ORF) tripped, causing interruption of gas supply to Sunon Asogli, Amandi and Karpower. The units were shut down immediately to avoid tripping. Customer loads were taken off at Mallam, Smelter II, Anwomaso, Winneba and VALCO.

ii. ESDV closure at WAPCO Tema RMS on March 1, 2021

At 14:55 h on March 1, 2021, the emergency shutdown valve at the WAPCO Regulatory and Metering Station (RMS) in Tema closed, cutting off gas supply to Sunon Asogli. The plant was shut down immediately. Customer loads were taken off at Mallam, Winneba, Kumasi and Cape Coast to correct the dipping frequency.

iii. ESDV closure at WAPCO Tema RMS on March 3, 2021

At 06:31 h on March 3, 2021, the emergency shutdown valve at the WAPCO regulatory and metering station in Tema closed, cutting off gas supply to Sunon Asogli. The plant was shut down immediately. Customer loads were taken off at Mallam to correct the falling frequency.

iv. Compressor trip at ENI Sankofa ORF on March 5, 2021

At 03:10 h on March 5, 2021, a compressor at the ENI Sankofa Onshore Receiving Facility (ORF) tripped, causing interruption of gas supply to Amandi and Karpower. Customer loads were taken off at Winneba to balance the frequency following the sudden generation shortfall when the generating units were shut down.

v. Sudden gas pressure dip at Takoradi RMS at Aboadze on March 5, 2021

At 10:08 h on March 5, 2021, TAPCO and TICO units suddenly deloaded due to sudden dip in gas pressure. KTPP was instructed to switch from gas to DFO due to falling gas pressure. The unit however, tripped while switching over. Customer loads were taken off at Mallam and Asawinso to correct the falling frequency.

vi. ESDV closure at WAPCO Tema RMS on March 14, 2021

At 12:45 h on March 14, 2021, the emergency shutdown valve at the WAPCO regulatory and metering station in Tema closed, cutting off gas supply to Sunon Asogli, TT1PP, TT2PP, CENIT. The

plants were shut down immediately. Customer loads were taken off at Mallam, Accra East and Kumasi to correct the falling frequency.

vii. Compressor trip at Ghana Gas on March 24, 2021

At 01:02 h on March 24, 2021, a compressor trip at Ghana Gas resulted in interruption of gas supply to KARPOWER, CENIT, and part loading of TICO and TAPCO. Customer loads were taken off at Accra East and Winneba to correct the falling frequency.

viii. Compressor trip at Ghana Gas on March 31, 2021

Reduced gas pressures from WAPCO resulted in shutdown of some generating plants and taking out loads at Accra East and Tamale to correct decaying frequency.

2.10 System Reliability

2.10.1 Quality of Supply

Technical Schedule TS-L of the Ghana Electricity Grid Code states that the NITS frequency shall be always maintained between 49.8 Hz and 50.2 Hz under normal state of operation. It also states that NITS voltage magnitudes shall be kept within ±5% of the nominal voltage at all times under normal state. In this section, some quality of supply parameters are considered.

2.10.2 System Frequency

In the first half of the year 2021, system frequency was within the normal range of 49.8Hz - 50.2Hz for 75.50% of the time as compared to the 78.56% recorded in the same period in 2020.

The others are:

- 49.5Hz - 49.8Hz – 0.64% of the time.
- 50.2 Hz - 50.5 Hz – 23.38% of the time.

Fig 2.9 shows the details system frequency performance for the first half of the year.

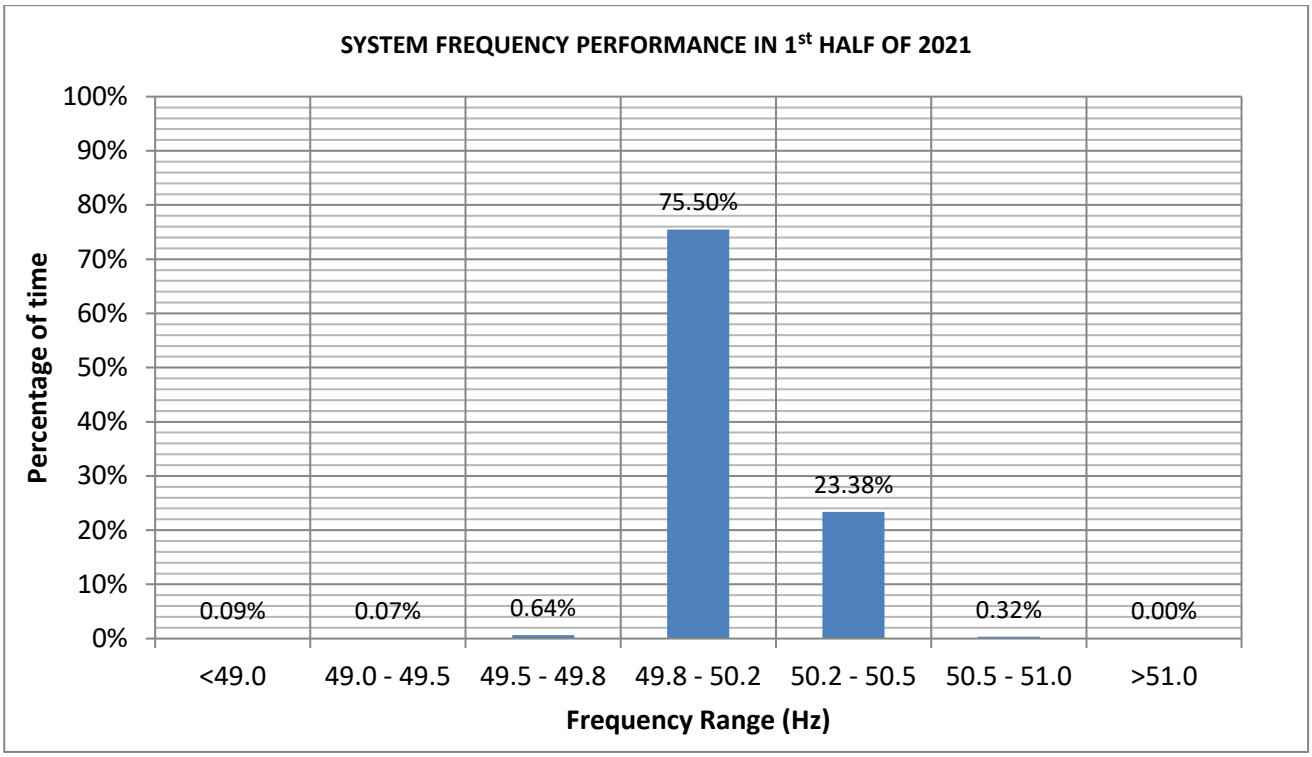

Figure 2.6: System Frequency for 1st half of 2021

2.10.3 System Voltages

An analysis of voltage statistics at selected Bulk Supply Points (BSP) at peak time shows that voltages across the NITS were poor for Achimota, Mallam and Kumasi substations. The Takoradi, Tamale and New Tema substations were however largely within the normal limits. The low voltages observed at Achimota and Mallam is attributable to increased demand in Accra and the congestion on the Volta – Achimota line circuits. Low voltages in Kumasi on the other hand were due to limited generation from Bui. Table 2.12 shows the details from the selected substations.

Table 2.9: System Voltages

Station	Number Of Days in the 1st Half of 2021			Percentage for the 1st Half of 2021		
	Normal	Below Normal	Above Normal	Normal	Below Normal	Above Normal
Achimota	108	73	0	60%	40%	0%
Mallam	58	123	0	32%	68%	0%
New Tema	148	0	33	82%	0%	18%
Kumasi	107	74	0	59%	41%	0%
Takoradi	170	11	0	94%	6%	0%
Tamale	180	1	0	99%	1%	0%

2.11 Transmission Network Performance:

2.11.1 Power Supply (Feeder) Availability

The GRIDCo network registered an average feeder availability of 99.63% during the period. This performance was above the approved PURC 95% benchmark.

2.11.2 Transmission Line Availability

The transmission lines recorded an average availability of 99.59% for the period, as shown in Table 2.10. The Table also shows average availability for the transmission lines of the various voltage classes.

Table 2.10: the transmission line availability for 1st half of 2021.

Voltage Class	Availability %
69kV	99.50%
161kV	99.11%
225kV	94.79%
330kV	99.22%
System Average Availability	99.10%

2.12 Transmission System Losses

The average transmission losses recorded during the period was 589.01 GWh which represents 5.51% of the total energy transmitted (10,845.70 GWh). The actual transmission losses recorded are 1.15% more than what was projected (582.29 GWh).

Table 2.11 shows the monthly losses recorded for the first half.

Table 2.11 Monthly transmission losses for first half 2021

Month	January	February	March	April	May	June
Transmission Losses%	4.12	4.98	5.55	6.27	6.01	5.62

Table 2.12 also shows system transmission losses for the period 2018 - 2020

Table 2.12: Transmission losses from 2018-2020 for the same period

Year	2019	2020	2021
Transmission Losses%	5.12	4.6	5.51

2.13 Transformer Capacity

Within the period from January 1 – June 30, 2021 there was an increase in transformer capacity on the NITS by 580 MVA, bringing the total transformer capacity as at the end of the first half to 9,481.8 MVA. The total capacity of conventional step-down transformers within the NITS is 5,939.9 MVA. The Transformer Utilisation Factor (TUF) of the transmission system is 47.50%, computed based on the peak load of 2,821.8 MVA and system average load factor of 0.88 for the period. This is indicative of a high transformer redundancy within the NITS for adequate and reliable power supply.

2.14 Distribution Network Performance (Southern Network)

Electricity Company of Ghana is the operator of the Southern Electricity Distribution Zone (SEDZ) Concession and accounts for about 89% of electricity consumption in Ghana due to the dense population in within the zone. ECG's performance for the first half (January to May) of 2021 is examined as follows:

2.14.1 Purchases, Sales and System Losses

Total electricity purchases for ECG as of May 2021 was **GWh6,269.86** compared to GWh5,555.32 recorded for the same period of 2020 representing about 13% increase. Electricity sales for the same period was **GWh3,982.46** culminating in system losses of about **36.5%**. The system loss as of May 2021 was high because of two major factors. They are:

- The slow returns of customer sales data from prepaid customers; and
- The time lag in capturing of energy recoveries from illegal connections leading to a shift in records to reflect in subsequent quarters.

Therefore, system losses are usually reflective of the utilities performance if annualized rather than assessing it on a quarterly basis. The regulatory benchmark for the Discos is 23.4%. It is envisaged that the end of year results will be approaching the regulatory benchmark.
On the average, technical losses within the distribution network is about 10.55% whilst non-technical losses is about 25% (which would improve with full returns sales and recoveries data).

2.14.2 Commercial Performance

Total average active customer population of ECG for the period under review was **4.08million** compared to 3.62million for the same period of 2020 representing an increase of about **12.5%** (452,839 customers).

The customer population for Residential customers contributed largely to the increase in the total customer population of ECG rising from a 2020 figure of 3.11million to 3.5million in 2021 representing an increase of 12.5% (388,297 customers)

Electricity prices remained the same as prices of the last quarter 2020. The average tariff to residential customers ranged between GH¢0.65/kWh and GH¢0.70/kWh; the average for non-residential customers ranged from Gh¢0.85/kWh to Gh¢1.34/kWh; and that of Special Load Tariff (industrial) customers ranged from Gh¢0.79/kWh to Gh¢1.05/kWh.

2.14.3 Operational Performance

The distribution network was stable and available for most of the periods except for intermittent load management periods occasioned by challenges on the NITS and isolation for project works at the Pokuase and Kasoa BSP's.

The Pokuase BSP (with 4No. 120/145MVA Power Transformers) has since been commissioned and is anchoring close to 200MVA of loads that have been transferred from Achimota, Adjiriganor (3BSP), Central Accra (4BSP) and Mallam Bulk Supply Points.

Below are the reliability indices realized for the months of January to May 2021 for ECG:

Table 2.13: Reliability indices for ECG (January to May 2021)

RELIABILITY INDICES JAN TO MAY 2021				
		Metro	Urban	Rural
JAN	SAIDI	1.87	2.83	4.55
	SAIFI	1.18	1.48	2.81
	CAIDI	1.58	1.91	1.62
FEB	SAIDI	2.13	4.43	4.79
	SAIFI	1.34	2.4	2.35
	CAIDI	1.59	1.85	2.04
MARCH	SAIDI	2.64	5.51	6.69
	SAIFI	1.82	2.94	3.07

	CAIDI	1.45	1.87	2.18
APRIL	**SAIDI**	2.33	4.92	5.26
	SAIFI	1.54	2.62	2.39
	CAIDI	1.51	1.88	2.2
MAY	**SAIDI**	2.01	3.69	4.02
	SAIFI	1.29	1.73	2.3
	CAIDI	1.56	2.13	1.75

2.14.4 Interventions for Network Improvement

- Completed Projects in ECG (SEDZ)

The following projects and works successfully commissioned within the Southern Electricity Distribution Zone (SEDZ) to help augment ECG's ability to deliver quality electricity services to its customers:

- ✓ Pokuase Bulk Supply Point (BSP) with four (4No.) 120/145MVA Power Transformers
- ✓ Construction of a 2x40MVA DCTLfrom GRIDCo Aflao BSP to ECG Denu Substation
- ✓ Construction of 33kV switching station at Peki
- ✓ Construction of 33kV Quadruple and Double Circuit Tower Lines from the Graphic road BSP to connect the Korle-Bu and Awudome Substations

- Ongoing Projects in ECG (SEDZ)

The following projects are at various stages of completion aimed at further improving supply delivery within the ECG Network in a bid to delight our customers.

- ✓ Kasoa Bulk Supply Point to relieve loads from Mallam and Cape Coast BSPs and to offer supply reliability within that enclave.
- ✓ Conversion of portion of the Mankesim 11kVfeeder from Jedu to Dominase to 33kV under Saltpond Primary Substation.
- ✓ Creation of 33kV Circuits from the Suhum Primary Substation to Apedwa-Kibi and Okonam-Asamankese

3 DEMAND OUTLOOK FOR SECOND HALF OF 2021

3.1 Introduction

As projected in the 2021 Electricity Supply Plan (ESP), the electricity demand in the first half of 2021 showed significant growth over demand for the same period in 2020. However due especially to the impact of the COVID-19 pandemic and challenges at VALCO etc., there has been some notable deviation to demand as projected. Thus, in this chapter, we present the updated demand projection for the second half of 2021, adjusted based on the noted deviation factors.

3.2 2021 Peak and Energy Demand update

Electricity consumption on the NITS in the first half of the year has been high. Accordingly, the projected coincident peak demand for Ghana has been reviewed upwards to 3,354.36 MW from the initial projection of 3,303.76 MW (2021 ESP). The new demand projection represents an increase of 264.36 MW (a growth of 7.9%) over the 2020 system peak of 3,090 MW. Similarly, the projected energy consumption has also been reviewed upwards to 21,601.26 GWh, from 21,265.52 GWh**.** The upward adjustment was occasioned by higher growth in demand driven largely by ECG and NEDCo demand growth. Analyses of actual demand for the distribution companies in the first half of 2021 show substantial growth in the residential (13.3 %), as well as the commercial and industrial (20.7 %) consumer categories.

The high growth rate in the residential demand could be attributed to covid-19 pathemic that is making a significant section of Ghanaian workforce to be working from home and relatively higher temperatures recorded in the period. On the other hand, the high growth in the commercial and industrial sectors points to economic recovery and gradual return to increasing economic activities.

3.3 Assumptions for Demand Forecast (review)

The following are the assumptions used for the review of the 2021 load forecast:

3.3.1 VALCO

Due to challenges encountered in the first half of the year, VALCO has revised its load plan for the rest of year 2021, reducing the projected demand of the plant from 150 MW to 92 MW. Energy consumption projections have also been reduced to 763.34 GWh from 1055.13 GWh (2021 ESP).

3.3.2 Mines

The projections made in the 2021 ESP largely remain valid. However, few adjustments were made to the projection for some mines as follows:

- ✓ **Golden Star Wasa (Akyempim):** projected demand for the plant has been reduced to 7.26 GWh from 69.91 GWh, the mine has contracted a captive (embedded) generation.
- ✓ **Earl International:** Consumption reviewed downwards to 17.67 GWh from 35.67 GWh.

3.3.3 Other Bulk Customers

- ✓ **Savanna Cement:** The consumption adjusted to 47.32 GWh from 30.06 GWh.

3.3.4 Exports

- ✓ Projected energy export to SONABEL has been reviewed downwards to 937.49 GWh from 1000 GWh. This is due to poor network challenges for which reason the scheduled export for the first half of 2021 could not be met.
- ✓ Export to CEB has been adjusted slightly upwards to 541.01GWh from 512.14 GWh.

3.4 Details of Revised 2021 Peak Demand Projections

Table 3.1 shows a detailed breakdown of 2021 Projected Peak Demand showing the individual Load Entity/Distribution Company.

Table 3.1 Summary of Revised 2021Projected Peak Demand

Demand	Customer		2020 – Projected Coincident Peak (MW)
Domestic Peak Demand	ECG		1,858.86
	NEDCo		243.3
	Enclave Power		57.04
	Mines		246.01
	Other Bulk Customers	Akosombo Textiles Aluworks Ghana Water Company Ltd Enclave Power Company Diamond Cement Volta Hotel Savana Cement (Buipe) VRATownships	50.14
	Losses +Network Usage		175.37
Total Domestic Peak Demand			2,630.72
Exports	CEB	180	
	CIE	0	
	SONABEL	150	
Total Exports			330
VALCO			100
Coincident Peak Demand MW			3,060.72

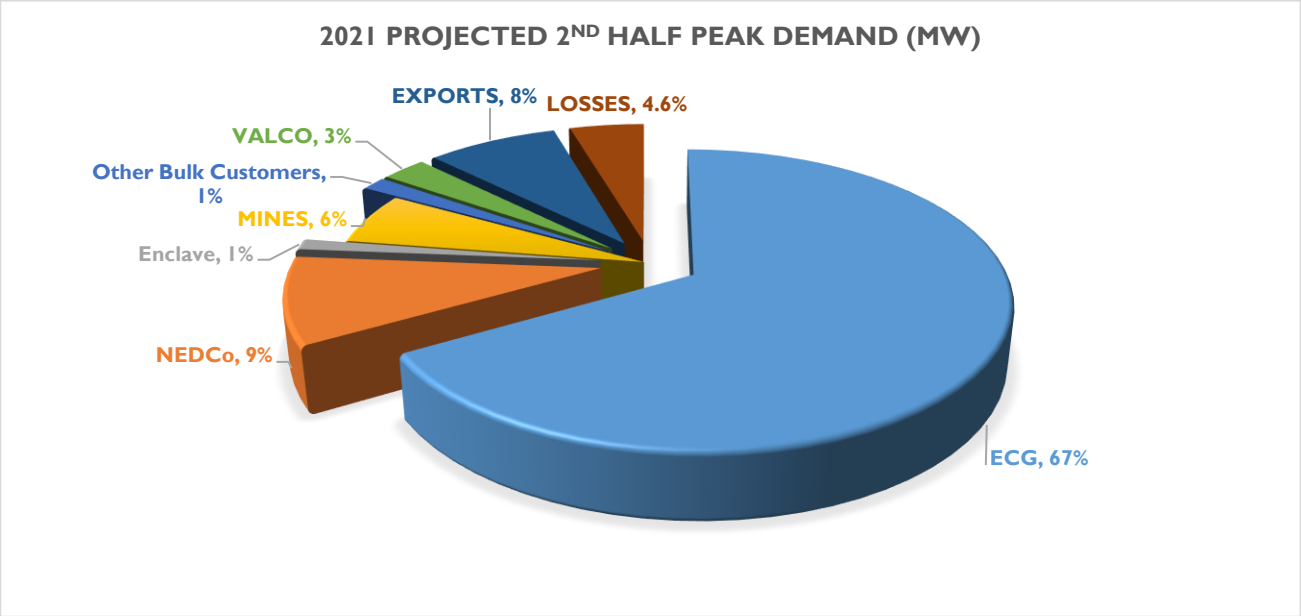

Figure 3.1: 2021 projected peak demand

3.5 Details of Energy Consumption Projections

The revised 2021 projected energy consumption is 21,601.25 GWh, which includes transmission network losses of 1084.49 GWh. The transmission losses estimated amounts to 5.02% of total projected energy supply. The projected 2021 energy consumption represents an increase of 1,884.66 GWh (growth of approximately 9.6%) over the 2020 consumption of 19,716.59 GWh.

The summary of 2021 consumption by customer class is presented in Table 3.2

Table 3.2: Summary of 2021 consumption by customer class

Energy	Customer	2021 – Projected Consumption (GWh)
Domestic Consumption	ECG	14,350.50
	NEDCo	1,813.52
	Enclave Power Company	284.25
	Mines	1,446.27
	Other Bulk Customers	275.15
	Losses + Network Usage	1,095.09
Total Domestic		19,264.78
Exports	CEB	541.01
	CIE	94.63
	SONijrABEL	937.49
VALCO		763.34
Total Energy (GWh)		21,601.25

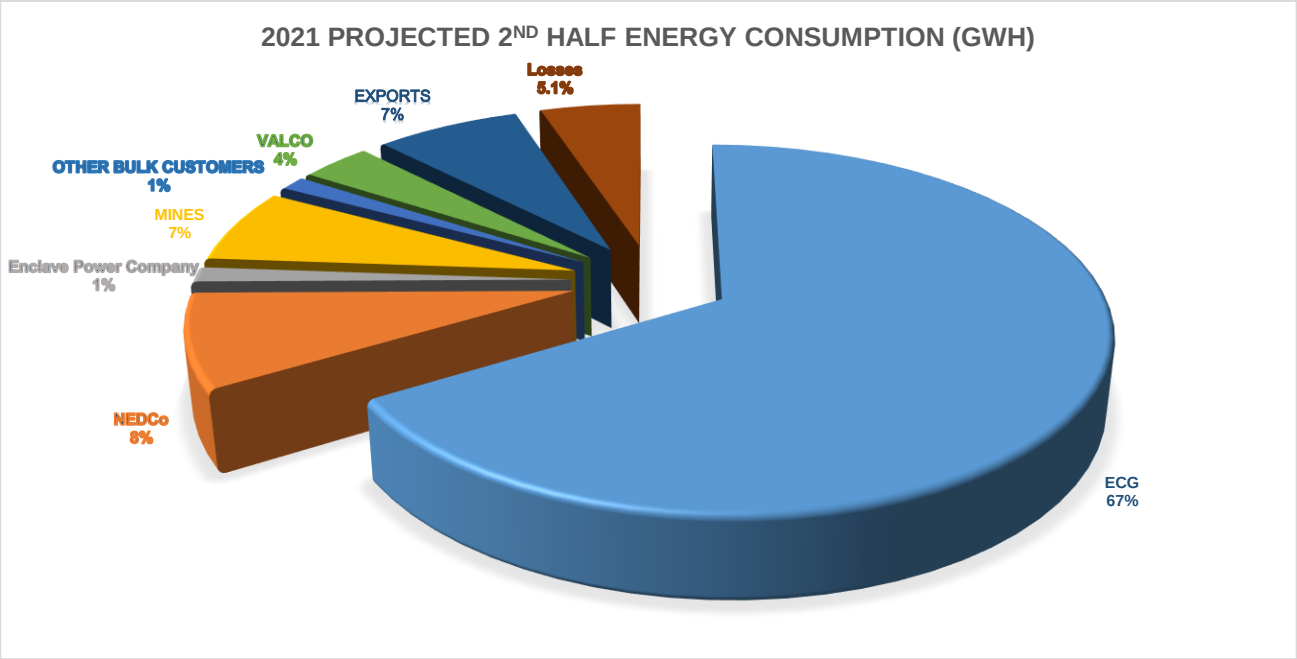

Figure 3.2: Project second half energy consumption

3.6 Projected Monthly Peak and Energy Demand for 2021

A summary of monthly energy consumption and the corresponding peak demand for the various customer classes is shown in Tables 3.3 and 3.4.

Table 3.3: Summary of Projected 2021 Monthly Energy (GWh) Consumption –Base Case Scenario

Energy Forecast (GWh)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total GWh
ECG	1205.37	1129.87	1220.09	1217.23	1245.08	1151.40	1121.52	1113.61	1113.18	1226.11	1276.15	1330.90	**14,350.50**
NEDCo	146.81	141.75	161.58	157.14	152.94	140.50	144.20	141.97	139.68	156.43	162.27	168.24	**1,813.52**
Enclave Power Company	19.33	19.19	22.14	19.28	19.33	19.22	27.91	28.73	28.00	27.96	27.51	25.65	**284.25**
MINES	125.82	108.90	119.43	115.25	119.05	109.92	122.28	126.48	123.25	125.93	123.57	126.39	**1,446.27**
Other Bulk Customers	24.03	22.04	24.81	24.79	25.54	25.79	21.35	21.61	21.17	21.56	20.74	21.72	**275.15**
VALCO	64.02	57.48	62.47	62.14	65.91	63.44	65.91	65.91	62.14	65.91	62.14	65.91	**763.34**
CEB (Togo/Benin)	59.68	50.62	51.04	63.97	38.30	37.31	37.86	27.84	26.95	38.93	44.21	64.30	**541.01**
SONABEL (Burkina)	82.90	75.31	75.90	59.25	75.68	77.76	75.68	82.00	83.00	86.00	84.00	80.00	**937.49**
CIE (Ivory Coast)	39.23	17.65	9.26	11.91	10.53	6.05	0.00	0.00	0.00	0.00	0.00	0.00	**94.63**
Network Usage	0.85	0.80	0.90	0.90	0.89	0.88	0.85	0.84	0.84	0.92	0.94	0.99	**10.60**
LOSSES	76.03	85.06	102.79	115.77	112.21	97.18	92.18	91.69	91.08	70.98	73.09	76.43	**1,084.49**
Total	**1,844.06**	**1,708.68**	**1,850.40**	**1,847.64**	**1,865.46**	**1,729.45**	**1,709.72**	**1,700.68**	**1,689.27**	**1,820.73**	**1,874.61**	**1,960.53**	**21,601.25**

Table 3.4: Summary of Projected 2021 Monthly Peak (MW) demand – Base Case Scenario

Coincident Peak Demand (MW)	Jul	Aug	Sep	Oct	Nov	Dec
ECG	1,886.24	1,872.94	1,934.63	2,062.16	2,217.86	2,238.40
NEDCo	274.44	270.20	274.70	297.73	319.14	320.21
Enclave Power Company	45.52	42.07	41.47	39.22	37.53	38.99
MINES	186.11	192.70	192.10	191.92	191.40	191.31
Other Bulk Customers	50.08	48.89	47.74	51.18	50.60	50.14
VALCO	92.00	92.00	92.00	92.00	92.00	92.00
CEB(Togo/Benin)	100.00	100.00	100.00	100.00	120.00	120.00
SONABEL(Burkina)	120.00	140.00	140.00	155.00	160.00	150.00
CIE(Ivory Coast)	0.00	0.00	0.00	0.00	0.00	0.00
Network Usage	1.63	1.63	1.67	1.76	1.88	1.89
LOSSES	169.87	170.14	174.08	141.16	150.83	151.42
System Peak(Coincident)	**2,925.89**	**2,930.58**	**2,998.38**	**3,132.14**	**3,341.24**	**3,354.36**

4 SUPPLY OUTLOOK FOR SECOND HALF OF 2021

4.1 Introduction

Existing of generating facilities in Ghana presently comprise Hydroelectric, Thermal and Renewable Energy sources. These existing generating plants as well as committed power generation plant projects that are expected to come on-line before the end of 2021 are considered in the supply outlook for the second half of 2021.

4.2 Summary of Generation Sources

Table 4.1 presents a summary of Existing generation sources and committed generation plant projects expected to be completed within the planning period which have been considered for the mid-year review. The total installed capacity generation is 5,238.05 MW with a dependable capacity of 4,747.65 MW is considered for 2021.

Table 4.1: Existing Generation Sources for 2021

Plants	Installed Capacity (MW)	Dependable Capacity (MW)	Fuel Type
Akosombo GS	1020	900	Hydro
Kpong GS	160	140	Hydro
TAPCO (T1)	330	300	LCO/Gas
TICO (T2)	340	320	LCO/Gas
TT1PP	110	100	LCO/Gas
TT2PP	80	70	Gas
KTPP	220	200	Gas/ Diesel
VRA Solar Plants	22	0	Solar
AMERI	250	230	Gas
Takoradi Thermal Expansion (T3)	132	120	Gas
Bui GS	404	360	Hydro
Tsatsadu Hydro	0.045	0.045	Mini Hydro
CENIT	110	100	Gas
SAPP 161	200	180	Gas
SAPP 330	360	340	LCO/Gas
KAR Power	470	450	Gas
AKSA	370	350	HFO
BXC Solar	20	0	Solar
Meinergy Solar	20	0	Solar
Trojan	44	39.6	Diesel/Gas
Genser	22	18	Gas
CEN Power	360	340	LCO/Gas
Twin City	194	190	LCO/Gas
TOTAL	**5,238.05**	**4,747.65**	

4.3 Key Assumptions Underpinning the Supply Outlook

In reviewing the 2021 Supply Outlook, the following key assumptions were made:

4.3.1 Hydro Power Generation for 2021

Projected total annual hydro generation for 2021 has been revised to 7,422.71 GWh. This is made up of 5,605.6 GWh from Akosombo GS, 894.2 GWh from Kpong GS and 752.3 GWh from Bui GS. The Micro Hydro plant at Tsatsadu is projected to operate at an average capacity of 40kW in the second half of the year.

a. Akosombo & Kpong Hydro

The Akosombo GS started a SCADA work at the station in the first half of the year. The project is expected to continue in the second half of the year. This planned work which will progress from unit to unit is expected to render one (1) unit at the plant unavailable for much of the rest of the year. At an average capacity of 150 MW per unit, the Akosombo GS is expected to have a maximum of 750 MW available.

The Kpong GS has had all four (4) units available for a greater part of the first half of the year. The total average capacity that is expected to be available at Kpong GS for the rest of the year is 140 MW.

The projected total annual generation from Akosombo and Kpong generating stations is 6,500 GWh.

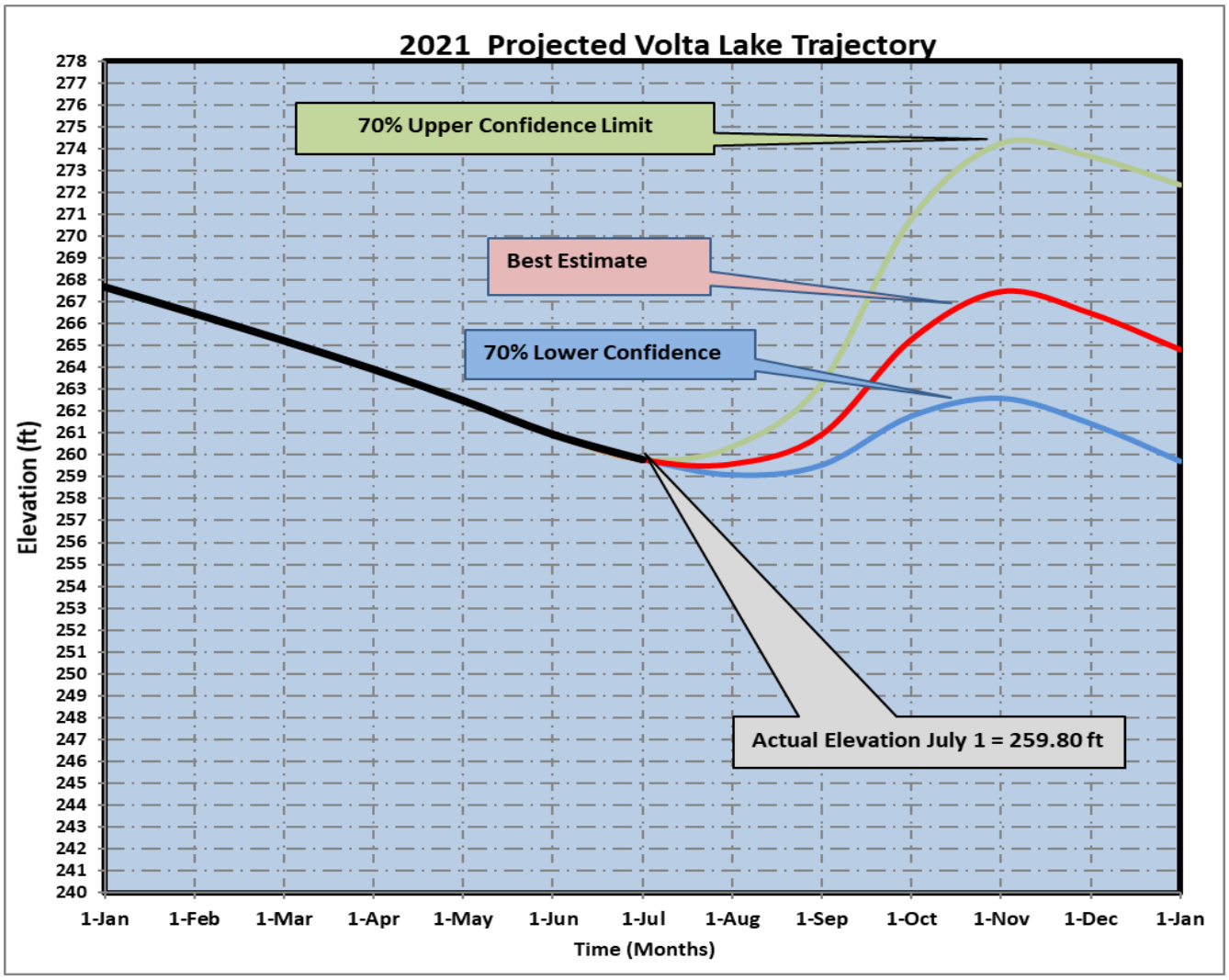

Figure 4.1: 2021 Actual vrs Projected Akosombo Reservoir Trajectory for Different Levels of Inflows

4.3.1.1 Bui Hydro

Bui Generating Station was scheduled to carry out planned Level 'A' Maintenance on 54G2 and 54G1 successively from August 2021 to December 2021 hoever, this has been suspended to enable increased generation from the plant in case of heavy inflows. Two units are expected to be ran continuously during the month of September and reduced to one (1) unit continuous and the other for peaking for the rest of the year. This mode of operation is projected to result in a second half year generation of 464 GWh (a cumulative annual total generation of 752.32 GWh).

Hydro Energy Supply Projections for the second half of 2021

Table 4.2: Monthly Projected Hydro energy for the 2nd half of 2021

Plant	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Akosombo GS	443.09	487.63	479.74	516.03	517.61	526.03	2,970.14
Kpong GS	82.32	66.95	65.87	70.85	71.07	72.22	429.27
Bui GS	28.50	21.39	155.52	100.44	77.76	80.35	463.96

4.3.2 New Renewable Generation Sources

New renewable generation projects expected to be commissioned into service is as follows:

- ✓ **VRA Kaleo and Lawra Solar Power Plants**: – VRA commenced construction of 17 MWp solar power plant in September 2019. It was initially planned that 4 MWp would be commissioned by June 2020, increasing to 12 MWp in October 2020 and then to 17 MWp in First Quarter of 2021. However, because of the COVID-19 pandemic, a total of 6 MWp will be commissioned by October 2020. The remaining 11 MWp will be commissioned during the first quarter of 2021.

- ✓ **Bui Solar Plant:** The initial 10 MWp, which is part of the first phase of 50MWp Solar Project, is scheduled to be commissioned in September 2020. The remaining 40 MWp is expected to be commissioned by end of December 2020, to complete the first phase of the Bui Solar development.

4.3.3 Thermal Power Generation for Second Half of 2021

The Projected Dependable Thermal Capacity from the existing generation resources in the 2021 ESP is 3,347.6 MW. The 203 MW Twin City Thermal Power Plant and 144 MW Early Power Plant were projected to have been commissioned in the first half of the year. This was not realized due to challenges; however, the projects are still undergoing commissioning. It is expected that the two plants will be fully commissioned before the end of the year.

The AMERI power plant was shut down in February 2021 to enable it to undergo a Technical Audit towards the transfer of ownership to Government of Ghana and subsequently relocation to Kumasi. The power plant is not expected to come into operation before the end of the year.

The projected total thermal energy generation for 2021 is consequently 14,466.51 GWh, made up of generation from VRA's portfolio of Thermal power plants and IPPs as shown in figure 4.3

4.3.4 Natural Gas Quantities and Availabilities

Natural gas is the primary source of fuel for thermal power generation in Ghana. Here we look at assumptions for gas supply.

a. Natural Gas Supply from Ghana Fields

About 125MMscfd of additional Natural Gas supply from the Tema LNG Project initially expected to become operational in April 2021 has encountered delays. It is however expected to become operational before the end of 2021.

Sankofa is expected to maintain its capacity to supply up to 210MMscfd (with an average supply of 180 MMscfd), whilst Jubilee and TEN together are expected to supply 125MMscfd. Expected import from Nigeria is 50MMscfd. The average daily quantity of gas expected for the rest of the year 2021 is therefore projected at **355 MMscfd** from July to September and 415MMscfd in November and December when LNG commissioning starts in Q4**.** Tema LNG is expected to add intermittent flows of between 60MMscfd and 180MMscfd.

Planned maintenance activities by the various facilities are still in discussion to ensure effective coordination among the various stakeholders and to minimize its impact on power supply. However, these have been coordinated to minimize their impact on the reliability of gas supply. The Sankofa gas production facility is expected to shut down for maintenance for five (5) days in October 2021. During this period, a combination of increased supply from Jubilee, and TEN, will make up for the Sankofa volumes.

The Jubilee production facility is scheduled for maintenance from 7th to 28th September 2021 (21 days). During this period, the TEN and Sankofa fields are expected to make up for the Jubilee flows. The TEN facility is not scheduled for any planned maintenance in 2021.

A planned shutdown of the Takoradi Distribution Station (TDS) and pipeline for maintenance works in mid-April 2021 has been rescheduled and synchronized with the Jubilee shutdown in September 2021. This is the most critical outage scheduled in 2021, because it could take out all domestic gas supply. However, GNGC is expected to sequence the maintenance of individual discrete units to ensure continued operation of the rest of the system and minimize disruption. During this period, increased imports from Nigeria are expected to make-up. Maintenance of the West African Gas Pipeline (WAGP) has been scheduled to coincide with the TDS maintenance schedule to limit the impact of gas supply disruptions in 2021. 2021 Maintenance activities on gas importing facilities in Nigeria are expected to be undertaken in the third (3rd) quarter and involve a two (2) day shutdown at Itoki Station and a five (5) day pigging operation on the Itoki to Lagos Beach stretch of the pipeline. This will lead to reduced flow of gas from Nigeria over the period of work.

Natural gas supply in the second half of 2021 from the various sources are shown in figure 4.2. These reflect expected shutdowns for maintenance in the second half of the year.

Figure 4.2 Forecasted Supply Gas Volumes (MMscfd) - 2021

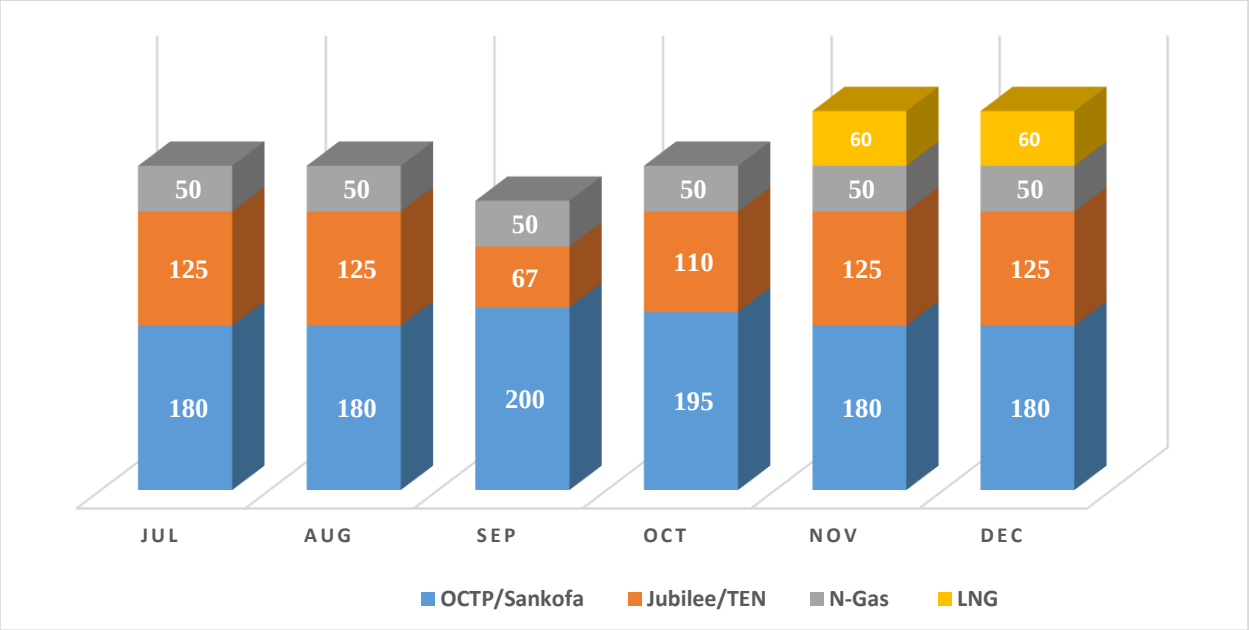

Figure 4.2: Forecasted Supply Gas Volumes

Assuming each 100 MW generation capacity (simple cycle) will use a total of 30 MMscfd of natural gas, then the 355 MMscfd can be used for approximately **1,184 MW** of simple cycle generation. If all units using the gas are combined cycle units then approximately **1,775 MW** of combined cycle generation could be realized from the 355 MMscfd of natural gas.

4.3.4.1 West to East Reverse Flow

4.3.5 Fuel Allocation/Use

Due to the quantities of natural gas supply for the rest of 2021 as projected above, fuel usage at the Tema and Takoradi Power Enclaves of the various power plants when they are operating at full capacity is as shown below. We note that depending on the output of the power plant and ambient conditions the fuel usage could be less.

Tema

- 100 MMscfd Sunon-Asogli power plants at full capacity.
- 30 MMscfd for TT1PP at full capacity
- 60 MMscfday for KTPP at full capacity
- Up to about 18 MMscfd to be used by TT2PP/TT2PP-X (on standby)
- 30 MMscfd for CENIT from reverse flow at full capacity
- 60 MMscfd to be used by Cenpower at full capacity
- AKSA to operate on HFO

Takoradi

- 60 MMscfd to be used by T1 at full capacity
- 60 MMscfd to be used T2 at full capacity
- 90 MMscfd to be used by Karpower at full capacity
- 35 MMscfd to be used by Twin City at full capacity

4.3.6 Fuel Price

The following assumptions on price of fuel delivered made:

- ✓ Natural Gas – US$ 6.08/MMbtu
- ✓ Delivered LCO – US$ 60/barrel
- ✓ Delivered HFO – US$ 321/MT.

4.4 Demand - Supply Analysis

4.4.1 Hydro Dispatch

For the second half of the year, it is expected that Akosombo and Kpong GS hydro power stations will be dispatched to meet EMOP allocated hydro generation of 6,500 GWh.

Also, the Bui hydro power plant is dispatched conservatively taking into consideration the low level of inflows during the just ended inflow season and actual generation of the first half of the year. Based on this the Bui hydro plant is projected to generate 505.15 GWh by the end of 2021.

Thus, a total of 7,004.91 GWh of energy generation is projected from the hydro power plants by the end of the year.

4.4.2 Must-Run Plants (Renewable Energy Plants)

The solar power plants must run plants and hence are largely dispatched based on expected energy from the plants. A total of about 146.94 GWh is expected from all the solar and other renewable sources.

4.4.3 Thermal Power Plants Dispatch

To meet projected demand, the thermal plants are dispatched after determining how much hydro and renewable generation is to be dispatched. The dispatch of the thermal power plants takes into consideration the fact that to achieve system stability there is the requirement to have at least 300 MW of generation capacity from the Western Corridor, 650 MW of generation capacity from the Eastern Corridor. Additionally, not all thermal power plants have secured fuel supply and hence that is also

taking into consideration. Taking all these constraints into consideration, merit order is then applied to meet projected demand.

4.4.4 Power Imports

No power import is anticipated till the end of the year. However, inadvertent energy exchanges on tie-lines could result from transient flows or emergency imports in case of short-term capacity shortages caused by faults or fuel supply contingencies.

Based on the above assumptions the 2021 demand/supply balance is shown in Table 4.3. The table shows annual energy and supply projections for 2021.

Table 4.3: Projected energy and Supply Balance in GWh

Category	2021 Projected Consumption (GWh)
Domestic	19,319.30
VALCO	763.3
Export (CEB+SONABEL+CIE)	1,571.93
Projected System Energy Requirement	**21,654.53**
Generation Sources	**2021 Projected Supply (GWh)**
Akosombo	5,605.80
Kpong GS	894.2
TAPCO	2,281.60
TICO	1,943.88
TT1PP	306.94
KTPP	246.17
TT2PP	86.31
VRA Solar (Navrongo)	2.87
VRA Solar (Kaleo/Lawra)	18.40
AMERI Power Plant	66.8
Imports From Cote d'Ivoire	26.32
Bui GS	752.32
Bui Solar Farm	62.24
SAPP	3,066.12
CENIT	334.46
Karpower Barge	2,692.63
AKSA	225.38
CEN Power	1,895.61
Twin City	1,068.33
Early Power	28.37
BxC Solar	24.71
Meinergy	24.71
Safisana	0.64
Total Supply (GWh)	**21,654.53**

Table 4.4:2021 Projected Annual Energy Generation and Consumption Balance in GWh

Customer Category	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL (GWh)
Domestic	1,530.3	1,524.9	1,517.2	1,629.9	1,684.3	1,750.3	**9,636.9**
VALCO	65.9	65.9	62.1	65.9	62.1	65.9	**387.9**
Export (CEB+SONABEL+CIE)	113.5	109.8	110.0	124.9	128.2	144.3	**730.8**
Projected Energy Consumption	**1,709.7**	**1,700.7**	**1,689.3**	**1,820.7**	**1,874.6**	**1,960.5**	**10,755.55**
Generation Sources							**Total Supply (GWh)**
Akosombo GS	443.1	487.6	479.7	516.0	517.6	526.0	**2,970.1**
Kpong GS	82.3	66.9	65.9	70.8	71.1	72.2	**429.3**
TAPCO	227.4	205.5	198.9	205.5	198.9	205.5	**1,241.8**
TICO	193.6	215.0	208.1	121.4	104.0	107.5	**949.6**
TT1PP	79.7	-		-		-	**79.7**
KTPP	-		-		-		**-**
TT2PP	9.8						**9.8**
AMERI Power Plant	-						**-**
VRA Solar (Navrongo)		0.3	0.2	0.3	0.2	0.3	**1.3**
VRA Solar (Kaleo/Lawra)		2.7	2.6	2.7	2.6	2.7	**13.4**
Imports From Cote d'Ivoire	6						**6.2**
Bui GS	28.5	21.4	155.5	100.4	77.8	80.4	**464.0**
Bui Solar Farm		5.8	5.6	5.8	5.6	5.8	**28.5**
SAPP	257.5	263.1	110.2	206.9	241.8	282.7	**1,362.3**
CENIT	11.7						**11.7**
Karpower Barge	216.5	160.7	84.0	253.2	275.4	284.6	**1,274.3**
AKSA	18.9	9.5	9.2	9.5	9.2	9.2	**65.4**
CEN Power	133.0	120.5	233.3	186.6	233.3	241.1	**1,147.8**
Twin City	-	133.9	129.6	133.9	129.6	133.9	**661.0**
Bridge Power	1.5	3.0	2.0	3.0	3.0	4.0	**16.5**
BxC Solar		2.3	2.2	2.3	2.2	2.3	**11.3**
Meinergy		2.3	2.2	2.3	2.2	2.3	**11.3**
Safisana		0.1	0.1	0.1	0.1	0.1	**0.3**
Total Supply (GWh)	**1,709.7**	**1,700.7**	**1,689.3**	**1,820.7**	**1,874.6**	**1,960.5**	**10,755.55**

Figure 4.3 shows a graphical presentation of the generation mix (hydro, Thermal, Renewable) that is projected to be used to serve demand in Ghana. The Chart indicates that, thermal generation will constitute 66.8% of projected total generation whilst generation from hydro and Solar PV will constitute 32.5% and 0.7% respectively. This indicates the diminishing dominance of hydro power generation in Ghana's overall generation mix.

The high penetration and increasing dominance of thermal generation in the overall generation mix could have serious implications for the sector for the following reasons;

- ✓ Since the tariffs are cedi-denominated and the utilities purchase fuel and other consumables in mostly United States Dollars (USD), any major depreciation of the Ghana Cedi against the major foreign currencies, particularly the USD, could cause financial challenges
- ✓ The thermal plants are predominantly gas-fired, consequently any disruption in gas supply could have dire consequences on the security of power supply.

Figure 4.3: Contribution of Supply by Generation Types

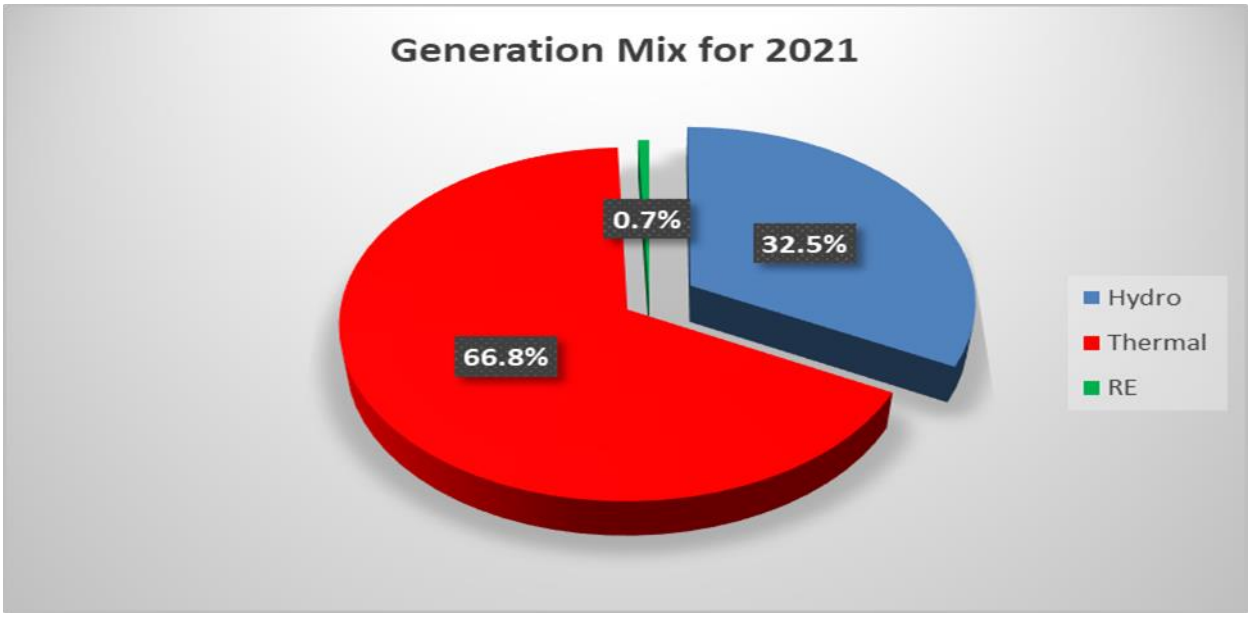

Figure 4.3: Contribution of Supply by Generation Types

4.5 Projected Capacity Situation

The projected monthly Supply Capacity levels, taking planned unit maintenance and Fuel Supply into consideration is shown in Table 4.5.

Table 4.5: Projected Monthly Capacity Situation for July - December 2021

Customer Category	2021 Projected System Peak (MW)	Jul	Aug	Sep	Oct	Nov	Dec
Domestic	2798.38	2,614	2,599	2,666	2,785	2,969	2,992
VALCO	130.00	92	92	92	92	92	92
Export (CEB+SONABEL)	290.00	220	240	240	255	280	270
Projected System Demand	**3354.36**	**2,926**	**2,931**	**2,998**	**3,132**	**3,341**	**3,354**
Generation Sources	**Dependable Gen. Capacity (MW)**						
Akosombo	900	750	750	750	750	750	750
Kpong GS	140	140	140	140	140	140	140
TAPCO	300	300	300	300	300	300	220
TICO	320	320	165	165	320	320	320
TT1PP	100	100	0	100	0	100	0
KTPP	200	0	100	0	100	0	100
TT2PP	80	22	22	22	22	22	22
AMERI Power Plant	230	0	0	0	0	0	0
T3	0	-	-	-	-	-	-
VRA Solar	9						
Imports From Cote d'Ivoire	0	-	-	-	-	-	-
Bui GS	345	110	110	110	220	220	220
Bui Mini Unit	4	4	4	4	4	4	4
SAPP 161	180	150	180	180	180	180	180
SAPP 330	350	350	350	350	350	350	350
CENIT	100	100	100	100	100	100	100
Karpower Barge	450	420	420	420	420	420	420
AKSA	330	330	330	330	330	330	330
CEN Power	325	325	325	325	325	325	325
Twin City	192	190	190	190	190	190	190
Bridge Power	144	0	0	0	0	0	0
Trojan	0	0	0	0	0	0	0
Genser	60	60	60	60	60	60	60
Safisana	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Meinergy	20						
Solar (Central Region)	20						
Total Available Generation (MW)	**4,799**	**3,671**	**3,546**	**3,546**	**3,811**	**3,811**	**3,731**
Surplus/deficit (MW)	**1,445**	**745**	**616**	**548**	**679**	**470**	**377**
Required Reserve (18%)	**604**	**527**	**528**	**540**	**564**	**601**	**604**
Actual Reserve Margin	43%	25%	21%	18%	22%	14%	11%

The analysis of the above monthly demand and supply situation for the rest of the year 2021 shows monthly positive generation reserve margins of up to 25%. However, in November and December, projected reserve margins are lower than the target of 18% mainly because of expected high demand in November and December. Nevertheless, the lowest observed generation reserve capacity is projected to be 377 MW. This is adequate to manage a contingency situation of loss of two large units of 180 MW (total of 360 MW).

4.6 Fuel Requirement

The main sources of fuel for thermal power generation are Natural Gas, Heavy Fuel Oil (HFO), Light Crude Oil (LCO) and Diesel Fuel Oil (DFO). The Bridge Power Plant when fully commissioned will use Liquified Petroleum Gas (LPG). The estimates of monthly quantity and cost of fuel requirement for July - December 2021 is indicated in Table 4.6.

The summary of fuel requirements for the rest of the year 2021 is as presented below:

- **Natural Gas:** Based on the assumed gas supply from Nigeria and Ghana, the total natural gas consumption for the period July – December 2021 is projected to be about 59.682 Tbtu.
- **LCO:** There would be no significant requirement for LCO for the rest of the year 2021. This is due to anticipated high volumes of gas from Sankofa, Jubilee and TEN fields as well as from Nigeria and the envisaged LNG project. LCO stock as at June 30, 2021 at VRA power station at Tema and Takoradi was 43,605.49 barrels and 368,405 barrels.
- **HFO:** The AKSA Plant is scheduled to operate on HFO from July to December. Therefore, an estimated 144,771 barrels would be required by AKSA.
- **Diesel.** Diesel is not projected to be used for the rest of the year 2021. The diesel stock as at June 30, 2021 was 4,337 barrels.

4.7 Monthly Fuel Requirement

The breakdown of Monthly fuel requirements and their associated costs are as shown in Table 4.6.

Table 4.6: Monthly fuel requirements and associated costs

	Units	Jul	Aug	Sep	Oct	Nov	Dec	Total
Estimated Thermal Fuel Requirement	**Units**							
TAPCO - GAS	mmbtu	1,675,918	1,675,918	1,627,626	1,675,918	1,627,626	1,176,899	**9,459,905**
TICO - GAS	mmbtu	1,736,491	989,165	963,502	1,519,526	1,686,721	1,736,491	**8,631,897**
TT1PP - GAS	mmbtu	731,484	-	732,420	-	732,420	-	**2,196,324**
KTPP - GAS	mmbtu	-	744,967	-	744,967	-	744,967	**2,234,902**
TT2PP - GAS	mmbtu	177,000	177,000	177,000	177,000	177,000	177,000	**1,062,000**
AMERI Power Plant - GAS	mmbtu	-	-	-	-	-	-	**-**
Karpower Barge - GAS	mmbtu	1,433,996	2,163,470	1,932,131	2,020,736	2,276,690	2,276,554	**12,103,577**
SAPP - GAS	mmbtu	1,814,459	1,814,459	1,755,928	1,814,459	1,755,928	2,086,563	**11,041,797**
CENIT - GAS	mmbtu	344,139	414,644	394,809	268,343	373,556	759,226	**2,554,716**
AMANDI - GAS	mmbtu	456,908	354,093	815,713	685,373	766,296	852,513	**3,930,895**
CENPOWER - GAS	mmbtu	1,013,248	1,013,248	1,008,767	1,013,248	1,145,043	1,079,040	**6,272,594**
Early Power - GAS	mmbtu	22,800	34,200	22,800	34,200	34,200	45,600	**193,800**
AKSA - HFO	barrels	20,869	20,869	20,196	20,869	20,196	93,705	**196,705**
Total Natural Gas Volume (MMBtu)		**9,406,444**	**9,381,163**	**9,430,696**	**9,953,771**	**10,575,480**	**10,934,853**	**59,682,407**
ESTIMATED FUEL COST								
Total Natural Gas Cost @ US$ 6.08/mmbtu	MMUS$	57.19	57.04	57.34	60.52	64.30	66.48	**362.87**
Total HFO Cost @ US$ 70/bbl	MMUS$	1.46	1.46	1.41	1.46	1.41	6.56	**13.77**
								-
Total Fuel Cost (US$ Million)	**MMUS$**	**58.65**	**58.50**	**58.75**	**61.98**	**65.71**	**73.04**	**376.6**

4.8 Estimates of Fuel Cost

The breakdown of the estimated cost of fuel for running all the Thermal Plants in for the period July to December 2021 is US$ 376.6 Million. This translates into an approximate monthly average of US$ 62.77 Million. The cost is made up of US$ 362.87 Million for Natural gas at an average cost of US$ 6.08/MMbtu and US$ 13.77 Million for HFO at US$ 70/barrel.

5 TRANSMISSION SYSTEM UPDATE

5.1 Introduction

The Section analysis and reviews the progress of the ongoing transmission projects as mentioned in the 2021 Electricity Supply Plan (ESP). It also gives the transmission outlook of the second half of the year. The following are the ongoing projects and their status:

5.1.1 330kV Anwomaso – Kintampo Line

Analysis shows that when the 330kV Anwomaso – Kintampo line is energized in the 2nd half of 2021, it will reduce transmission losses by 62 MW from 215.96 MW to 153.30 MW (4.74 % of 3,231.26 MW generation). It is expected to relieve power flow on the Anwomaso - Kumasi 161kV line. It will also boost power export to Burkina from the current 120 MW to 180 MW.

As of ending July 2021, all tower foundations had been completed and erected except six. Transmission line stringing is 118/183 km complete. Overall progress of works is 93% complete, whereas access clearing is in progress and 135.12 km has cumulatively been completed.

5.1.2 330/34.5 kV Pokuase(A4BSP) Substation

The 330/34.5 kV Pokuase (A4BSP) substation was completed and commissioned on May 17, 2021, permits for the commission process was approved and granted. Three (3) power transformers are presently in service at the substation and the fourth transformer, 86T3 is undergoing insulation test. The overall works completion is at 98%.

5.1.3 161 kV Volta - Achimota - Mallam Corridor Upgrade

The The 2021 Electricity Supply Plan Report envisaged significant transmission loss reduction by 12 MW upon the completion of the full complement of line upgrades within this corridor. For implementation purposes, this upgrade was packaged into two lots, namely the Volta-Achimota and Achimota-Mallam lots.

The works under the 161kV Volta-Achimota lot is ongoing at 73% completion. The Control Building expansion and the new 161kV 488MVA Volta - Accra East Transmission line bay works at the Accra-East substation have been substantially completed.

The conductors on the existing 161kV 213MVA Volta - Achimota lot were decommissioned to facilitate the commencement of stringing works, on outstanding sections of the new 488MVA 161kV Volta-Achimota and Volta-Accra East Transmission lines. The erection of gantries for these circuits at the 161kV Volta Substation are in progress.

5.1.4 330 kV Anwomaso – Kintampo line

So far the project is approximately 90 percent (90%) completed. As at the end of June, 460 out of 470 towers foundation had been completed. 453 towers had been erected and 37 km out of the total 184 km had been strung.

The challenge is compensation payments to project affected persons which is estimated to be about 25 million cedis. The project is planned to be completed within 12 months.

5.1.5 161/34.5 kV Kasoa Bulk Supply Point

This When completed, this Bulk Supply Point is expected to serve Kasoa and its surroundings. The expected completion period is the end of fourth quarter of 2021. It is being constructed with a transformation capacity of 3x145 MVA (i.e. 435 MVA).

As at June 2021 the status of works were as follows:

- Gantry erection works have been completed.
- Construction of the GIS basement substantially completed with painting works in progress.
- GRIDCo and ECG control building works at 52% and 78% completion, respectively.
- Grounding grid works in progress and at 65% completion.
- Installation of MV panels in the ECG Control building in progress at 90% completion.
- Installation of Protection panels in the GRIDCo control room at 30% completion.

- MV Feeder Structure construction works in progress at 60% completion.
- Laying of underground cables from MV switchyard to ECG end at 35% completion.
- Installation works on the Power Transformer at 95% completion.
- Installation of the 161kV GIS Substation equipment in progress at 75% completion.

Overall progress of works was at 67% completionproject involves the break-in of the 330 kV Aboadze – Volta line at Pokuase. The station will be equipped with 4 x 145 MVA, 330/34.5 kV transformers. All transformers have been delivered, however installation remains outstanding due to COVID–19 related restrictions. The project is approximately 61 percent completed. The project is expected to be fully completed in June 2021.

5.1.6 Relocation of Ameri Power Plant from Aboadze to Kumasi

In line with recommendations made in previous Electricity Supply Plans for the siting of generating plants in Kumasi, the Volta River Authority together with the Ministry of Energy are working to explore the possibility of relocating the Ameri Power Plant which is currently located at Aboadze to Kumasi. This is expected to improve overall power system stability and the reliability of supply to Kumasi and the northern parts of the grid as well as minimise transmission system losses.

It will also complement the Bui Plant in providing critically needed voltage control in the mid-sections of the NITS. As at June 2021, Grid Impact Studies were being conducted for the project.

Analyses conducted so far indicates that the relocation improves overall power system stability and performance. It shows savings in losses by 15 MW (which potentially translates into monetary savings of up to $4 million USD/annum). Additionally, the relocation of the 250 MW Ameri Power Plant to Kumasi will enable export of up to 200 MW of power from Ghana to Burkina.

5.2 Outlook for the rest of the year

Analyses were conducted on the Ghana power network and loading condition at the end of the year 2021 (assuming and all other transmission investments expected to be completed in the period which does not include Ameri at Kumasi.) The analysis assumed a total generation equivalent to the projected peak demand for the year, i.e. 3,316.1 MW with 147.0 MW (4.43%) losses. Generally, bus voltages recorded were within the acceptable limits. The simulation results

further indicated that, with only one Bui unit in service at peak time, up to 180 MW export to SONABEL is possible.

6 CONCLUSION

The following conclusions are drawn in respect of the mid-year review of the Electricity Supply Plan for 2021:

The power system performed fairly well according to projections per the 2021 ESP in the first half of the year, however thermal generation and losses was slightly higher than projected.

In light of the above, the Projected Coincident Peak Load for Ghana has been reviewed upwards to 3,354.36 MW from the initial projection of 3,303.76 MW (2020 ESP) due to notable deviation in demand as projected. The new demand projection represents a growth of 8.6%, an increase of 264.86 MW over the 2020 Ghana Peak Load of 3,089.5 MW. The total projected energy consumption has also been reviewed up to 21,601.26 GWh, from 21,265.52 GWh.

Taking into consideration the total hydro generation as at the end of June 2021, the total projected hydro generation for 2021 is 7,042.28 GWh. This is made up of 5,605.8 GWh, 894.2 GWh and 542.3 GWh expected from Akosombo, Kpong and Bui Generating Stations respectively. The micro hydro plant at Tsatsadu is projected to operate at an average of 40kW.

Dependable Thermal Capacity for the 2nd half-year is projected at 3,301 MW. The reviewed projected total thermal energy generation for 2021 is 14,466.51 GWh.

The total installed RE generation capacity in Ghana for 2021 is projected at 53.51 MWp with an expected total projected generation of 146.94 GWh.

Total of 59.682 Million MMbtu of natural gas is projected to be consumed for the 2nd half of the year.

The total estimated fuel cost is US$ 376.60 Million. This translates into an approximate monthly average of US$ 62.77 Million.

The NITS will be capable of evacuating all the power that is projected to be generated from all generating enclaves to the major load centres. Assuming all expected transmission investments are completed within the period, which does not include Ameri at Kumasi, congestions found within some corridors such as Volta-Achimota-Mallam161kV corridor, and low voltages

experienced in the Kumasi and the northern part of the grid will be alleviated. Further to this, with only one Bui unit in service at peak time, up to 180 MW export to SONABEL is possible.

In a bid to to deliver quality electricity services to its customers, ECG has successfully commissioned several works and projects within the Southern Electricity Distribution Zone (SEDZ).

Electricity distribution losses for the quarter was 36.5%, about 5.6% higher than the regulatory benchmark of 23.4%. Technical loss was about 10.5% whilst commercial loss was 25.0%.

7 RECOMMENDATIONS

Based on the above conclusions, the following recommendations are made:

a) The ongoing transmission expansion projects should be expedited and completed in 2021 to ensure that the peak demand can be supplied. These are:
   - ✓ Volta – Achimota – Mallam Transmission Line Upgrade Project.
   - ✓ Kumasi – kintampo 330 kV transmission line Project.
   - ✓ Kasoa Bulk Supply Point.

b) A well-coordinated maintenance programme should be pursued by both GRIDCo and the Generating Companies (GENCOs).

c) Fuel supply security and adequacy remains the single most important risk to power supply reliability in Ghana. In this vein, it is strongly recommended that all the relevant sector agencies stakeholders work conscientiously together to ensure that fuel supply is adequate and secure at all times.

d) In order to meet the transmission reliability indices, the following are the critical transmissions additions and upgrades are required:
   - ✓ Upgrade of 161kV Aboadze-Takoradi-Tarkwa-Prestea
   - ✓ Construction of a second 330 kV Prestea - Dunkwa – Kumasi line
   - ✓ Upgrade of 161kV Aboadze-Mallam transmission lines
   - ✓ 161 kV Mallam – A4BSP transmission line link
   - ✓ Construction of a second 330 kV Aboadze – A4 BSP circuit
   - ✓ Construction of a double circuit 330 kV line from A4BSP to Kumasi
   - ✓ Construction of a 330 kV substation at Dunkwa with a link to the existing 161 kV substation

8 APPENDICES

Appendix A – Glossary

Appendix B – Grid Map

APPENDIX A: GLOSSARY OF ELECTRICAL UTILITY TERMS

1000 Watt-hours = 1 Kilo Watt-hour (kWh)

1000 Kilo Watt-hour = 1 Mega Watt-hour (MWh)

1000 Mega Watt-hour = 1 Giga Watt-hour (GWh)

1000 Giga Watt-hour = 1 Tera Watt-hour (TWh)

Average Day Load

The average system demand is indicative of the system's load during most part of the day that is from 7: am – 5: pm apart from the peak load.

Capability

The maximum load a generator, piece of equipment, substation, or system can carry under specified (standardized) conditions for a given time interval without exceeding approved limits.

Capacitor

1) In a power system, installed to supply reactive power.

2) A device to store an electrical charge (usually made of two or more conductors separated by a non-conductor such as glass, paper, air, oil, or mica) that will not pass direct current and whose impedance for alternating current frequencies is inversely proportional to frequency. 3) In a power system, capacitors consist of metal-foil plates separated by paper or plastic insulation in oil or other suitable insulating fluid and sealed in metal tanks.

Capacitor bank

A grouping of capacitors used to maintain or increase voltages in power lines and to improve system efficiency by reducing inductive losses.

Capacity

The rated continuous load-carrying ability, expressed in megawatts (MW) or megavolt-amperes (MVA) of generation, transmission, or other electrical equipment.

Installed Capacity

The total of the capacities shown by the name plate ratings of similar kinds of apparatus, such as generators, transformers, or other equipment in a station or system.

Combined Cycle

An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. Such designs increase the efficiency of the electric generating unit.

Conductor

A substance or body that allows an electric current to pas continuously along it.

Contingency

In a power system, the possibility of a fault or equipment failure. First contingency disturbances (outages) involve only one system element, such as a transmission line fault or a transformer failure. A second contingency disturbance would have one system element out of service and subject the system to a fault and loss of a second element.

Demand

The rate at which electric energy is delivered to or by the System or part of the System and is the sum of both Active and Reactive Power, unless otherwise stated.

Demand, Peak:

The highest electric requirement occurring in a given period (e.g., an hour, a day, month, season, or year). For an electric system, it is equal to the sum of the metered net outputs of all generators within a system and the metered line flows into the system, less the metered line flows out of the system.

Dispatch

The operating control of an integrated electric system to: (1) assign specific generating units and other sources of supply to meet the relevant area Demand taken as load rises or falls; (2) control operations and maintenance of high voltage lines, substations and equipment, including administration of safety

procedures; (3) operate interconnections; (4) manage energy transactions with other interconnected Control Areas; and (5) curtail Demand.

Disturbance

An unplanned event that produces an abnormal system condition. Any occurrence that adversely affects normal power flow in a system.

Fault

An event occurring on an electric system such as a short circuit, a broken wire, or an intermittent connection.

Generation (Electricity)

The process of producing electric energy from other forms of energy; also, the amount of electric energy produced, expressed in watthours (Wh).

Giga (G)

A prefix indicating a billion (1,000,000,000); 109 in scientific notation. Hence Gigawatt (GW) and Gigawatt-hour (GWh).

Grid

The transmission network (or "highway") over which electricity moves from suppliers to customers.

Grid Operator

An entity that oversees the delivery of electricity over the grid to the customer, ensuring reliability and safety.

High voltage:

Descriptive of transmission lines and electrical equipment with voltage levels from 100 kV through 287 kV.

Independent Power Producer (IPP):

A private entity that operates a generation facility and sells power to electric utilities for resale to retail customers.

Insulator:

The porcelain support used to insulate electric service wires from the pole. All electric lines require an insulator to attach the wires to the pole or to a residence.

Interconnected System

A system consisting of two or more individual electric systems that normally operate in synchronism (matching frequency, voltage, phase angles, etc) and have connecting tie lines.

Kilowatt (kW)

One thousand watts of electricity (See Watt).

Kilo watthour (kWh):

One thousand watthours.

Load

The amount of power carried by a utility system or subsystem, or amount of power consumed by an electric device at a specified time. May also be referred to as demand. A connection point or defined set of connection points at which electrical power is delivered to a person or to another network or the amount of electrical power delivered at a defined instant at a connection point, or aggregated over a defined set of connection points.

Load Centers

A geographical area where large amounts of power are drawn by end-users.

Losses

Electric energy losses in the electric system which occur principally as energy transformation from kilowatt-hours (kWh) to waste heat in electrical conductors and apparatus.

Maximum Demand:

The highest amount of electrical power delivered, or forecast to be delivered, over a defined period (day, week, month, season or year) at a defined.

Megawatt (MW)

One million watts of electricity (See Watt).

masl

Metres above sea level

Overload

Operation of equipment in excess of its normal, full load rating or operation of a conductor in excess of ampacity, and if continued for a sufficient length of time, would cause damage or overheating.

System Planning

The process by which the performance of the electric system is evaluated and future changes and additions to the bulk electric systems are determined.

Power System

The electricity power system of the national grid including associated generation and transmission and distribution networks for the supply of electricity, operated as an integrated arrangement.

Reactive Power

Means the product of voltage and current and the sine of the phase angle between them measured in units of volt-amperes reactive and standard multiples thereof. Reactive power is a necessary component of alternating current electricity which is separate from active power and is predominantly consumed in the creation of magnetic fields in motors and transformers and produced by plant such as: (a) alternating current generators (b) capacitors, including the capacitive effect of parallel transmission wires;(c) synchronous condensers.

Reliability

The degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. It is a measure of the ability of a power system to provide uninterrupted service, even while that system is under stress. Reliability may be measured by the frequency, duration, and magnitude of adverse effects on the electric supply. Electric system reliability has two components -- adequacy and security.

Adequacy is the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

Security is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system facilities.

Single Contingency

The sudden, unexpected failure or outage of a system facility(s) or element(s) (generating unit, transmission line, transformer, etc.). Elements removed from service as part of the operation of a remedial action scheme are considered part of a single contingency.

Stability

The ability of an electric system to maintain a state of equilibrium during normal and abnormal system conditions or disturbances.

Supervisory Control and Data Acquisition (SCADA)

A computer system that allows an electric system operator to remotely monitor and control elements of an electric system.

Switching Station

An installation of equipment where several transmission lines are interconnected. Does not include equipment for transforming voltage levels.

Power System

An interconnected combination of generation, transmission, and distribution components comprising an electric utility, an electric utility and independent power producer(s) (IPP), or group of utilities and IPP(s).

Right of Way (ROW)

A corridor of land on which electric lines may be located. The Transmission Owner may own the land in fee, own an easement, or have certain franchise, prescription, or license rights to construct and maintain lines.

Thermal Limit

The maximum amount of electrical current that a transmission line or electrical facility can conduct over a specified time period before it sustains permanent damage by overheating or before it violates public safety requirements.

Transfer Capability

The amount of power, usually the maximum amount, that can be transmitted between one system and another; power flow and stability studies determine transfer capability under various outage, system loading, and system operating conditions.

Transformer

A device for transferring electrical energy from one circuit to another by magnetic induction, usually between circuits of different voltages. Consists of a magnetic core on which there are two or more windings. In power systems, most frequently used for changing voltage levels.

Transmission System (Electric)

An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.

APPENDIX B – GRID MAP