ENERGY COMMISSION, GHANA

2020 ENERGY (SUPPLY AND DEMAND) OUTLOOK FOR GHANA

April 2020

EXECUTIVE SUMMARY

The Energy Commission in fulfilment of its mandate under the Energy Commission Act (Act 541, 1997) presents supply and demand forecasts for electricity, crude oil, petroleum products and natural gas for the year 2020.

Electricity

1. As at the end of 2019, the **installed electricity generation capacity** available for grid power supply at the transmission level in the country was about **4,990 Megawatt (MW)**. The installed capacity increases to **5,171.6 MW** if primary embedded generation, including the two major solar power plants at the sub-transmission (distribution grid) level are added[1]. This was about 4.2% expansion over the installed capacity in 2018.

2. Total grid electricity generation in the country including the embedded generation[2] was **18,187.9 Gigawatt-hours (GWh),** comprising 39.9% hydro, 59.8% thermal and about 0.3% solar power. It was about 12.2% more than in 2018.

3. Including imports, the grid electricity at the **transmission[3] level**, was around 17,886.8 GWh comprising about 7,251.6 GWh (40.5%) from hydro generation, 10,507.8 GWh (58.7%) from thermal generation and about 127.4 GWh (0.7%) of import. It was about 12.1% increase over gross transmission in 2018.

4. **Peak load** on the transmission grid excluding export[4], i.e. the maximum capacity utilised within the country was **2,612.6 MW**; roughly 10.2% more than in 2018. The system (maximum including exports) peak i.e. the maximum capacity utilised on the transmission grid was **2,803.7 MW**, which was about 11.0% more than in 2018.

5. The total dependable grid capacity 4,580.0 MW in 2019 was thus in excess of the Peak load by 1,776.3 MW.

6. In 2019, the average electricity end-user tariff was Ghp71.6 per unit of electricity (kilowatt-hour), an increase from Ghp70.5 per kilowatt-hour in 2018.

[1] i.e. Trojan (44 MW), Genser (95 MW), BXC Solar (20 MW), Meinenergy (20 MW) and VRA Solar (2.5 MW).
[2] i.e. Trojan, Genser thermal plants and the grid-tied solar plants
[3] i.e. does not include embedded generation and solar since they are at the distribution grid level.
[4] Referred to as Domestic Peak Load by some of the utilities

7. Average end-user tariff since the previous load shedding in 2007 to the beginning of the most recent load shedding in 2012 averaged up to Ghp17.0 per kilowatt-hour (kWh) whilst the average end-user tariff from 2013 to 2019 was Ghp57.3 per kWh.

8. The relatively high end-user tariff is likely to have contributed to the significant surge in the installation of alternative or captive or self-electricity back-up generation largely by the non-residential and industrial customers of the utilities. The said customers apparently found the self back-up generation more cost-competitive compared to the grid as their cumulative electricity consumption units exceeded 300 units per month during the year and thus making it more attractive for the switch at that consumption level. If this trend continues, it could worsen the income and profitability of the existing electricity utility companies.

9. With the Government's projected real **GDP growth of 6.8%**[5] and particularly **6.7%** (***non-oil growth)***, the total electricity required for the expansion of the country's economy in **2020** is expected to be as follows:

- ✓ **19,594.4 GWh** (*with VALCO constrained to operate at most two potlines*). Expected peak capacity demand required would lie within **3,115.2 MW**. *Average End-User tariff to make it realized should be within US cents 13-15 per kWh.*

This projection is achievable provided the following are accomplished:

i. There is adequate financial resource to procure all the fuel needed to run the thermal power plants even at higher utilisation factors; and

ii. Average end-user-tariff is reduced to within **13-15 US** cents per kWh.

[5] The World Bank and the IMF projects 5.6-6.8% for Ghana for 2020.

Fuel for Power Generation

10. In 2019, total gas flow to the thermal power plants rose to about 65 million mmBTU (61,092 mmscf), almost 17.5% more than the supply of 2018; with about 36.6% coming from Nigeria (46% in 2018) via the WAGP and the remaining 63.4% (54% in 2018) coming from domestic gas, i.e. the Atuabo gas processing plant and Sankafo field. The average daily flows were about 61.3 mmscfd from WAGP and about 102.3 mmscfd from domestic gas.

11. For **2020**, total gas available for power generation would be almost **107.6 million mmBTU** largely coming from the local fields. VRA power plants are expected to receive about 44.4 million mmBTU (about an average of 140 mmscfd) whilst the IPPs receive the balance of 63.1 million mmBTU (about an average of 160 mmscfd). The expected WAGP gas flow would remain around **70 mmscfd** throughout the year, whilst an average of **300 mmscfd** could come from domestic gas during the year.

12. 1n 2019, the average delivery price of the WAGP gas was $7.01/mmBTU and that of the indigenous gas was a uniform $6.08/mmBTU throughout the year.

13. For **2020**, delivery price of WAGP and domestic gas would be a weighted average price of $7.29/mmBTU ($7.56/mscf).

14. In 2019, the total cost of gas for power generation was almost **$455.8 million**.

15. For **2020**, the total cost of gas for power generation is estimated to cost almost **$673.4 million.**

16. In 2019, light crude oil (LCO) consumed by the thermal power plants for grid power production was about 913,648.1 barrels.

17. For **2020**, no significant requirement for LCO should be anticipated, if high volumes of gas from Sankofa, Jubilee and TEN fields are realised and made available timely. Thus, only Cenpower is expected to operate on LCO. The estimated LCO for this power plant is 495,733 barrels.

18. In 2019, the average delivery price[6] of LCO for power generation was $64.2 per barrel.

[6] i.e. including transportation and treatment.

19. **For 2020**, it is expected that the average delivery price of the light crude would increase to about **$85** per barrel. The total cost of LCO required would thus be about **$42.14 million**.

20. In 2019, total diesel consumed by the thermal power plants for grid power production as well as for starting and switching off the plants was about 79,606.5 barrels.

21. For **2020**, it is estimated that the diesel required largely for the same exercise would remain the same and usage limited largely for starting and switching off the plants due to expected improvement in supply of gas and LCO which are cheaper alternative for power generation.

22. In 2019, HFO was largely used as fuel by the Karpower Barge and the AKSA power plant for electricity production. HFO consumed was about 2.5 million barrels and at an average delivery price of $65.4 per barrel.

23. For **2020**, only AKSA power plant is expected to operate on HFO due to the relocation of the Karpower Barge to Takoradi to operate on gas. Thus, the estimated HFO required would be about 212,858 barrels (30,408.3 **tonnes**) at the average delivery price of **$119** per barrel, bringing the total cost of supply to around **$25.3 million**.

24. In all, about **$740.8 million** would thus be needed to procure **fuel** for grid or public electricity generation.

Crude oil and petroleum products

25. Ghana's oil production in 2019 was about 72.1 million barrels coming from the three main commercial fields, Jubilee (45%), TEN (31%) and Sankofa-Gye Nyame (24%) compared to about 62.1 million barrels in 2018, representing an increase of about 15.0% over the previous year. Average daily production for the year was about 196,000 barrels as against 186,000 barrels in 2018, but still below the targeted average daily production of about 250,000 barrels.

26. In 2019, crude oil production from the Jubilee field again increased to about 32.6 million barrels from 28.5 million barrels in 2018. Corresponding average daily production, however, dropped from an average of 87,844 barrels in 2018 to 87,439 barrels in 2019.

27. For **2020**, average crude production from Jubilee is likely to increase to within **90,000-95,000** barrels per day.

28. In 2019, total oil production from the TEN field dropped from 23.6 million barrels in 2018 to 22.3 million barrels. The corresponding average daily production equally dropped from about 64,000 barrels in 2018 to about 61,100 barrels.

29. For **2020**, average daily crude production from the TEN field is expected to increase to the range of 65,000-**90,000** barrels per day.

30. In 2019, crude oil production from the Sankofa-Gye Nyame field[7] was about 17.2 million barrels, about 70% increase from 10 million barrels in 2018. Corresponding average daily production equally rose to 46,950 barrels from 27,500 barrels in 2018.

31. For **2020**, the Sankofa field average daily crude production is expected to fall within the range of 48,000-**50,000** barrels per day.

32. In 2019, the average price of Brent crude on the global market increased to $64.19 per barrel from about $71.5 per barrel in 2018, about 10.2% drop from the previous year.

33. For **2020**, the average price at which Ghana would source Brent crude is expected to decrease from an average $58 per barrel to **$30-32** per barrel due to the outbreak of coronavirus (Covid-19). The average price for other light crudes for refinery operations would also fall within **$58-60** per barrel. Average delivery price for light crude oil for power generation would decrease from **$85** per barrel to **$43** per barrel.

34. In 2019, crude oil from the Jubilee field was sold at $63.8 per barrel ($70.6 per barrel in 2018). Those of the TEN and the Sankofa-Gye Nyame fields in 2018 were sold at an average price of $61.6 and $65.3 per barrel compared with $71.6 and $72 per barrel in 2018 respectively.

35. For **2020**, average oil price from the **Jubilee field** is likely to drop to within **$57-60** per barrel whilst those of TEN and Sankofa fields would also range from **$52-57 and $60-$65** per barrel respectively.

36. In 2019, total petroleum products pumped into the economy increased to 4.1 million tonnes from 3.9 million tonnes in 2018

37. For **2020**, total petroleum products required would continue to increase, ranging from

[7] Also called OCTP (Offshore Cape Three Point) field

3.7-3.8 million tonnes, equivalent to **68,000-74,000** barrels per stream day refinery capacity. It would still largely comprise gasoline about 34-35% and diesel of about 46-47% (*excluding products directly destined for the grid power generating plants*).

38. In 2019, LPG supplied dropped to almost 340,000 tonnes from around 397,000 tonnes, about 14.4 percent lower than in 2018. About 80.9% was imported and the rest from local production. About 20% of the local supply came from the Atuabo Gas Processing Plant, which is producing LPG as by-product from processing the wet associated gas from the local fields into dry gas largely for electricity generation.

39. In 2019, about 770 tonnes (0.2% of supply) of LPG was exported, a drop from about 4,800 tonnes exported in 2018; 3% of total supply that year.

40. For **2020**, the Government's 6.8% GDP growth *(6.7% non-oil*) for the year would require 294,000-**313,000 tonnes** of LPG of which about 25% is likely to come from the Atuabo gas processing plant. Imports could still dominate since TOR is not likely to operate at full capacity largely due to financial challenges. There is still the growing demand for LPG as cooking fuel in homes and particularly as transport fuel.

Natural Gas

41. Total indigenous wet gas produced in 2019 was about 140,853.67 mmscf coming from the three main commercial fields, Jubilee (36.4%), TEN (34.4%) and Sankofa Gye-Nyame (29.2%) compared to about 91,459 mmscf in 2018, representing an increase of about 54% over the previous year.

42. In 2019, wet gas exported from the Jubilee Field, TEN and Sankofa Gye-Nyame to Atuabo gas processing plant (Ghana Gas) was 20,689.05, 694 and 32,670 mmscf respectively. Thus, total raw gas receipt at Atuabo gas processing plant was 54,053.83 mmscf.

43. In 2019, about 56,118,413 mmBTU, representing 95% of the resulting processed (also called dry or lean) gas was shipped for power production whilst the remaining 5% was exported for non-power activities (fuel for industrial processing).

44. Total gas flow to consuming facilities in Ghana in 2019 was 75,798.75 mmscf. About 28.7% was from Nigeria via the WAGP and the remaining 71.3% coming from indigenous

sources. About 42% of the gas was supplied to the thermal plants in the Tema power enclave, 54% went to the Takoradi power enclave and the remaining 4% went for non-power activities.

45. In 2019, average daily production of raw gas decreased from 137 mmscfd in 2018 to about 65 mmscfd. The Sankofa take-or-pay obligations have ensured that gas from the Sankofa Field is the first to be dispatched. This makes gas supply from the Jubilee Field interruptible.

46. In 2019, daily production of the raw gas from TEN fields decreased from about 93.7 mmscfd in 2018 to about 21 mmscfd in 2019. Just like Jubilee Field, the Sankofa take-or-pay obligations have ensured that gas from the Sankofa Field is the first to be dispatched, which makes gas supply from the TEN Field interruptible.

47. Daily production of raw gas from Sankofa field in 2019 increased from about 40 mmscfd in 2018 to over 88 mmscfd in 2019. Raw gas produced is processed at this field and exported through the Onshore Receiving Facility (ORF) to the Ghana National Gas Company (GNGC) pipeline to comingle with the other indigenous sources for power generation in Aboadze by VRA generation plants.

48. For 2020, the expected volumes of gas from OCTP and Jubilee fields are 180-200 mmscf/day and 100-120 mmscf/day respectively.

49. Given the availability of domestic gas, in 2020 priority will be given to usage of gas from the Ghana fields. Thus, we anticipate a daily average flow rate of about 73 mmscf/day, 24 mmscf/day and 180-200 mmscf/day from the Jubilee, TEN and Sankofa Fields respectively.

50. On the average, gas still remains the most sustainable and relatively cost-competitive fuel supply to produce affordable power in the country. The key challenges hampering reliability of gas supply are inadequate supply, particularly from Nigeria through the WAGP and finance (domestic and international payment deficits).

Progress of Planned LNG projects

51. Two major liquefied Natural Gas (LNG) projects are currently underway: the Tema LNG Terminal Company and a small-scale virtual LNG pipeline project.

52. The **Tema LNG Terminal Company** project which is currently under construction is a

Floating Storage and Floating Regasification Unit with expected capacity of **250 mmscfd**, which is expected to be completed in 2020**.** The Tema LNG Project is expected to commence supply by the fourth quarter of 2020. Expected volumes from Tema LNG in 2020 is 75 mmscfd.

53. The **small-scale virtual LNG pipeline** is a virtual pipeline project to supply gas to Sunon-Asogli and Trojan power plants. Initial contract quantity is said to be 60 mmscfd. This project is currently on hold if not cancelled facing challenges with the supply of the LNG for the project. The source of LNG for the small-scale project is the **LNG2Africa initiative;** an Equatorial Guinea initiative to sell small-scale LNG for utilisation in Africa. Initial target countries are Togo, Burkina Faso and Ghana.

Recommended Actions

Ameliorating the overall power supply shortage

54. For 2020, Akosombo Generating Station **would be required to operate four generating units during the off-peak period and up to five units during the peak period**. This mode of operation is expected to result in operating capacity of up to 750 MW, which would ensure that the reservoir level is kept above the minimum operating level of 240ft (73.15m). This mode of operation would result in a projected minimum elevation of 255ft (77.7m) at the end of the dry season in 2020. It should be noted however that some thermal power plants will be rendered inoperable sometime in 2020, due to the WAGP Intelligent Pigging exercise that will curtail gas supply to Tema. As a result, all six units at Akosombo GS will be put in operation to ensure security of supply.

55. Kpong hydroelectric station, which is currently undergoing retrofit, **would continue to run three out of the four total installed turbine units.** Consequently, the total average plant output at the Kpong Station would remain at 105 MW. However, the retrofit is expected to be completed by April 2020 and all four units are expected to be available, increasing the dependable capacity of Kpong GS to 140 MW

56. 1n 2020, Bui hydropower plant is expected to operate an average of two turbine units throughout the year. This mode of operation would lead to a projected annual production of 764 GWh and is expected to ensure that its reservoir level would be about 5 metres

above its target minimum level of 170 metres-high compared to its 168m-minimum operating level. It is **estimated that for continuous and sustainable operation of the Bui Power Station for 2020** and for the subsequent years (in the likely event of low inflows), **the reservoir level at the end of the dry season of 2020 should not drop below its 170 m elevation**.

57. **For 2020,** as a result of the operations of the three hydropower plants, the expected total annual electricity generation from hydropower would not exceed 6,229 **GWh.**

58. **Failure to adhere to the plan for hydropower production could significantly compromise reservoir integrity for subsequent years.**

59. Crucial requirements for reliable power supply are the availability of the required plant capacities, quantities of fuel and funds to purchase the required fuel in a timely manner.

60. Inadequacy fuel when it is required and gas pricing remain the major risks to reliable electricity supply in Ghana. The present installed capacity is capable of generating over 25,000 GWh, which is enough to meet the country's electricity requirement including suppressed demand, should there be adequate and cost-competitive fuel. The key challenge however is competitive grid electricity tariff.

61. The fuel supply challenge also has to do with financing besides technical constraints. It is therefore necessary to arrange to secure the needed funds to purchase the needed quantities of fuel on time.

62. Furthermore, **there is also the need to pay off any indebtedness to fuel suppliers** so that the required volumes would be obtained for thermal generation timely.

Energy Sector Recovery Programme

63. Energy Sector arrears and debt situation was about $2.7 billion as at January 2018, and it was forecast that additional $1.3 billion will be added to this deficit in 2019. The sector arrears will grow to more than $12.5 billion by the end of 2023 if urgent actions are not taken. Most of the debt have been due to short term loan contracted by the power producers culminating in the 'take or pay' and the distribution utilities' inability to collect adequate revenue to cover their operations. Also, persistent untimely and insufficient payments for

gas delivered also contributes to the huge debt burdens of the gas off-takers, most of them public entities. The Power subsector debt alone is increasing by about $300 million every quarter.

64. In order to address the chronic debt challenges and to facilitate equitable distribution of all cash collected in the power sector value chain using the end user tariff as a basis, the Cash Waterfall Mechanism (CWM) concept was instituted in 2016. It is expected to be operational in 2020 and implemented through the development of a formula, for adequate distribution of revenue to all stakeholders in the power sector value chain.

65. Further, the Energy Sector Recovery Program (ESRP) outlined more actions that Government must take to improve the financial health of the energy sector. The ESRP is a roadmap of immediate, near-term, and medium-term actions needed to achieve Government's aim to bring the sector into balance by the end of 2023, and a commitment by Government to fund the Annual Sector Shortfall (with Sector Stabilization Payments) from 2020 onwards until the sector is in balance to prevent further accumulation of arrears.

66. The identified actions are classified into three phases: Phase I, II and III. Phase I actions are to be taken immediately while Phase II actions will be initiated within twelve months. Together Phase I and Phase II actions are expected to reduce the annual sector shortfall and prevent future imbalances, thereby minimizing needed increases in electricity tariffs and/or Sector Stabilization Payments by Government. Finally, Phase III actions will be required within two years to reduce further the shortfall until no Sector Stabilization Payments are required by 2023.

Achieving 50% nationwide penetration of LPG

67. National LPG penetration rate increased from 6% in 2000 to 18% in 2010 and is currently around 25%.

68. The sector ministry is targeting 50% LPG penetration by 2030 but it is not likely to be achieved if limited distribution outlets nationwide remain the same and the its price continue to remain high.

69. The LPG consumption growth could surpass charcoal consumption again by implementing deliberate government policy not only to make the LPG produced available for local

consumption as against export but **producing LPG adequately to cover both local consumption and for export** taking advantage of the market opportunities within the West Africa sub-region.

70. In addition, constructing LPG storage and supply infrastructure in all regional and district capitals in the long term.

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

72. There would also be the need to re-capitalised Ghana Cylinder Manufacturing Company (GCMC) to expand production capacity with the production of cylinders focused on small sized cylinders that would be portable and affordable to households in rural communities. Such can be achieved through private sector participation through Public-Private Partnership (PPP).

Expanding Crude Oil Strategic Reserve

73. Fuel supply security and erratic fuel prices have compelled countries to set up strategic stocks both for crude oil and refined products. Crude oil storage however, has the comparative advantage of far longer lifespan and could even be indefinite depending upon the blend and state. Many developed countries have such storage mix and for OECD countries, minimum of six month storage is mandatory.

74. The Commission would continue **to recommend for the inclusion of crude oil** in the country's strategic reserve.

Expanding crude refining operations

75. Equivalent of 78,000-82,000 barrels per stream day refinery capacity would be required to enable the country meet its projected economic growth for 2020.

76. However, low capacity utilisation of TOR which has not made the facility profitable to operate in the past should not be lost in sight in future operations though still dependent on the production configuration. Profit could start emerging as the capacity utilisation increases, in most cases 90% and above.

PREFACE

ENERGY COMMISSION has the mandate to prepare, review and update periodically indicative national plans to ensure that reasonable demands for energy are met in a sustainable manner. In addition, the Energy Commission is mandated to secure and maintain a comprehensive data base for national decision making for the efficient development and utilisation of energy resources available to the nation. Energy Commission's jurisdiction include promoting and ensuring uniform rules of practice for the production, transmission, wholesale supply, distribution and sale of electricity and natural gas.

In fulfilment of its mandates, the Commission has been preparing annual energy demand and supply outlook to provide guidelines to the energy sector operators and potential investors as well as the wider business community wishing to operate in the country. The purpose of the 2020 Annual Energy Outlook therefore is to give government, industry and business, indications of the levels/quantities of electricity, liquid and gaseous fuels that would be required to be provided by the energy producers for this year.

This document covers demand and supply of electricity, crude oil, petroleum products and natural gas. In the document, 'Demand' is used when referring to gross fuel or energy required by a demand sector, e.g. Residential, Commercial, or Industry. 'Supply Requirement' is Supply or Generation/Production plus transmission/transport losses.

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

Your comments are most welcome.

Ing. Oscar Amonoo Neizer

Executive Secretary

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ACRONYMS

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

1.0 Power Subsector

1.1 Overview of Grid Power Supply in 2019

Installed generation capacity available for grid power supply at the transmission level as at the end of 2019 was about **4,990 Megawatt** (MW) with a dependable capacity of 4,580 MW.

It totaled **5,171.6 MW** if primary embedded generation including the listed solar plants[8] at the sub-transmission level are included. This was about 4.2% expansion over last year's compared to 13% increment from 2017 to 2018. The **dependable capacity in this case is 4,738.6 MW which is about** 4.4% more than in 2018 (*see Table 1*).

The 20 MW BXC Solar, 20 MW Meinergy Solar[9] and 2.5 MW VRA Solar are grid-tied plants connected at the distribution level, just as the Trojan and the Genser power plants.

The **gross grid generation** in the country including the embedded generation[10] in 2019 was **18,187.9 Gigawatt-hours** (GWh), about 12.2% more than in 2018, comprising 39.9% hydro, 59.8% thermal and about 0.3% solar power. It increased to **18,315.1 GWh** if imports was added.

Without the primary embedded generation, the country's gross generation in 2019 was **17,759.4 GWh**, about 12.3% more than in 2018, comprising 40.8% hydro, 59.2% thermal power.

Grid electricity made available for **gross transmission[11]**, during the year however was around **17,886.8 GWh** consisting of about 7,251.6 GWh (40.5%) from hydro generation, 10,507.8 GWh (58.8%) from thermal generation and about 127.4 GWh (0.7%) of import. It was almost 12.1% improvement over 2018. Supply in 2018 was about 11.5% more than in 2017.

Power exports to Togo/Benin (CEB) and Burkina Faso (SONABEL) reached a maximum of 120 MW and 60 MW respectively in 2019.

A total of about **777.5 GWh** of electricity was exported to Togo and Benin whilst about **576.5 GWh** was also exported to Burkina Faso. A net of about **203.6 GWh** was exchanged between Ghana and Cote d'Ivoire. This was made up of about 127.4 GWh imports and about 76.2 GWh

[8] This does not include embedded or captive back-up generation.
[9] The 20 MW Meinenergy was commissioned in 2018.
[10] i.e. Trojan, Genser thermal plants and the grid-tied solar plants
[11] Total generation, less own-use plus total imports. Does not include embedded generation and solar since they are at the distribution grid level.

exports.

Total grid electricity supplied to the economy[12], was about **17,042.8 GWh** including about 0.7% net imports (127.4 GWh)[13] and about 0.3% solar (51.3 GWh). It was about 8.9% increase over 2018 and 1.4% less than the minimum projected requirement of 17,277.5 GWh for the year.

[12] Total generation + the net imports – transmission losses.
[13] Total imports less wheeled from CIE to CEB.

Table 1: Installed Grid Electricity Generation Capacity operational as of December 2019

GENERATION PLANT	FUEL TYPE	CAPACITY (MW)				TOTAL GENERATION		
		Installed Capacity (name plate)	% Share	Average Dependable	Average Available	GWh	% Share (Incl. embedded)	% Share (excl. embedded)
Hydro Power Plants								
Akosombo	Hydro	1020		900	849.2	5365.8	29.5	30.2
Bui	Hydro	400		360	280.9	1043.9	5.7	5.9
Kpong	Hydro	160		140	100.2	842.0	4.6	4.7
	Sub-total	***1,580***	***30.6#*** ***31.7##***	***1,400***	***1,230***	***7,251.6***	***39.9***	***40.8***
Thermal Power Plants								
Takoradi Power Company (TAPCO)	Oil/NG	330		300	161.9	1,067.4	5.9	6.0
Takoradi International Company (TICO)	Oil/NG	340		320	240.0	1,616.3	8.9	9.1
Sunon–Asogli Power (SAPP)	NG	560		520	320.9	2,622.2	14.4	14.8
Tema Thermal Plant1 (TT1P)	Oil/NG	110**		100	56.5	377.3	2.1	2.1
Tema Thermal Plant2 (TT2P)	Oil/NG	87		70	37.9	138.4	0.8	0.8
CENIT Energy Ltd (CEL)	Oil/NG	110**		100	209.6	183.4	1.0	1.0
KTPP	Oil	220		200	127.6	393.0	2.2	2.2
AMERI	NG	250		230	162.9	1,483.4	8.2	8.4
Karpower	HFO/NG	470		450	312.9	1,510.2	8.3	8.5
AKSA	HFO	370		350	252.4	608.4	3.3	3.4
Cenpower	Oil/DFO	360		340	111.7	359.0	2.0	2.0
Amandi	Oil/NG	203		200	22.8	148.8	0.8	0.8
	Sub-total	***3,410***	***68.3***	***3,180***	***2,017.2***	***10,507.8***		***59.2***
Genser*	Coal/LPG	95		85	82.5	377.1	2.1	
Trojan*	Diesel/NG	44		40	0.0	0.0	0.0	
Sub – total (incl. embedded generation)		***3,549***	***68.6***	***3,305***	***2,099.6***	***10,884.9***	***59.8***	
Renewables (excluding hydro)								
VRA Solar	Solar	2.5		1.5	1.5	3.3	0.02	
Meinergy Solar	Solar	20		16	15.8	21.0	0.1	
BXC Solar	Solar	20		16	15.8	26.9	0.1	
Safisana Biogas	Biogas	0.1		0.1	0.1	0.3	0.001	
	Sub-total	***42.6***	***0.8***	***33.6***	***33.2***	***51.3***	***0.3***	
Total (including embedded gen.)		***5,171.6***		***4,738.6***	***3,363.0***	***18,187.9***		
Total (excluding embedded gen.)		***4,990.0***		***4,580.0***	***3,247.4***	***17,759.4***		

*NG is Natural gas. * Sub-transmission (primary embedded) connection. #Including embedded generation and solar. ##Excluding embedded generation and solar. **Nameplate as licensed by Energy Commission is 126 MW.*

The net grid electricity supplied[14] to the country was about **15,612.6 GWh**; about 706.6 GWh (about 4.7%) more than in 2018.

Peak load on the transmission grid excluding export[15] was **2,612.6 MW**; 241.6 MW, roughly 10.2% more than in 2018 and was about 10.8% above the **2,358.3 MW** projected for 2019.

The total (maximum) system peak on the transmission grid[16] was however **2,803.7 MW**, which was about 6.8 MW (0.2%) more than the projected peak of 2,796.9 MW but 278.7 MW (about 11.0%) more than in 2018. The high growth in peak demand is attributed to the increased availability of natural gas for thermal generation especially in the western corridor coupled with an increase in exports facilitated by the construction of 330 kV transmission circuit.

Total power transmission loss in 2019 was 844 GWh which is 4.7% of gross transmission, 0.3 percentage point higher than in 2018 (*see Table 2*). The increased in losses is as a result of increased system load and congestion in some sections of the transmission system.

Table 2: Grid Power Transmission losses since 2010

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Transmission losses as % of gross transmission	3.7	4.7	4.3	4.4	4.3	3.8	4.4	4.1	4.4	4.7

1.2 State of the Generation Sources in 2019

1.2.1 The Hydro generation

1.2.1.1 Akosombo and Kpong

Akosombo was made to produce about 5,365.8GWh against projected supply of 4,258.4 GWh about 26.0% more than estimated[17]. On the other hand, Kpong was made to generate about 842.0 GWh as against a projected generation of 811.5 GWh which is about 3.8% more than projected.

The Volta Lake started the year 2019 at an elevation of 261.85ft (79.81m), about 26.85ft (8.18m) above the Extreme Minimum Operating level of 235ft (71.6m).

[14] Gross grid electricity plus imports, less wheeled, less exports, less transmission loss.
[15] Referred to as Domestic Peak Load by some of the utilities
[16] Ghana Peak load + Exports
[17] Projected for Akosombo was 4,258.4 GWh and for Kpong was 811.5 GWh in 2019 Electricity Supply plan, p4.

Based on this low reservoir elevation, it was recommended to operate four (4) and five (5) units at off-peak and peak respectively. However, the plant did more than the projected due to the unavailability of some thermal plants. Consequently, the reservoir elevation dropped to a minimum of 252.25 ft (76.89 m) during the dry season in 2019. This elevation was 0.75 ft (0.23 m) lesser than the projected for the year. Figure 1 shows the Akosombo reservoir trajectory recorded for 2018 and 2019.

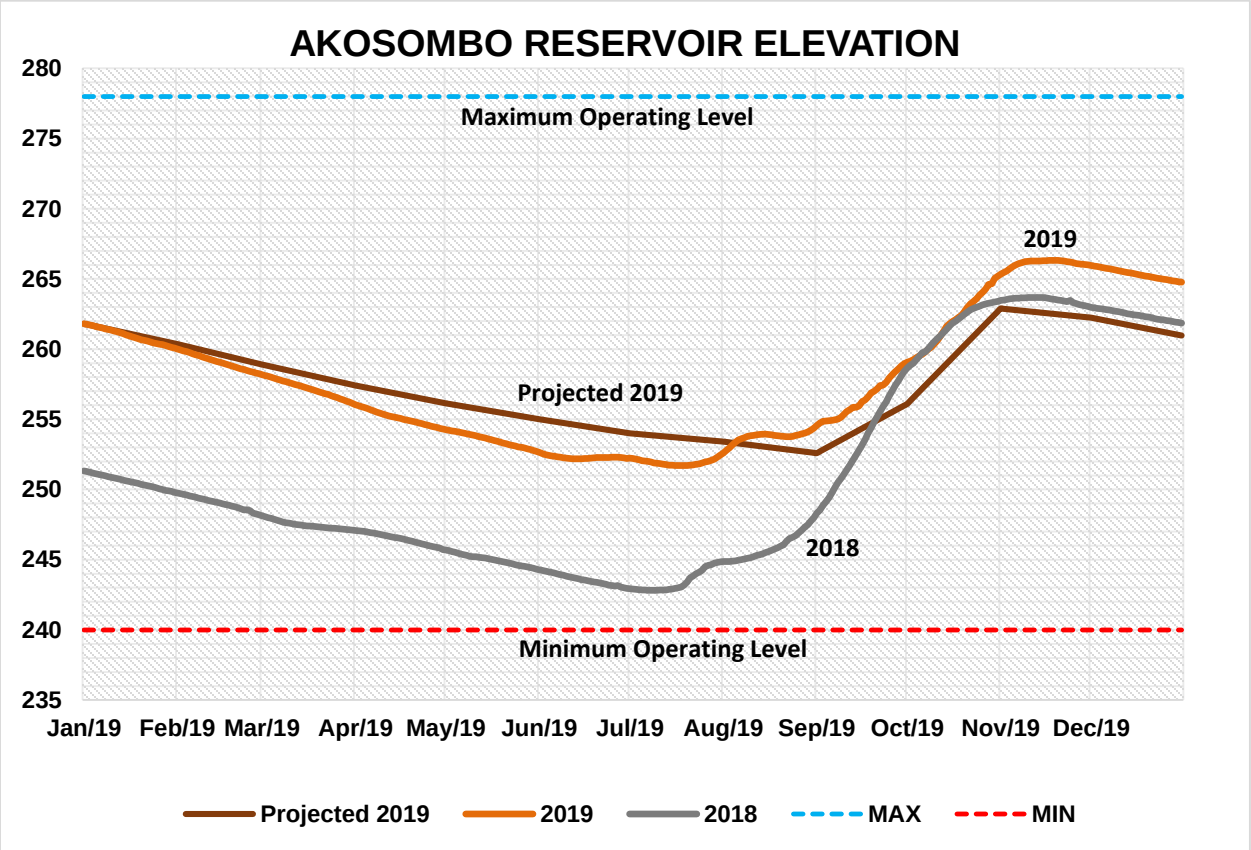

Figure 1 Akosombo Reservoir Trajectory for 2019

The reservoir elevation at the end of 2019 was 264.76 ft, (80.70 m) representing an increase of 3.80 ft (1.16 m) above the projected of 260.96 ft (79.54 m) for the year. The recorded maximum lake elevation at the end of 2019 inflow season was 266.31 ft, (81.17 m) a rise of 26.31 ft (8.02 m) above the regular Minimum Operating Level of 240 ft (73.2 m). The total net inflow recorded in 2019 was 33.43 MAF (million acre feet), which implied that an above average inflow of 25.21 MAF was obtained in 2019[18].

[18] Long term average inflow into Akosombo is about 30.6 MAF or 37,600 million cubic metres.

Kpong Hydroelectric Station which is currently undergoing retrofit, as expected ran three (3) out of the four (4) total installed turbine units resulted in an average plant output of 105 MW.

As a result of the two hydro plants operations, the projected total annual electricity generation from Kpong and Akosombo hydropower Stations was 5,069.9 GWh but it was exceeded by about 22.4% more.

1.2.1.2 Bui Hydro

In 2019, Bui hydropower plant was projected to operate an average of two turbine (2) units throughout the year. This mode of operation of the Bui Hydro was expected to lead to a projected annual production of 650.0 GWh and was expected to ensure that its reservoir level would be about 5 m above its target minimum level of 170 metres-high compared to its 168 m-minimum operating level to guarantee continuous and sustainable operation of the dam for 2019.

Bui reservoir started the year at an elevation of about 176.97 MASL[19] and dropped to 168.66 MASL at the end of the dry season thus about 2.19 MASL below the projected minimum of 170.85MASL for the year 2019. Figure 2 shows the Bui reservoir trajectory in 2018 and 2019.

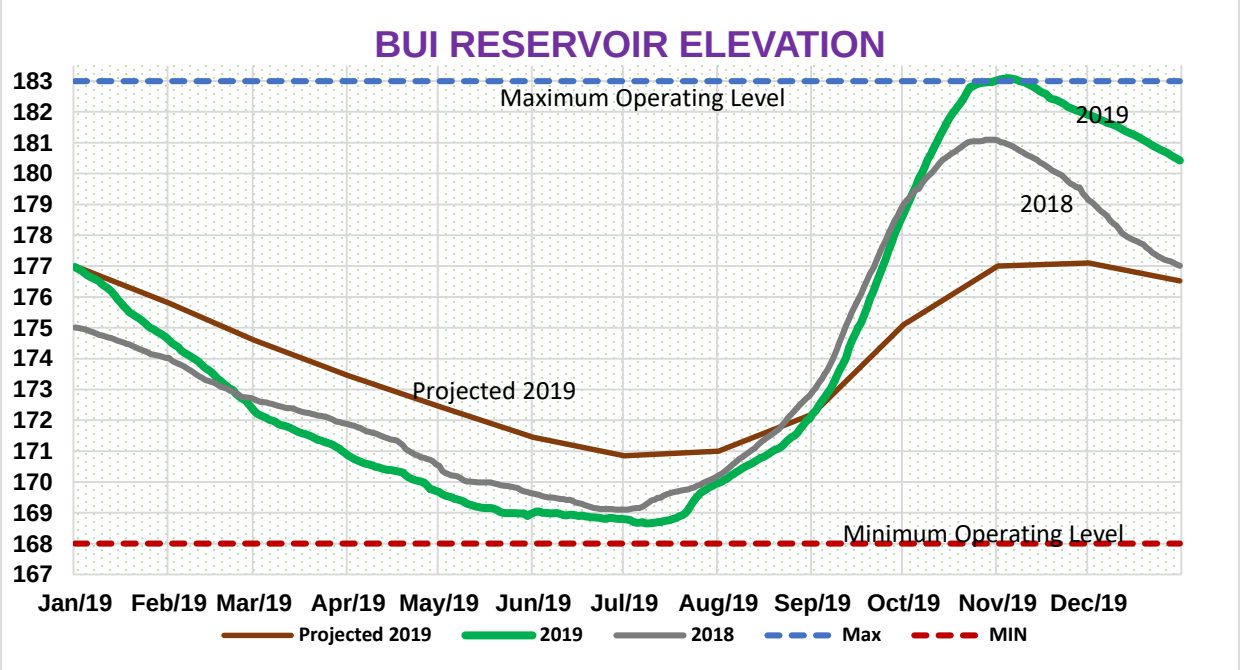

Figure 2: Bui Dam reservoir trajectory in 2019

[19] masl is metres above sea level.

The total generation for Bui was 1,043.9 GWh compared to the projected of 650.0 GWh[20]. The higher than projected generation was due to higher than average inflows into the reservoir in the flood season of 2019, forcing a revised strategy to avoid the spillage of the Bui reservoir. This resulted in a much higher than anticipated generation.

1.2.2 Thermal Generation

Total installed thermal generating capacity as at the end of 2019 was about 3,410 MW of which 3,180 MW was the Dependable Capacity; excluding the embedded generation (*see Table 1*).

Total grid electricity generated from the thermal plants excluding the embedded generation was 10,507.8 GWh which was about 8.3% less than what was projected for 2019 and this was attributed to inadequate gas supply from the WAGP, GNGC[21] (Ghana Gas) and Sankofa coupled with the inability of the thermal entities to purchase adequate liquid fuels to run the thermal plants just as it were in 2018 and 2017 *(see Figure 3).*

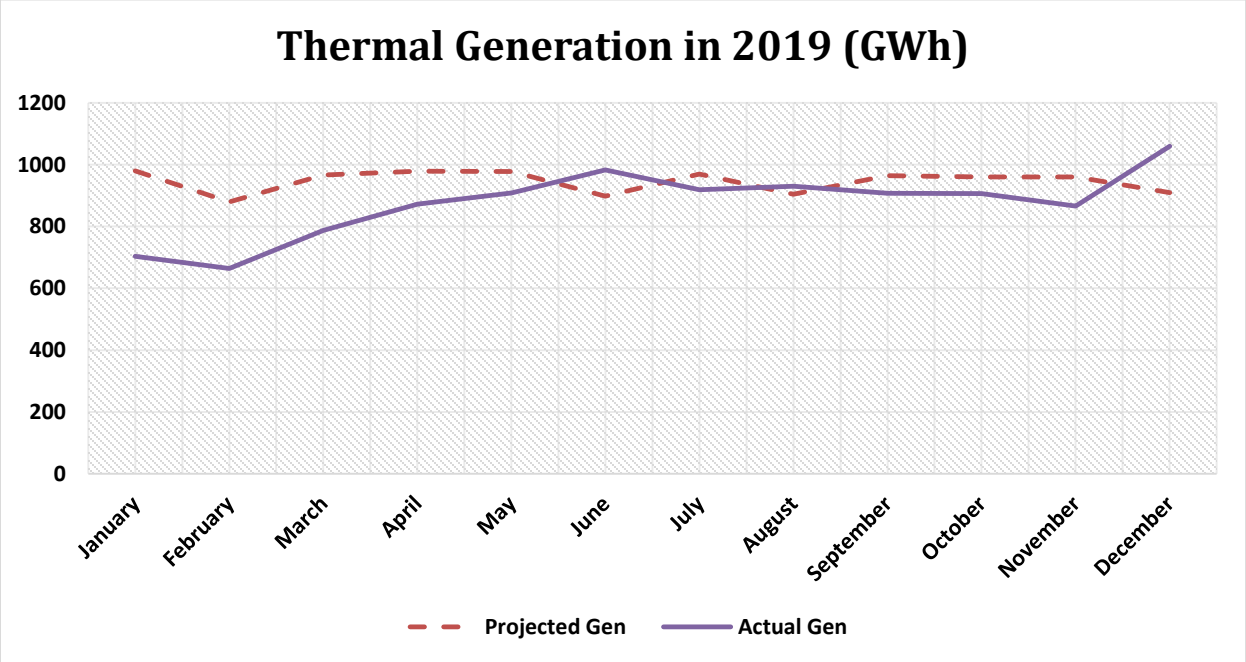

Figure 3: Total Grid Electricity Generation from Thermal Power Plants in 2019

[20] 2020 Electricity Supply Plan, p23
[21] Ghana National Gas Company

1.2.3 Embedded Generation

Grid-tied embedded generation at the distribution level accounted for 3.5% (181.6 *MW*) of installed capacity and 2.4% of generation *(428.3 GWh*) in 2019.

1.2.4 Renewable Energy Generation

Renewable Energy installations increased from about 71.3 MWp in 2018 to about 78.6 MW in 2019. Total grid tied Solar PV at the distribution level is 42.5 MW.

1.2.5 Electricity Exchanges (Export and Import)

The total energy exported in 2019 was 1,430.4 MW which is about 93% increase from 739.50 in 2018, largely due to major transmission expansion that allowed for increase in exports to Burkina and Togo/Benin over the period. This was made up of 777.5 GWh, 576.5 GWh and 76.4 GWh of exports to Togo/Benin (CEB),Burkina Faso (SONABEL) and la Côte d'Ivoire (CIE) respectively. Electricity import in 2019 from Côte d'Ivoire was 127.4 GWh which means an aggregate of 203.8 GWh was exchanged between Ghana and Côte d'Ivoire.

1.3 2019 Forecast and Actuals

For 2019, two scenarios were projected[22]:

a) **17,238-18,014 GWh** (*with VALCO constrained to operate at most two potlines*). Expected peak capacity demand required would lie within **2,666-2,797 MW**. *Average End-User tariff to make it realized should be within US cents 15-16 per kWh.*

b) **18,020-18,400 GWh** (*with VALCO constrained to operate at most two potlines*). Expected peak capacity demand required would lie within **2,800-2,900 MW**. *Average End-User tariff to make it realized should be within US cents 14-15 per kWh.*

We indicated that all the two scenarios, (a) and (b) were achievable provided there is adequate financial resources to procure all the fuel needed to run the thermal power plants even at higher utilisation factors.

[22] that all things being equal

The total grid electricity supplied inclusive of embedded generation in 2019 was about 18,187.7 GWh which fell within scenario (b) projection. The average end-user tariff was 13.7 US cents per kWh which is just about 0.3 US cents outside the scenario (b) projection.

The economic growth rate for 2019, was 6.5% (for oil) and 5.8% (non-oil), were also somehow comparable to the Government's projected GDP growth rate of 6.8% (*oil growth)* and maximum of 6.7% (for non-oil) for the year.

1.3.1 Fuel Supply Issues

In 2019, there was about 3.4% (5*% in 2018*) increase in electricity supplied against what was projected (*see Table 3*). The increase in grid electricity demand also led to greater fuel demand. However, there was still inadequate stocks of liquid fuels (LCO and diesel) at the thermal plants which compelled some hydro plants to be operated beyond the projected (27.9%) (*see Table 3*).

Table 3: Projected and Actual Generation of the Power Plants at Transmission level in 2019

Generation Source	Fuel type	Generation (GWh)			Remarks
		Projected	Actual	Net	
Hydro Power Plants					
Akosombo	Hydro	4,258.4	5,365.8	1,107.4	To make up for inadequate thermal supply
Bui	Hydro	650.0	1,043.9	443.9	
Kpong	Hydro	811.5	842.0	30.5	
	Sub-Total	***5,719.9***	***7,251.6***	***1,531.7***	
Thermal Power Plants					
Takoradi Power Company (TAPCO)	Oil/NG	1,491.8	1,067.4	-424.3	Maintenance & fuel issues
Takoradi Inter. Company (TICO)	Oil/NG	1,933.6	1,616.3	-317.3	Within range
Sunon–Asogli Power (SAPP2)	NG	2,655.9	2,622.2	-33.7	Within range
Kpone Thermal Power Plant (KTPP)	Oil/DFO	158.2	393.0	234.8	Back up
Tema Thermal Plant1 (TT1PP)	Oil/NG	211.4	377.3	165.9	Back up
Tema Thermal Plant2 (TT2PP)	Oil/NG	0.0	138.4	138.4	Fuel issue
CENIT Energy Ltd (CEL)	Oil/NG	0.0	183.4	183.4	Fuel issue
AMERI	NG	1,007.2	1,483.4	476.3	Within range
Karpower	HFO	2,775.2	1,510.2	-1,265.0	Relocation to Takoradi
AKSA	HFO	1,227.0	608.4	-618.6	Fuel issue
CenPower	Diesel/NG	0.0	359.0	359.0	Test-run mode
Amandi	Oil/NG	0.0	148.8	148.8	Test-run mode
	Sub – Total	***11,460.1***	***10,507.8***	***-1,124.0***	
	Total	***17,180.0***	***17,759.4***	***579.4***	

The Akosombo and Kpong reservoirs were over-drafted to make up for power deficit arising from the fuel supply shortfall[23]; an offset which could have been addressed with thermal generation to maintain the integrity of the reservoirs. However, the variation of 74% for Bui plant was due to the high elevation of the reservoir, and therefore the plant was dispatched to utilize the excess inflows.

The thermal generation, on the other hand, dropped by 8.3% just as in 2018. This was largely due to the inability of the generating entities to finance fuel purchases and perhaps the relocation of the Karpowership to Takoradi in the third quarter of 2019.

Thus about 5.3 million barrels of liquid fuels (about 13.1 cargoes) projected dropped to about 3.8 million barrels (about 9.3 cargoes), a drop of about 28.3% (*see Table 4*). No LCO and DFO was projected for 2019, but about 2.3 cargos and less than half a cargo respectively was used[24].

Table 4: Projected and Actual fuel used by the thermal power plants in 2019

THERMAL POWER PLANTS	FUELS							
	GAS		LCO		DFO		HFO	
	1000 mmscf		Bbls					
	Projected	*Actual*	Projected	*Actual*	Projected	*Actual*	Projected	*Actual*
TAPCO	14.73	*9.39*	-	-	-	-	-	-
TICO	16.67	*11.93*	-	*76,449.40*	-	*211.70*	-	-
AMERI	10.68	*14.16*	-	-	-	-	-	-
SAPP	20.93	*18.65*	-	*165,008.18*	-	-	-	-
TT1PP	2.28	*4.14*	-	-	-	-	-	-
CENIT	-	*1.87*		-	-	-		
TT2PP	-	*1.68*	-	-	-	-	-	-
KARPOWER	8.38	*1.50*	-	-	-	-	2,447,363.00	*1,737,705.43*
TROJAN	-	-	-	-	-	-	-	-
KTPP	1.75	*3.87*	-	-	-	*63,403.27*	-	-
AKSA	-	-	-	-	-	-	2,861,364.00	*790,439.85*
CENPOWER	-	*0.22*	-	*495,864.11*	-	*4,440.41*	-	-
AMANDI	-	-	-	*176,326.42*	-	*11,551.13*	-	-
GENSER	-	*2.52*	-	-	-	-	-	-
Total	**75.42**	***69.93***	-	***913,648.11***	-	***79,606.51***	**5,308,727.00**	***2,528,145.28***
Esti. Cargos[25]	**-**	**-**	**-**	***~2.3***	**-**	***<0.5***	***~13.1***	***~6.2***
Delivery Price US$/bbl	**-**	**-**	**70**	***64.19***	**84**	-	**84**	***65.40***

[23] A similar instance in 2018
[24] Based on a usual cargo size of 405,000 barrels.
[25] Estimated cargo ships; about 405,000 bbls per cargo.

Heavy fuel oil (HFO), destined for Karpower and AKSA plants, was below the projected thirteen cargos by seven less. Importing more HFO was favoured than LCO due to its lower price. Although, diesel (DFO) is largely used for starting and stopping the thermal plant operations, about 79.3% and 6.0% went to operate KTPP and Cenpower as back-up plants and around 14.4% went to Amandi for the latter's test-runs during the year.

Total lean gas supplied in 2019 for electricity production was 65,002,087 mmBTU comprising 63.4% indigenous sources, i.e., supply from Ghana Gas and Sankofa Gas and the remaining 36.6% import from Nigeria, i.e. WAGP supply (*see Table 5).* This was about 17.5% increase over supply in 2018.

Total gas supply from domestic gas (Atuobo Gas and Sankofa Gas) was about 41.2 million mmBTU in 2019, about 37% increase from 2018. Average daily gas flow from domestic gas also increased from about 80.0 mmscfd to 102.3 mmscfd, about 28% more. Daily flow during the first quarter averaged 106.7 mmscfd, a sharp increase from about 69.5 mmscfd in the last quarter of 2018. The average gas flow in the first quarter then dropped to about 87.2 mmscfd during the second quarter then ramped up again to about 112.1 mmscfd in the third quarter and then dropped again to about 102.1 mmscfd in the last quarter of 2019. Majority of the domestic gas supply (accounting for about 63.4% of total supply) was to the power plants located at the Takoradi power plants enclave, while the WAGP supply (accounting for the remaining 36.6%) was destined to the Tema enclave. However, there was occasional flow of gas from WAGP to Takoradi, and domestic gas now flows through a reverse flow system to Tema enclave.

Table 5: Monthly and Daily Natural Gas Supply for Electricity Production in 2019

Month	Domestic Gas Supply		WAGPCo Supply	
	Monthly flow in mmBTU	Daily flow in mmscf	Monthly flow in mmBTU	Daily flow in mmscf
January	4,234,928.32	120.13	1,862,224.36	55.49
February	3,663,565.98	117.86	1,362,289.02	45.47
March	2,705,220.24	81.96	1,519,494.89	45.9
April	2,202,171.36	82.27	1,863,654.39	57.81
May	3,098,802.36	88.21	2,167,784.65	71.18
June	3,041,673.62	91.21	2,025,474.04	66.43
July	3,454,651.97	98.69	2,406,898.73	71.28
August	4,201,699.11	119.53	3,062,869.05	88.53
September	4,010,601.00	118.07	1,776,610.34	59.25
October	3,775,140.43	107.54	2,000,399.83	59.96
November	3,276,082.05	96.3	1,568,357.01	49.11
December	3,573,017.62	102.37	2,148,476.61	63.36
Total	***41,237,554.06***		***23,764,532.93***	
Average	***3,436,462.84***	***102.32***	***1,980,377.74***	***61.25***

Total gas flow from WAGP was about 23.8 million mmBTU in 2019, a drop from 2018. Average daily flow for the entire year declined from about 67.5 mmscfd, in 2018 to about 61.3 mmscfd in 2019. The average daily flow during the first quarter of 2019 was 49.0 mmscfd, about 34.2% decrease from the last quarter of 2018. It increased significantly to 65.1 mmscfd in the second quarter, then jumped to 73.0% by the end of the third quarter, but dropped to an average of about 57.5 mmscfd during the last quarter of the year.

1.3.2 Fuel Cost

In 2019 and unlike 2018, all the prices of the liquid fuels purchased purposely for power generation were below the projected; a decrease of about 8.3% for the LCO and about 22.2% decrease for HFO.

Average N-Gas delivery price to VRA, the foundation customer, was $7.14 per mmBTU in 2019; about 18% decrease from 2018. It averaged $7.3 per mmBTU during the first quarter, decreased to $7.2 per mmBTU in the second quarter, then $7.0 during the third, before increasing to $7.1 per mmBTU in the fourth quarter of the year.

However, the average delivered price of gas from domestic sources (Atuabo GPP and Sankofa) was $6.78 per mmBTU throughout the year, about 5% lower than the N-Gas. The first quarter average was $7.5 per mmBTU same as the N-Gas, decreased to $7.29 in the second quarter, then $6.48 during the third, then reaching $6.08 per mmBTU in the fourth quarter of the year (same as the current PURC's WACOG).

In all about, $1,039.7 million was estimated for fuel procurement; US$ 593.8 million (i.e. 57.1%) for oil fuels and about $445.9 million (42.9%) for gas. However, only about 65.4%, amounting to $679.9 million, could be secured. Thus the gas purchased was 2.2% more, and total liquid fuels were 62.3% less than the estimated requirement. Based on the original projected fuel prices, only $693.4 million would have been needed, but the relatively low actual prices brought down the actual expenditure on fuel to about $679.9 million, i.e. about $13.5 million less (*see Table 6*).

Table 6: Costs due to Projected and Actual Price of the fuels in 2019

	GAS		LCO		HFO	
	Projected	**Actual**	**Projected**	**Actual**	**Projected**	Actual
Price US$/unit	7.4	6.91	70	64.19	84	**65.40**
Fuel consumed	65,002.087 mmBTU		913,648.11bbl		2,528,145.28 bbl	
Cost US$1000	481,015.4	455,813.3	-	58,647	212,364.2	**165,429.2**
Net gain US$1000		**25,202.1**		**-58,647**		**46,935.0**
Total Savings						***13,490.1***

US$/unit: mmBTU for gas and bbl for the liquid fuels

Table 7 shows the summary of some of projected and actual indicators in 2019.

Table 7: Grid Electricity and Associated fuels: Forecast and Actuals in 2019

		2018	2019	
			Forecast	Actual
Ghana's Electricity requirement (GWh)				
VALCO @ 2potlines (EUT @ 14-15US cents/kWh)			*17,238-18,014*	
VALCO @ 2potlines (EUT @ 13-14US cents/kWh)			*18,020-18,400*	
Total Grid Electricity available *(i.e. including imports)* GWh		16,353		17,887
Grid Electricity generation available *(i.e. excluding imports)* GWh		16,213		17,759
Percentage hydropower of generation (%)		37-38* *(6,017 GWh)*	*33 (5,669.9 GWh)*	*40-41* (7,251.6 GWh)*
Ghana System Peak *(Domestic peak)* MW		*2,271*	2,469.5	*2,612.6*
GRIDCO Transmission System Peak/Maximum Demand MW		2,525	2,796.9	2,803.7
Average WAGP gas flow (mmscf per day)		67	57	61.3
Average domestic gas flow (mmscf per day)		80	187	102.3
Average Delivered WAGP gas price *(VRA receipt +other charges included#)* US$ per mmBTU *($ per mscf)*		8.71 *(9.54)*	*7.4 (8.15)*	*7.14 (8.05)*
Average Delivered GhanaGas gas price * *(other charges included)* US$ per mmBTU *($ per mscf)*		7.53 *(8.25)*	*7.4 (8.15)*	*6.78 (7.20)*
Oil required (Million barrels)	LCO		-	
	Diesel		-	
	HFO		5.31	
Oil consumed (Million barrels)	LCO	0.35		0.91
	Diesel	0.08		
	HFO	4.41		2.53
Average delivered light crude oil price *dedicated for power* $ per bbl *($ per mmBTU)*	LCO	*80 (13.79)*	*70*	64.19
	Diesel	109 *(18.73)*	-	-
	HFO	*60 (9.68)*	*84*	*65.4*

EUT implies End-User Tariff

**** Low-side included embedded generation; High-side excluded imbedded generation***

1.4 Forecast for 2020

1.4.1 Electricity Requirement of the Economy

The real GDP growth rate for 2019 was 6.5% (5.8*% non-oil*), a slight increase from the 6.3% (6.5*% for non-oil*) in 2018. The increase in the Petroleum subsector growth, from about 3.6% in 2018 to about 15.1% in 2019 may have contributed to the slight increase in the GDP growth in 2019. There was however 0.7 percentage points drop in the non-oil GDP which was attributed to a decline in the growth of the Mining and Quarrying (excluding oil) sector, from 48.6% in 2018 to about 10.4% in 2019.

Before the novel coronavirus (Covid-19) pandemic, Ghana's overall **real GDP growth** is projected to expand from the 6.5**% in 2019 to 6.8% this year** and the non-oil component is expected to also expand to about 6.7% from the 5.8% last year[26].

At this Government's projected **GDP growth rate of 6.8%** (5.6-6.8*% by donor agencies*) and particularly 6.7**% (*non-oil growth)*** for the country in **2020**, we expect the total electricity required for the GDP growth to be as follows:

- ✓ **19,594.4 GWh** (*with VALCO constrained to operate at most two potlines*). Expected peak capacity demand required would be **3,115.2 MW**. *Average End-User tariff to make it realized should be within US cents 13-15 per kWh.*

This projected electricity requirement is achievable provided there is adequate financial resource to procure all the fuel needed to run the thermal power plants even at higher utilisation factors.

[26] 2020 Ghana Government's Budget Statement and Economic Policy. The World Bank and the IMF forecasts 6.8% and 5.6% respectively. https://www.imf.org/en/Countries/GHA https://www.worldbank.org/en/country/ghana/overview

1.4.2 The 2020 Grid Electricity Demand and Supply Outlook[27]

1.4.2.1 Peak Power Demand

The following spot loads are expected to contribute to peak demand growth in 2020:

a) Full operation of the second potline of VALCO, increasing its peak demand from the current 55 MW to 150 MW.

b) Increase in export to Togo/Benin and SONABEL (Burkina Faso) - from 120 MW in 2019 to 180 MW in 2020 for Togo/Benin and from 120 MW in 2019 to 150 MW by close of 2020 for SONABEL.

c) On-going distribution network expansion works intended to extend coverage and improve service quality to consumers nationwide.

d) Expected completion and commissioning of various ongoing rural electrification projects under the National Electrification Programme in 2020.

Figure 4 describes the percentage share of Peak Demand on the grid of each of the customer class.

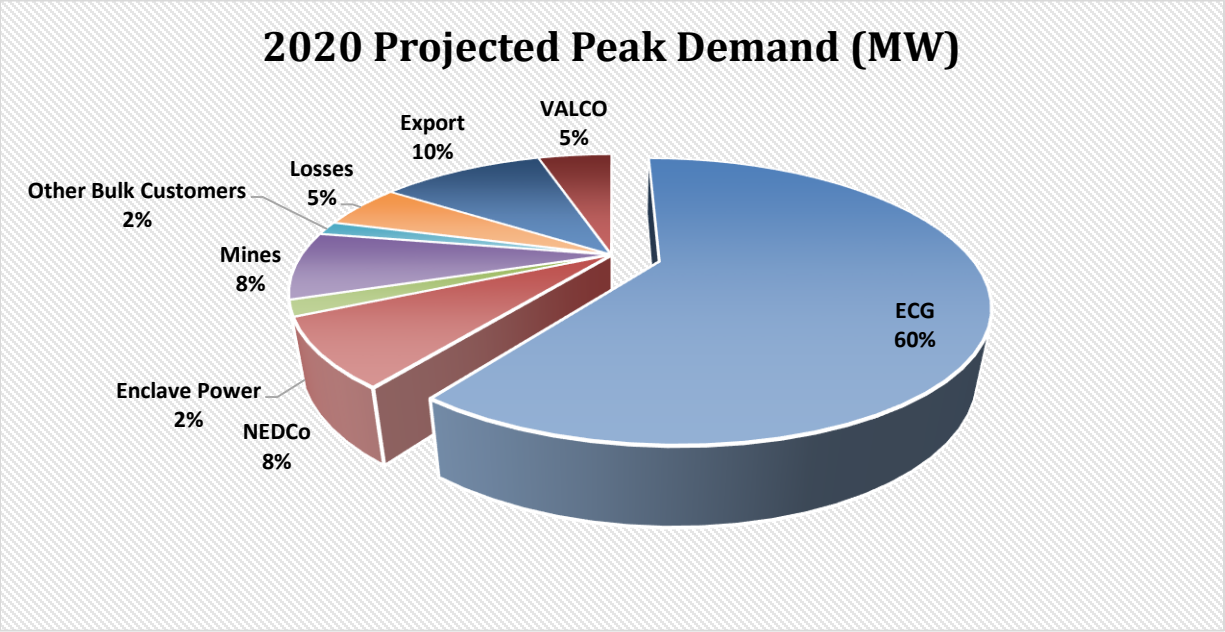

Figure 4: Share of projected peak power demand based on Customer Classes for 2020

[27] This work mostly adapted from the 2019 Electricity Supply report jointly produced by Energy Commission, GRIDCo, VRA, Bui, ECG and NEDCo, January, 2019. Available at www.energycom.gov.gh/planning

From Figure 4, ECG's demand would constitute 60% of the total system peak, followed by NEDCo at 8%, then Mines (8%) and VALCO (5%). Enclave Power (operating at the Free Zone) and Other Bulk Customers are expected to account for 2% each. Exports to Togo & Benin (CEB) and Burkina Faso (SONABEL) together would account for 10%[28]. The remaining 5% will be losses.

Table 8 shows a summary of 2020 peak grid power demand forecast based on the utilities' customer classes.

Table 8: Summary of 2020 Peak Grid Power Demand forecast by Customer Classes

DEMAND SECTOR	CUSTOMER CLASS	COINCIDENT PEAK DEMAND (MW)
Ghana Domestic Peak Demand[29]	ECG	1,874.73
	NEDCo	243.30
	Enclave Power	57.04
	Mines *(largely gold mining)*	246.01
	Other Bulk	50.14
	Losses+Network Usage	163.94
	Total Domestic Peak Demand	**2,635.15**
Exports	CEB *(Togo & Benin)*	180.00
	CIE *(la Cote d'Voire)*	0.00
	SONABEL *(Burkina Faso)*	150.00
	Total Exports	**330.00**
VALCO		150.00
	Coincident Peak Demand MW	**3,115.15**

1.4.2.2 Outlook of Grid Electricity Supply

For 2020, the total grid electricity supply including transmission network losses is projected to be between **19,594.4 GWh**. This includes estimated transmission losses and network usage of 876.2 GWh, representing 4.5% *(5.2% in 2019)* of the total projected electricity supply. The projected 2020 grid electricity supply represents a growth of approximately 9.1% over the 2019 actual consumption (*electricity made available for gross transmission*) of 17,886.8 GWh.

Table 9 presents the summary of 2020 grid electricity supply purchases by customer classes.

[28] ECG is Electricity Company of Ghana, a distribution utility for largely southern Ghana.
NEDCo is Northern Electrification Company of Ghana, a distribution utility for largely northern Ghana.
[29]Excluding VALCO

Table 9: Summary of Projected 2020 Grid Electricity Supply Purchases by Customer Classes

ENERGY	CUSTOMER	PROJECTED REQUIREMENT (GWh)
Ghana[35]/Domestic Consumption	ECG	12,234.84
	NEDCo	1,462.70
	Enclave Power Company	283.78
	Mines (largely gold mining)	1,618.69
	Other Bulk Customers	236.39
	Losses + Network Usage	876.22
	Total	**16,712.62**
Export	CEB (Togo & Benin)	902.06
	CIE (la Cote d'Voire)	0.00
	SONABEL (Burkina Faso)	750.00
VALCO		1,229.76
	Total Electricity (GWh)	***19,594.44***

Source: 2020 Electricity Supply Plan

Figure 5 shows a representation of the projected electricity consumption of the various customer groupings and their percentage share in 2020. As shown in Figure 5, ECG's uptake of 12,234.8 GWh for its customers represents about 62.4% of the total projected grid electricity requirement in 2020. It is followed by NEDCo, Mines and Exports with 8% a piece, while VALCO with a projected consumption of 1,229.8 GWh represent 6% of the total consumption.

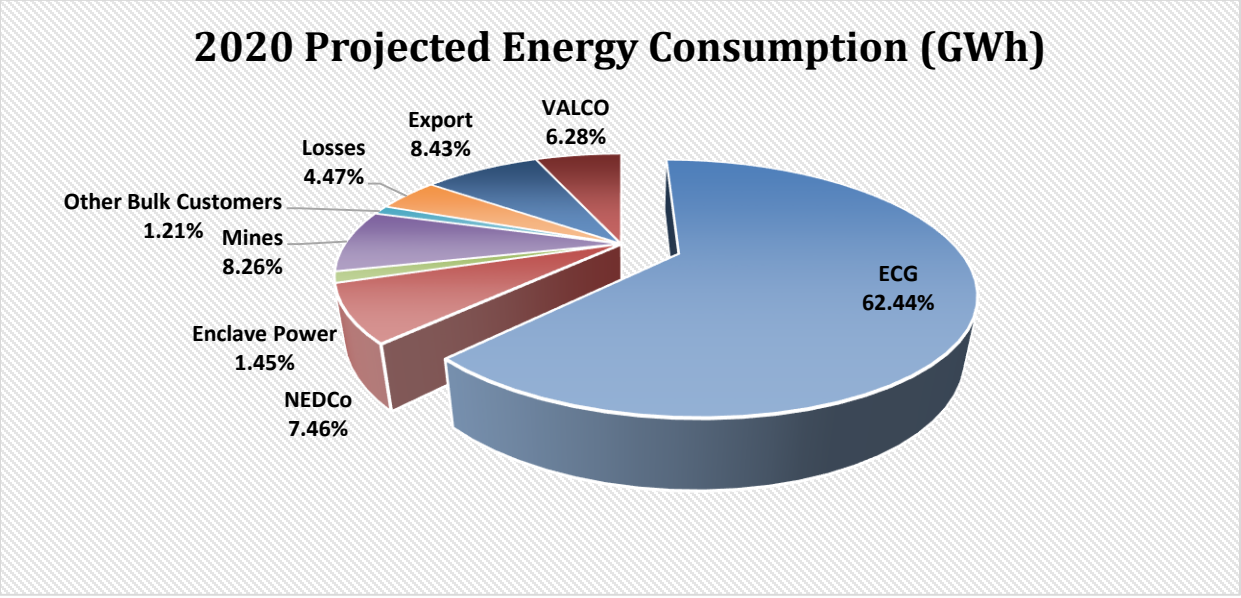

Figure 5: Share of Projected Grid Electricity Supply based on Customer Classes for 2020

1.4.3 Available Electricity Supply for 2020-Generation Sources[30]

The sources of generation considered are mainly from the existing generation and the committed projects expected to come online in 2020.

1.4.3.1 Existing Generation Sources – Hydropower

Akosombo and Kpong Hydro

Akosombo Generating Station (GS) is planned to operate to four generating units during the off-peak period and up to five (5) units during the peak period in the year 2020. This mode of operation is expected to result in operating capacity of up to 750 MW at Akosombo GS in 2020, which would ensure that the reservoir level is kept above the minimum operating level of 240 ft. This mode of operation would result in a projected minimum elevation of 255ft at the end of the dry season in 2020.

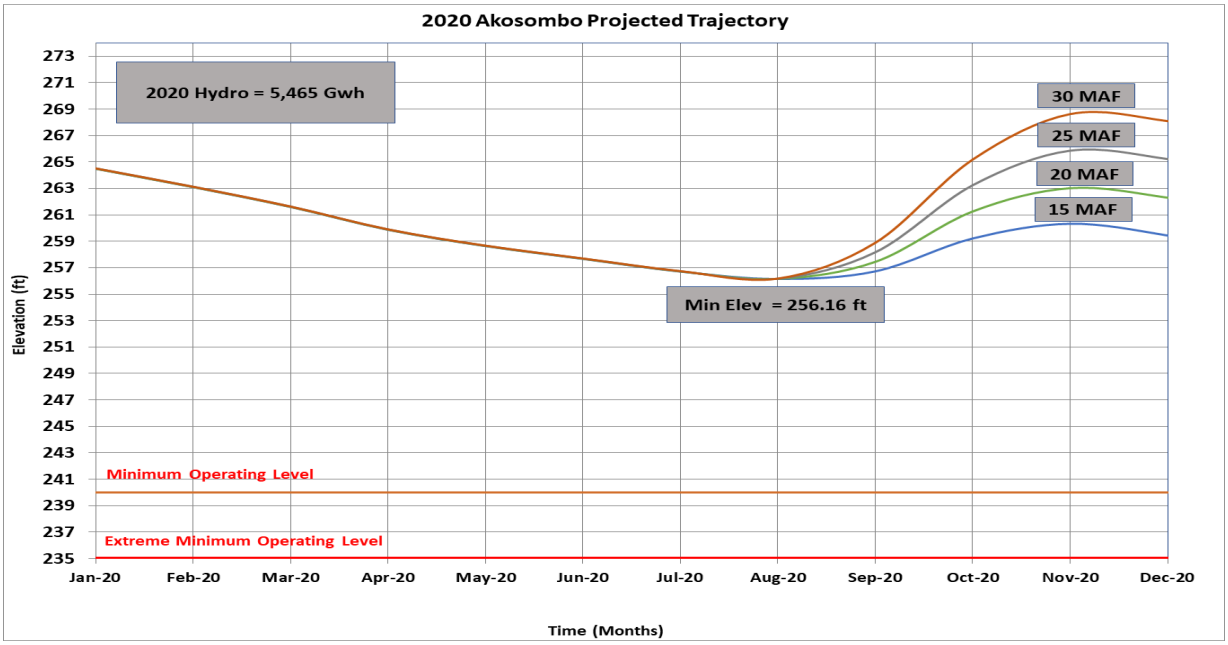

Figure 6: 2020 projected Akosombo reservoir trajectory

It is worth noting however that some thermal power plants will be rendered inoperable in the first quarter of 2020, due to the WAGP Intelligent Pigging exercise that will curtail gas supply to Tema.

[30] This work mostly adapted from a 2020 Electricity Supply Plan jointly produced with GRIDCo, VRA, Bui, ECG and NED, January, 2020.

Consequently, all 6 units at Akosombo GS will be put in operation to ensure security of supply.

Kpong Generation Station (Kpong GS), which is currently undergoing retrofit, would have three (3) out of the four (4) units available in the first quarter of 2020. The total average capacity that would be available at Kpong GS is 105 MW. However, the retrofit is expected to be completed by April 2020 and all four units are expected to be available, increasing the dependable capacity of Kpong GS to 140 MW.

As a result of the above mode of operation, the projected total annual hydro generation from Kpong and Akosombo generating stations is 5,465 GWh.

Bui Hydro

In 2020, Bui hydropower plant is projected to operate an average of two turbine (2) units throughout the year. This mode of operation would lead to a projected annual production of 764 GWh. Bui Hydro is assumed to provide an average generation capacity of 220 MW to support demand.

It is estimated that, for continuous and sustainable operation of the Bui Power Station for 2020 and for the subsequent years (in the likely event of low inflows), the reservoir level at the end of the dry season of 2020 should not drop below elevation 170 masl[31].

With a year-start elevation of 180.37 masl in 2020 and the total estimated total electricity production of 764 GWh for 2020, the year-end elevation is projected at 177.65 masl.

Figure 7 shows the 2020 projected trajectory for Bui hydropower plant.

[31] metres above sea level, a description used by the Bui Power Authority to describe the reservoir level at Bui.

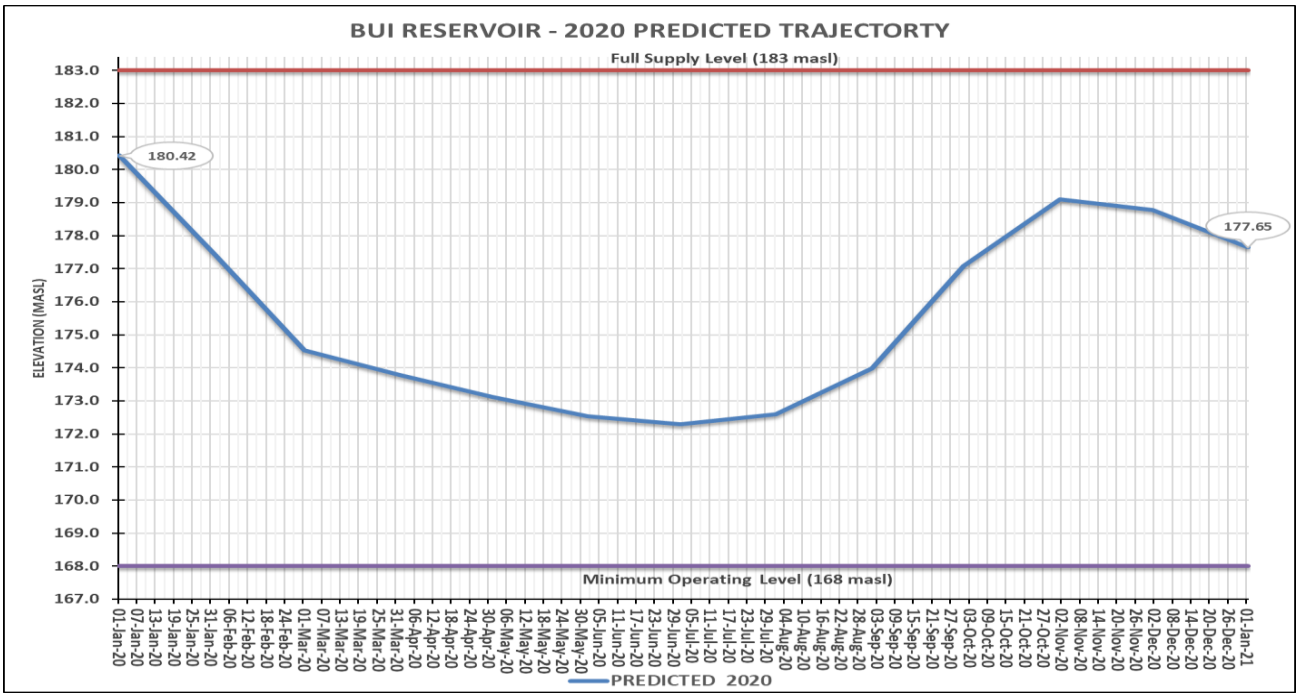

Figure 7: Bui Reservoir Trajectory projected for 2020

1.4.3.2 Existing Generation Sources - Thermal

Thermal

The total installed grid thermal generating capacity for **2020** is 3,542 **MW** of which dependable capacity would be 3,238 **MW** (*see Table 10*).

Table 10: Thermal Grid Electricity Generation Plants for 2020 (MW)

Power Plants	Installed Capacity	Dependable Capacity	Fuel Type
TAPCO (T1)	330	300	LCO/Gas
TICO (T2)	340	320	LCO/Gas
TT1PP	110 *(126*)*	100	LCO/Gas
TT2PP	87	70	Gas
KTPP	220	200	Gas/ Diesel
CENIT	110 *(126*)*	100	LCO/Gas
AMERI	250	230	Gas
SAPP	200	180	Gas
SAPP 2	360	340	Gas
Karpower	470	450	HFO/Gas

Power Plants	Installed Capacity	Dependable Capacity	Fuel Type
AKSA	370	350	HFO/Gas
CENPOWER	360	340	Gas/LCO
AMANDI	203	200	Gas/LCO
Sub-transmission level			
Trojan	44	39.6	Diesel/Gas
Genser	95	85	LPG
Total	**3,542** ***(3,574)***	**3,238**	

***** *Nameplate installed capacities of the TT1PP and CENIT as licensed by Energy Commission is 126 MW.*

In 2020, 203 MW Amandi Thermal Power Plant located in Takoradi which was completed and underwent test-runs in 2019 is expected to come online. Another new major plant coming online is the 144 MW Bridgepower Plant which is expected to be commissioned by April 2020. The projected total thermal generation for 2020 is 14,128 GWh.

1.4.3.3 Existing Generation Sources – Distributed Generation

As indicated earlier, electricity from distributed back-up generation in 2017 was estimated at 3,600 GWh. This was equivalent to generation from about 500 MW combined cycle thermal power plant[32].

With the prevailing relatively high grid electricity tariff, distributed generation would continue to serve as a supplementary source of electricity to help reduce energy cost. For instance, supply from embedded generation (Genser and Trojan) increased from about 359 GWh in 2018 to 377.1 GWh in 2019 (*see Table 1*).

1.4.3.4 Existing Generation Sources - Renewable Energy

Even though grid-tied Solar PV was almost 43 MW, significant embedded grid-connected solar power units totalling about 6.5 MW peak and largely owned by commercial customers of ECG are expected to come on line in 2020. There is also a 500 MWp solar irrigation system expected to be

[32] A nationwide survey by Energy Commission and METSS of USAID, Ghana, December, 2017

completed this year. However, these are likely to have an impact on grid electricity consumption.

1.4.3.5 New Generation Sources

In 2020, a number of new generation projects are expected to be commissioned into service as follows:

- ✓ 144 MW Bridgepower Plant located in Tema. The Plant would run on LGP or Gas and would be evacuated through the 161kV Collector Substation.
- ✓ VRA Kaleo and Lawra Solar Power Plants – VRA commenced construction of a 17 MW solar power plant at Kaleo in the Upper West region in September 2019. Commissioning for the first phase is expected to begin in June 2020 and the entire project completed in the First Quarter of 2021.

1.4.4 Grid Demand-Supply Balance

The criteria used to determine which power plants would be dispatched on a monthly basis during the year are as follows:

i. Merit order dispatch.
ii. Availability of fuel per plant.
iii. Must-run plants; *take-or-pay* plants.
iv. Variable or intermittent systems like the grid-tied solar plants.
v. System stability requirements.

Instances where there is supply surplus, some plants would not be dispatched under normal operating conditions. The grid electricity demand-supply balance for 2020 is presented in Table 11.

The total generation from VRA plants would be about 9,189 GWh, representing 47.4% of the projected total grid electricity generation for 2019. Generation from Bui Hydro would be 764.0 GWh (4.6%), while Independent Power Producers (IPPs) would generate about 10,404 GWh (47.4%).

Table 11: 2020 Projected Grid Electricity and Supply Balance in GWh

PROJECTED GRID DEMAND/SUPPLY	DEMAND/SUPPLY (GWh)
DEMAND: Customer Category	
Total Ghana (*so-called Domestic*)	16,712.62
VALCO	1,229.76
Exports (CEB+SONABEL+CIE)	1,652.06
Total Projected Electricity Requirement	**19,594.44**
PROJECTED SUPPLY	
Total VRA Hydro (Akosombo & Kpong GS)	5,465.00
Bui GS	764.00
Sub-Total: hydro	***6,229.00***
VRA Existing Thermal & Solar Generation	
TAPCO	1,414.00
TICO	1,968.00
TT1PP	97.00
KTPP	237.00
TT2PP	5.00
VRA Solar	3.00
Sub Total	***3,724.00***
Existing IPP Thermal & Solar Generation	
AMERI Power Plant	1,292.00
Karpower Barge	3,175.00
SAPP1+SAPP2	2,720.00
CENIT	364.00
AKSA	157.00
CENPOWER	997.00
Amandi	880.00
BXC Solar	27.00
MEINERGY Solar	27.00
Safisana	1.00
Sub Total	**10,404**
Total VRA Supply	**9,189.00**
Total Non-VRA Supply	**10,404.00**
Total Supply	**19,594.00**

Figure 8 shows a graphical representation of Table 11, giving the percentage share of each generation type. Thermal generation thus would constitute about 67.9% of projected total generation whilst hydro generation and generation from solar PV would constitute 31.8% and 0.3% respectively.

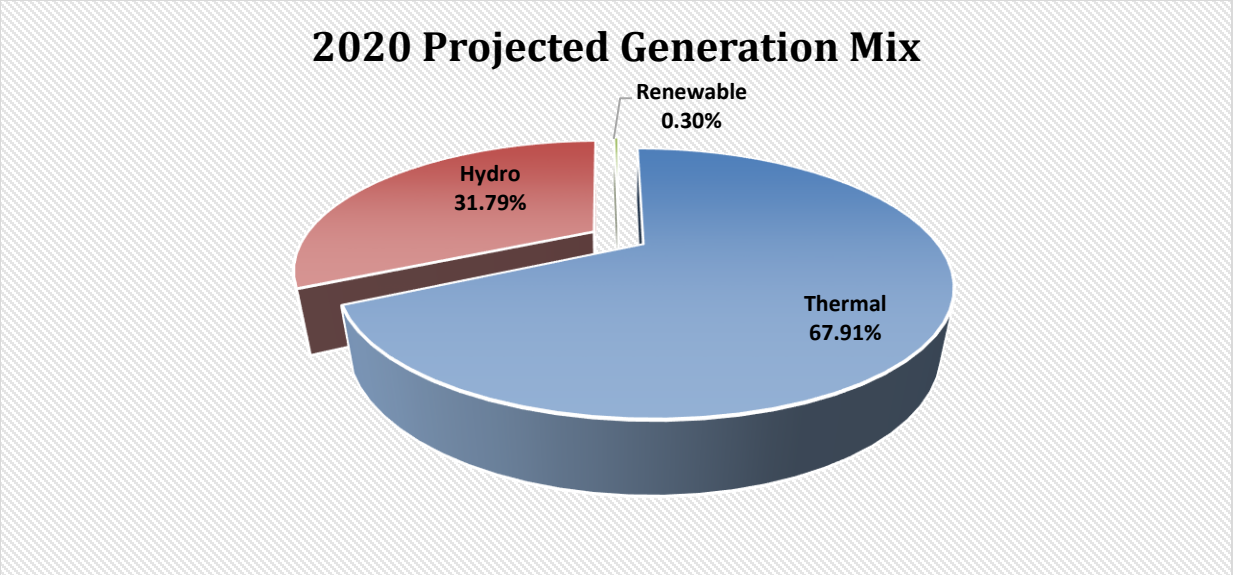

Figure 8: Share of Grid Electricity Supply by Generation Type for 2020

This implies that in 2020, as in 2019, generation from thermal sources would be more than twice that from hydro sources. This high percentage of thermal generation could have serious implications for the power sector for the following reasons:

i. It will adversely impact the finances of the local power utilities, since local tariffs are cedi denominated and if the cedi becomes relatively unstable during the year.

ii. Any prolong disruptions in gas supplywould have dire consequences on the power supply situation in the country in terms of reliability of supply and on generation costs since gas price is on the average cheaper than liquid fuels.

However, if VRA Hydro could generate 6000 GWh, without causing damage to the dam, then the share of Hydro would increase from 31.8% (6,229 GWh) to 34.5% (6,764 GWh).

1.4.5 Fuel Requirements and Cost Implications

In 2020, the main fuel for thermal power generation would be natural gas. However, some generating units such as AKSA will run on heavy fuel oil (HFO) whiles Bridgepower runs on LPG. Light Crude Oil (LCO) and Diesel (DFO) would remain as backup fuel for some plants.

1.4.5.1 Fuel Allocation and Cost

Fuel type

LCO

The total LCO used in 2019 was about 913,606.1 barrels. In 2020, only Cenpower is scheduled to operate on LCO. The estimated LCO for this power plant is **495,733 bbl**.

HFO

HFO would be used mainly by the AKSA power plant due to the relocation of the Karpowership to Takoradi to use gas. HFO used in 2019 was about 4.4 million barrels. In **2020**. the AKSA Plant is scheduled to operate on HFO throughout the year. Total requirement for the plant is estimated at **212,858 barrels**.

Natural Gas

Natural gas would as usual come from three sources; WAGP carrying gas from Nigeria; and Ghana Gas pipeline carrying indigenous gas from the Jubilee and TEN, then ENI gas from the Sankofa fields.

Average WAGP gas delivered in 2019 was about 61.3 mmscfd, whilst supply from domestic gas was about 102.3 mmscfd.

For **2020**, total gas consumption is projected to be about **107.6 million mmBTU** which translates to an average daily delivery of about 200-300 mmscfd. VRA power plants would require about 44.4 million mmBTU (about an average of 140 mmscfd) whilst the balance of 63.1 million mmBTU (about an average of 160 mmscfd) would go to the IPPs.

In 2020, priority is given to maximise the use of natural gas for generation. Expansion works are ongoing to increase the capacity of the gas infrastructure at Tema from 140 mmscfd to 235 mmscfd. This is expected to be completed by April 2020, which will allow up to approximately 120 mmscfd to be transported from the West to the East. The expected monthly volumes of gas from the various gas sources are shown in Table 12.

Table 12: 2020 monthly gas delivery profile (mmscfd)

Month	Source				
	OCTP	Jubilee / TEN	N-GAS	LNG	Total
Jan	128	87	80	-	295
Feb	128	87	80	-	295
Mar	128	87	80	-	295
Apr	130	125	30	-	285
May	130	125	30	-	285
Jun	130	125	30	-	285
Jul	130	125	30	75	360
Aug	130	125	30	75	360
Sep	130	125	30	75	360
Oct	130	125	30	75	360
Nov	130	25	30	75	360
Dec	130	125	30	75	360

In 2020 it is expected that a total of about 300 mmscfd of gas will be supplied by Ghana Gas fields. This could go up to 320 mmscfd, while a total of about 70 mmscfd will be supplied by Nigeria. Thus, total gas supply from Ghana fields and Nigeria is estimated to be 370 mmscfd.

It is assumed that Reverse Flow from Takoradi to Tema through the WAGP will be 60 mmscfd up to April 2020 and increase to 120 mmscfd from May 2020. Natural Gas availability and thermal plant availability in the West could limit the flows to 30 mmscfd.

Also, the Tema LNG Project is expected to commence supply by the fourth quarter of 2020. Expected volumes from Tema LNG in 2020 is 75 mmscfd. This would add to the diversity of gas sources and significantly improve gas supply reliability.

Diesel

As usual, diesel would be used mainly for starting and shutting down the thermal plants. In 2019, just about 79,606.5 **barrels** (about quarter of a cargo size of 405,000 barrels) was used. For 2020, we maintain the same quantity needed.

Fuel Prices

Total LCO of about 495,733 barrels estimated for 2020 would cost **$42.14 million** at delivery cost of **$85** per barrel.

It is expected that no power plant will use diesel as fuel for electricity generation in 2020. As stated earlier, diesel maybe used only for starting and shutting down the thermal plants.

Total HFO requirement of **212,858 barrels** translates to about half a cargo, assuming a cargo size of 405,000 barrels at an estimated delivery cost of about **$25.33 million** at **$119** per barrel.

Average delivery price of the WAGP gas in 2019 was $7.01/mmBTU and that of Ghana Gas was $6.08/mmBTU. For **2020**, the delivery gas price would be a weighted average price of $7.29/mmBTU but the delivery cost is estimated at $7.4/mmBTU. Consequently, about **$673.4 million** would be needed for the gas procurement.

In all, about **$740.8million** would be needed for **fuel** for the year **2020.** Summary of estimated amount of fuel needed and the cost involved are as presented in Table 13.

Table 13: Expected Average Delivered Fuel Prices for the Thermal Plants for 2020

FUEL TYPE	Average Delivered Cost and equivalent				Total Coast
	US$/mmBTU	US$/mscf	US$/bbl	US$/tonne	(US$) million
Gas	7.4 (7.29)	8.11	-	-	**673.35**
LCO	*12*	-	85	595	**42.14**
HFO	*9.7*	-	119	833	**25.33**
Total					***740.8***

The *US$/mmBTU in italics* are approximate equivalent prices of the liquid fuels.
**weighted gas price released by PURC, 1st july 2019.*

Fuel Allocation

Since the available gas would still not be enough for all the gas-fuelled thermal plants, fuel supply to the Tema and Takoradi Power Enclaves shall be strategically managed as follows:

Tema Enclave

- ✓ 30 mmscf/day allocated to Sunon-Asogli power plants
- ✓ 30 mmscf/day for VRA plants (TT1PP & KTPP) at Tema
- ✓ TT2PP/TT2PP-X operate on natural gas (on standby)
- ✓ AKSA to operate on HFO

Takoradi Enclave

- ✓ T1 to operate mainly of Gas
- ✓ T2 to operate mainly on Gas
- ✓ AMERI to operate mainly on Gas
- ✓ Karpower to operate on Gas from Sankofa fields from January 2020 onward

West-to-East Reverse Flow

The Takoradi-Tema Interconnection Project (TTIP) to allow transportation of domestic gas from gas producing fields in the West for use at Thermal Power plants in the East (Tema) using the West African Gas Pipeline is completed. So far this has made it possible for Ghana Gas to supply up to about 60 mmscfd of natural gas to power plants in the Tema Generation Enclave.

1.5 Transmission System Performance

1.5.1 State of the NITS[33]

In Ghana, the transmission of electricity is done at three main voltage levels, namely; 69 kV, 161 kV and 330 kV. There is also a 225 kV voltage level transmission that facilitates interconnection with Ghana's western neighbour Cote d'Ivoire and now with northern neighbour Burkina Faso as well. A similar interconnection with Togo is through two 161 kV lines and a 330 kV line.

The National Interconnected Transmission System (NITS) increased from approximately 5,284 circuit kilometres (km) of high voltage transmission lines in 2017 to about 5,965.83 circuit km at the end of 2018 and currently stands at 6,472.23 **circuit kilometres**. It connects all the major generation plants to sixty-five (65) Bulk Supply Points across the nation.

There is a 225 kV tie-line which interconnects the Ghana grid with that of Cote d'Ivoire and two 161 kV tie-lines that interconnect Ghana grid with that of Togo. In addition, there is a single circuit 225 kV tie-line of about 74 km linking the country's network with that of Cote d'Ivoire.

The network total transformer capacity increased from about 8,106.9 MVA[34] in 2018 to about

[33] See Annex 2
[34] MVA is Megavolt-Ampere

8,959.6 **MVA in 2019, an increase of 852.7 MVA.**

The National Interconnected Transmission System (NITS) has over 600 MVArs of fixed shunts installed at various Substations including Achimota, Mallam, Smelter, Winneba, Takoradi, Kumasi etc. and a 40 MVArs of Static Synchronous Compensator (STATCOM) installed at the Tamale substation. The fixed shunts and the STATCOM complement the generating units in providing the reactive power requirements of the NITS, to maintain good voltages and minimize overall transmission losses.

Ghana Grid Company (GRIDCo) is the operator of the NITS and is responsible for the real-time dispatch (monitoring, coordination and control) of power system operations on the Ghana Power System as well as cross-border power exchanges with neighbouring countries.

The System Control Centre (SCC) in Tema is responsible for the real-time dispatch (monitoring, coordination and control) of the Ghana Power System as well as cross-border power exchanges with neighbouring countries.

1.5.2 Transmission Line, Feeder and Sub-station Availability

The criteria for transmission Line, Feeder and Substation availability are as presented below;

i. All existing transmission lines are expected to be in service to ensure transmission of electricity from the generation stations to the Bulk Supply Points across the nation and to enable the execution of power exchanges with neighbouring countries.

ii. Maintenance work on transmission lines and substations is not to significantly affect power supply to customers except for single transformer substations and consumers served on radial lines.

In 2020, just as in the previous years, all existing transmission lines are expected to be in service for the transmission of electricity generated at the power plants to bulk supply points across the nation and as well to enable the execution of power exchange programmes with neighbouring countries.

Maintenance work on transmission lines and substations are not expected to significantly affect power supply to customers except for single transformer substations and consumers served on single radial lines. Most transformers in operation on the NITS are designed with a capability of

100% continuous loading and Transformer Utilization Factor (TUF). Indications from GRIDCo therefore suggests that there is adequate transformer capacity on the NITS for the supply of power under normal operating conditions[35].

1.5.3 Impacts of Transmission on Network Expansion Projects

There are some transmission expansion projects that have been completed and commissioned into service in 2019. They are:

- ✓ 161 kV Sunyani-Berekum line
- ✓ 161 kV Mim-Juabeso line
- ✓ 330kV Aboadze-Anwomaso
- ✓ 330kV Kintampo- Nayagnia
- ✓ 161 kV Buipe – Adubiliyi
- ✓ 161 kV Adubiliyi – Tamale
- ✓ 330 kV Kintampo-Adubiyili
- ✓ 330 kV Adubiyili-Nayagnia
- ✓ 330kV Karpowership -Takoradi Thermal Power Plant
- ✓ 161 kV Bolga – Nayagnia
- ✓ 161 kV Bridge Power Plant – New Tema Line 1
- ✓ 161 kV Bridge Power Plant – New Tema Line 2

1.6 Electricity Supply Challenges

1.6.1 Fuel Supply Challenges

Hydro Risk

Even though there are high prospects for rainfall this year, it would still be prudent to continue the conservative dispatch of the hydro plants to ensure that the reservoirs are not drawn down below their minimum operating levels to guarantee sustainable operations in the coming years. The availability and reliability of the thermal units are also very key to maintain the planned hydro draft rate.

Thermal Fuel Risk

Reliability of Gas supply from WAGP and Ghana Gas Company remains a major risk to electricity

[35] 2020 Electricity Supply Plan; joint work with GRIDCo, VRA, Bui Authority, ECG and NEDCo

supply reliability in Ghana. Although there is high installed generating capacity, gas supply sustainability remains one of the major risks to reliable electricity supply in Ghana. Any disruptions in fuel supply, mostly gas, would render some thermal plants inoperable and consequently adversely impact on supply reliability.

The Aboadze Power Enclave presently has a dependable total generation capacity of 1,490 MW as a result of the relocation of the 450 MW Karpoweship to Sekondi and the commissioning of the 190 MW Amandi Power Plant in 2020. Thus making the Western Enclave the largest generation enclave with over 53% of the overall system peak demand, outstripping both Tema and Akosombo generation enclaves.

This means any incident that affects either the ability of any power plant or the evacuation of power generated in the Western Enclave would have significant consequences on the nation's power system. For instance, there have been incidences of sudden losses of or drop in gas supplies to the power enclaves. The power system suffered a system disturbance as a result of sudden loss of gas supply from Ghana Gas to the generating plants in the Western enclave leading to sudden drop in generation. Should such and similar situations persist, there could result in prolonged load shedding.

Such could be averted by securing alternative fuels and supply for the power plants to make up for any shortfall in the supply of gas within the period of disruptions. Thus, there is the need to make advanced arrangements for adequate LCO storage at both Tema and Takoradi power enclaves.

It is also still imperative that the companies in the Gas Supply chain, namely, Tullow, ENI, GNPC, Ghana Gas, BOST and others collaborate strongly with the power supply entities to ensure effective planning and coordination.

1.6.2 Transmission Challenges

Power Evacuation

There are also transmission capacity constraints in some portions of the network which could lead to transmission line overloads. For instance, insufficient reactive power compensation could lead to poor customer supply voltage in areas such as Kumasi, Accra and some parts of the Western region.

Due to project financing issues, work on the following projects have delayed;

- ✓ 330kV Anwomaso – Kintampo transmission line
- ✓ 161kV Volta – Achimota – Mallam corridor upgrade

The 330kV Anwoamso – Kintampo line is the remaining section of the 330kV Central Transmission Backbone infrastructure. This project is to enable the NITS improve system stability whilst exporting at least 100MW power to Burkina. Due to the delays in delivering the project, the 161kV Anwwomaso –Kumasi line is experiencing high loading contributing to system losses. Any contingency on the line will create severe system disturbances which may collapse the power system. GRIDCo must get the necessary support from Government and AfD to complete this section of the line.

The 161kV Volta-Achimota-Mallam Corridor is the most heavily loaded corridor on the Ghana grid, supplying power to the Capital and surrounding towns. It is made up of light capacity conductors which are at least 50 years old. In 2018 GRIDCo secured funds to replace all the towers and transmission lines with high capacity conductors. The project has stopped due to project management issues and non-disbursement from AfD. As the demand for power increases in 2020, any line contingency on the corridor will mean severe load curtailment to the Capital. It is of utmost importance all efforts be harnessed to complete the project to avoid any load shedding to the Capital in 2020.

Radial Lines and Single Transformer Stations

Currently, supply reliability to customers served via single circuit radial lines is quite low. This is because an outage on such single circuit radial lines interrupts supply to such customers. Some of the single circuit radial lines on the NITS are the: Tamale–Yendi, Takoradi–Esiama; Dunkwa–Asawinso; Bogoso–Akyempim; Bolga- Zebilla; Zebila–Bawku lines, etc. Supply reliability to customers served on these lines would improve in future when such lines are upgraded through the construction of additional line(s) or by looping them into other adjoining substations.

Similar to single circuit radial lines, consumers supplied by single transformer substations also suffer low level of supply reliability. Maintenance and/or upgrade works at these stations are often a challenge due to difficulties in securing outages to carry out planned maintenance works. Such townships supplied via single transformer stations are Yendi, Sogakope, Esiama, Akosombo

Township, VRA Township at Akuse, etc.

There are also transmission capacity constraints in some portions of the network which could lead to transmission line overloads. For instance, insufficient reactive power compensation could lead to poor customer supply voltage in areas such as Kumasi, Accra, and some parts of the Western Region.

1.6.3 Impact of High Electricity Tariff on Demand

In July 2019, new tariff were released by the Government announcing an increment of 11.17% across all sectors. This came after a year in March 2018, when the Government announced the following reductions; about 17% reduction in Residential; 30% in Commercial and 25% in industrial tariffs. Table 14 compares the 2019 tariffs against the 2018 tariff regime.

Table 14: Comparison of Grid Electricity Tariffs Customer Class from 2018 to 2019

CONSUMPTION CLASS	RESIDENTIAL			NON-RESIDENTIAL			INDUSTRIES		
	(Domestic usage)			*(Commercial usage less than 100 kVA)*			*(SLT usage)**		
	Ghp/ kWh		*US cents/kWh*	Ghp/kWh		*US cents/kWh*	Ghp/kWh		*US cents/kWh*
	Oct-18	*Oct-19*		Oct-18	*Oct-19*		Oct-18	*Oct-19*	
51-300	55.54	65.42	***13***	67.75	79.79	***15***			
301-600	72.09	84.90	***16***	72.10	84.91	***16***			
601+	80.10	94.33	***18***	113.76	133.98	***26***			
SLT – L V							75.66	104.73	***20***
SLT – MV							58.57	79.52	***15***
SLT – HV							53.82	83.46	***16***
SLT – HV Mines							102.57	263.97	***51***

US cent 1 = 5.22 Ghana pesewas average as at the end of 2019. US cents/kWh rounded up to the nearest whole number.

*SLT is Special Load Tariff for energy usage for industrial purposes; supply voltages LV–Low Voltage (400V); MV- Medium Voltage (11,000 V) and HV-High Voltage (33,000 V).

The increase in tariff in 2019 may have led to a reduction in the rate of increase in electricity consumption from 8% in 2018 to 5% in 2019, about half of the annual average growth of 10% before the power crisis in 2012. This was after the drop in tariff in 2018 saw an improvement in electricity consumption from about 6% in 2017 to about 8% in 2018.

The tariffs are now on the high side from the 2018 reduced tariffs affecting the share of the wealth creation sectors, i.e. SLT consumption reduced by about 1.7 percentage points from 2018 to 2019. Also, the residential sector saw a decrease by almost 2.9% points during the same period as seen from Table 15.

Table 15: Sectoral Share of the Grid Electricity Consumption from 2010 to 2019

Year	SECTORS						Total	
	Residential		Non-residential		Industrial[36]			
	GWh	% share	GWh	% share	GWh	% share		
2010	2,483	*37.5*	966	*14.6*	3,174	*47.9*	**6,623**	***7.7***
2011	2,527	*33.1*	1,199	*15.7*	3,901	*51.1*	**7,627**	***15.2***
2012	2,819	*33.1*	1,549	*18.2*	4,153	*48.7*	**8,521**	***11.7***
2013	3,060	*33.9*	1,532	*17.0*	4,435	*49.1*	**9,027**	***5.9***
2014	2,772	*30.9*	1,529	*17.0*	4,680	*52.1*	**8,981**	***-0.5***
2015	2,436	*29.6*	1,531	*18.6*	4,274	*51.9*	**8,241**	***-8.2***
2016	3,932	*40.8*	1,068	*11.1*	4,626	*48.1*	**9,626**	***16.8***
2017	3,931	*38.7*	1,356	*13.3*	4,880	*48.0*	**10,167**	***5.6***
2018	4,824	*44.0*	1,103	*10.1*	5,046	*46.0*	**10,973**	***7.9***
2019	4,755	*41.1*	1,523	*13.2*	5,282	*45.7*	**11,560**	***5.3***

1.6.4 Excess Grid Capacity

Figure 9 shows the trend in installed grid capacity, dependable capacity and peak demand from 2009 to 2019. The excess grid capacity started to widen from 2014.

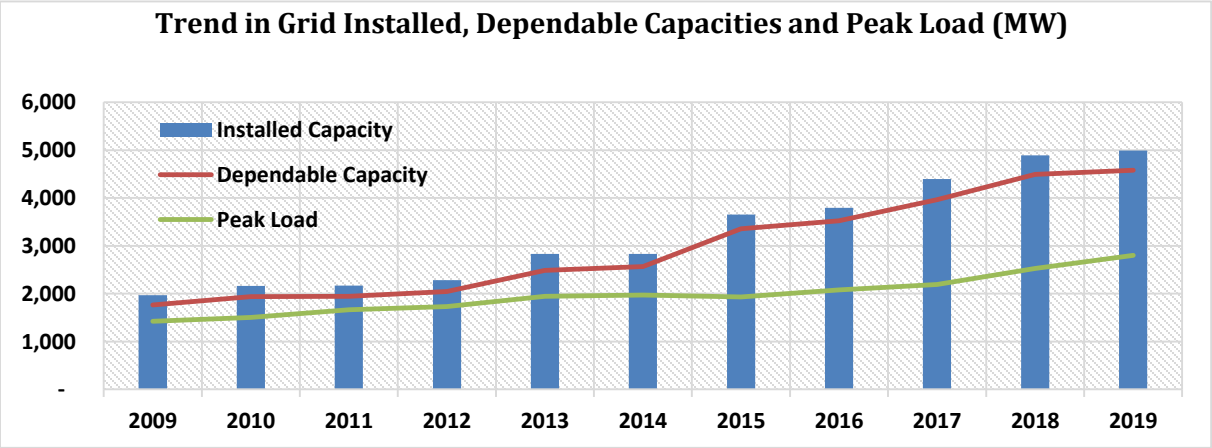

Figure 9: Trend in Installed Grid Capacity, Dependable Capacity and Peak Load; 2009-2019

[36] NB: Industrial are Special load tariff customers of ECG/PDS and NEDCo as well as bulk customers of VRA including VALCO.

Local Market

Though the share of the grid electricity consumption of the SLT customers shrank slightly from 46% in 2018 to 45.7% in 2019, it still has the highest share of the consumption (*see Table 15*). The 2019 Industrial consumption of about 5,282 GWh equivalent to about 750 MW gross demand accounted for estimated two-thirds of the sector's total electricity requirement, considering that the main consumers including the 320 MW capacity VALCO has been running just two of its five potlines whilst other manufacturers are producing on the average at half capacities. This has been attributed to the relatively high grid electricity tariff. Also, at a higher electricity consumption customer class of 600 units, most commercial entities and some industries find it cheaper to rely on embedded generation instead of the grid given rise to "excess grid capacity". Major consumers and businesses shifting from the grid to alternative sources are also contributing to the "excess grid capacity" besides importing products to maintain their market shares.

As indicated earlier[37], significant embedded grid-connected solar power units totalling about 6.5 MW peak and owned mainly by commercial customers of ECG are expected this year, and these are likely to have an impact on the grid electricity consumption. Some of the commercial and industrial entities have also adopted survival strategies to cope with the relatively high tariffs including resorting to product importation to maintain their market shares and these measures are contributing to the excess grid capacity.

Export Market

An option for the excess grid capacity is the export market through the West African Power Pool (WAPP). Net exports to Togo, Benin and Burkina in 2019 more than double from around 662.0 GWh in 2018 to 1,354.0 GWh. No net export, however, to la Cote d'Ivoire since the latter has lower tariff range (*see Table 17*).

Table 16: Comparison of Electricity Tariff ranges of Ghana and neighbouring countries in West Africa from 2018-2019

Country	La Cote d'Ivoire	Ghana	Togo	Benin	Nigeria
US cents/kWh	**9-12**	**11-20**	**16-18**	**17-19**	**7-11**

[37] Section 1.4.1 Existing Generation Sources

1.6.5 Impact of Novel Coronavirus on 2020 Electricity Demand

Worldwide, there is the imminent danger of disruptions in normal routines and operations as a result of the ongoing Covid-19 pandemic. Prominent of these is the disruptions in the operations of the transport, industrial and services sectors, since most operations have slowed down or ground to a halt. These sectors, with the exception of transport, largely rely on the use of electricity for their operations. Consequentially, reduction in their electricity consumption will lead to reduction in overall electricity demand. However, the quantum of reduction in demand depends on duration of disruption, number of affected productive entities, and of course level of disruption per entity.

The pandemic in Ghana has caused the closure of schools and more people are made to work from home owing to partial lockdown in selected towns but could become total lockdown nationwide depending on the spread of the virus. This is expected to increase residential electricity demand.

As a result of these, sectorial load profiles, especially the residential sector, and Ghana's electricity demand might change.

As at December 2019, the residential sector accounted for about 38.6% of the total electricity consumed in the country with Industry and Service contributing 42.9% and 12.4% respectively as illustrated in Figure 10.

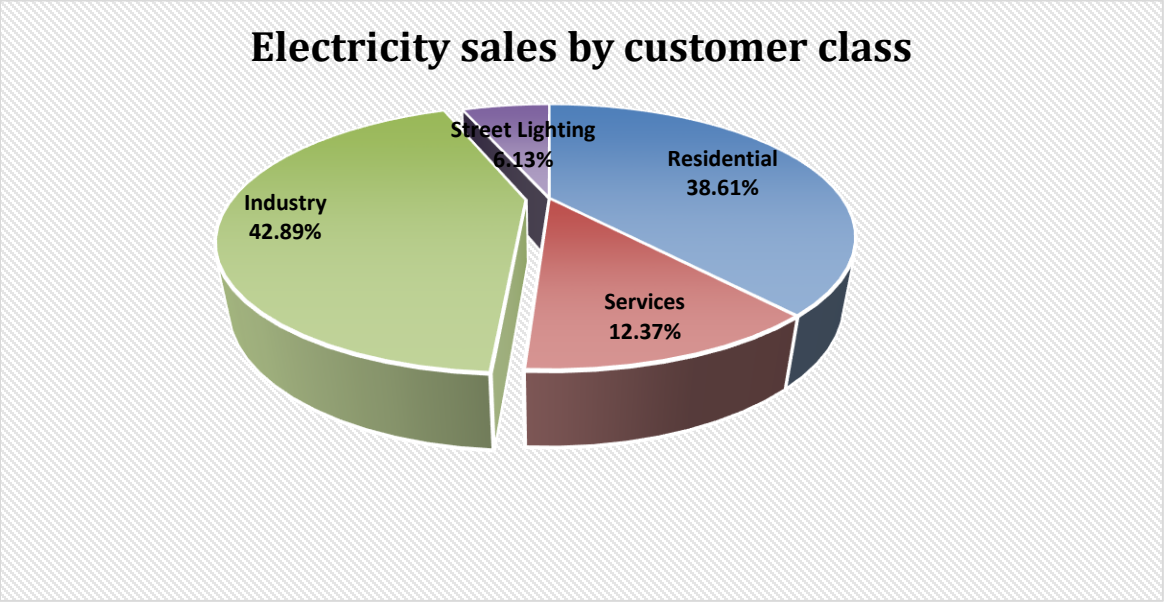

Figure 10: Electricity Consumption distribution in Ghana (2019)

Impact on Residential Sector

As stated earlier, the residential sector accounts for about 38.6% of the country's electricity consumption. This is expected to increase as more people are at home owing to Government mitigation measures ranging from the closure of educational institutions to a possible total lockdown of the country in order to curb the spread of Covid-19 As people spend more time at home, the average residential demand profile on a working day is expected to be similar to that of a weekend or a public holiday, as illustrated in Figure 11.

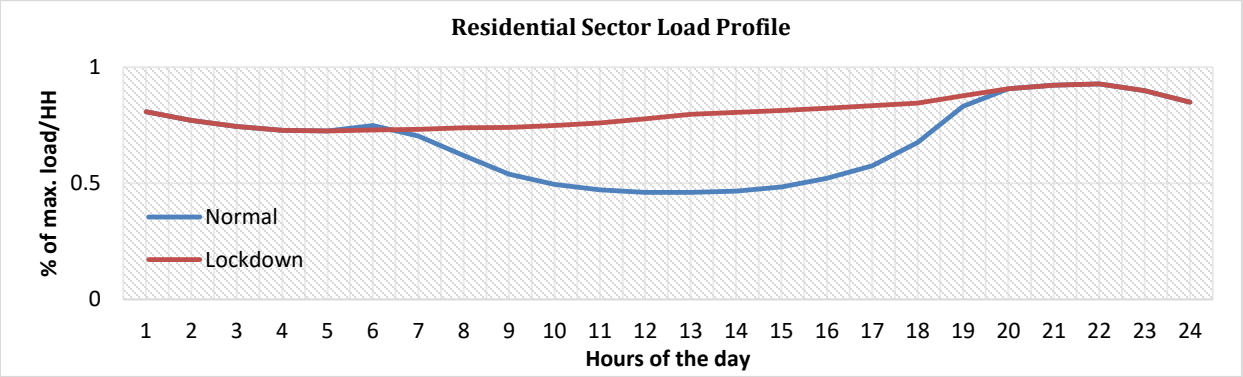

Figure 11: Residential Sector Load Profile in 24 hours

From the graph, it's expected that typical morning "peak" to flatten out, as the use of household appliances are spread over a longer period. As a result, the typical weekday demand curve (duck curve) is expected to flatten for the duration of the lockdown, but daily peak period will remain unchanged.

Impact on Services and Industrial Sector

Service sector power demand will be most negatively affected. Industrial demand could also be affected, especially if there are disruptions in energy intensive manufacturing sectors like steel fabrication, cement, rubber & plastic and mining. On the contrary, consumption by factories producing consumables needed for the fight against the virus, such as PPEs, will increase. Since the situation is fluid, we expect demand from these sectors to reduce by up to 20% depending on extent of lockdown and demand for respective products and services. Meanwhile, load profile is expected to remain same.

The growth in demand relative to previous years is expected to reduce. The extent of reduction will depend on the severity and duration of the pandemic.

2.0 Petroleum Subsector: Oil

2.1 Overview of Petroleum Supply in 2019

Ghana's oil production in 2019 was about 72.1 million barrels coming from the three main commercial fields, Jubilee (45%), TEN (31%) and Sankofa-Gye Nyame (24%) compared to about 62.1 million barrels in 2018, representing an increase of about 14.97% over the previous year. Average daily production for the year was over 196,000, as against 186,000 barrels in 2018 though still below the targeted production of about 250,000 barrels.

2.1.1 Indigenous Oil Production

2.1.1.1 Saltpond field

There was no production from the Saltpond field, it has been closed since 2016. It is currently awaiting decommissioning.

2.1.1.2 Jubilee field

Total oil production from the Jubilee field in 2019 was around 32.6 million barrels compared with 28.5 million barrels in 2018 and 32.7 million barrels in 2017.

Average daily oil production from the Jubilee field continued its downward trend -albeit at a slower pace-; dropped from about 87,844 barrels in 2018 to 87,439 barrels in 2019, unable to reach the target of 120,000 barrels per day as projected by the industry since 2012 (*see Figure 12*).

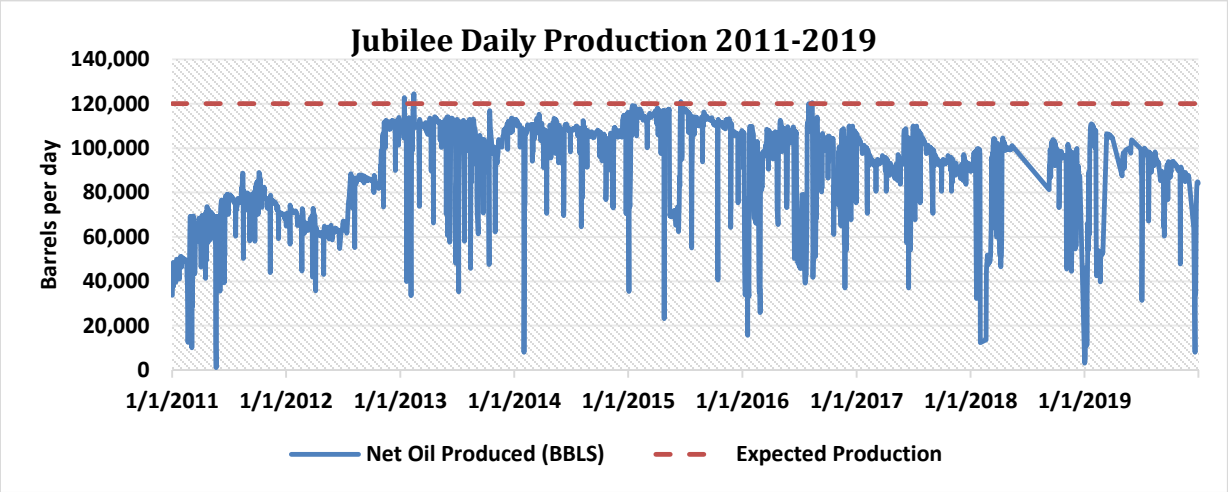

Figure 12: Jubilee field daily oil production trend; 2011-2019

Mean daily production rose from about 80,000 barrels during the first quarter to peak at about 97,000 during the second half of the year, then dropping to 90,000 at the end of the third quarter and further dropping to close the year at 82,000 to barrels in the last quarter.

2.1.1.3 TEN field

First oil from the TEN field was in August 2016 with production for that year totalling over 5 million barrels. Total production rose to 20.4 million barrels in 2017 and further increased by 15% in 2018 to 23.6 million. 2019 saw a 5% decrease in output to 22.3 million barrels. Average daily production rose from about 59,300 barrels in 2017 to about 64,000 barrels in 2018 but dropped to about 61,100 barrels in 2019 still falling short of the projected average production target of 80,000 barrels for the field. (*see Figure 13).*

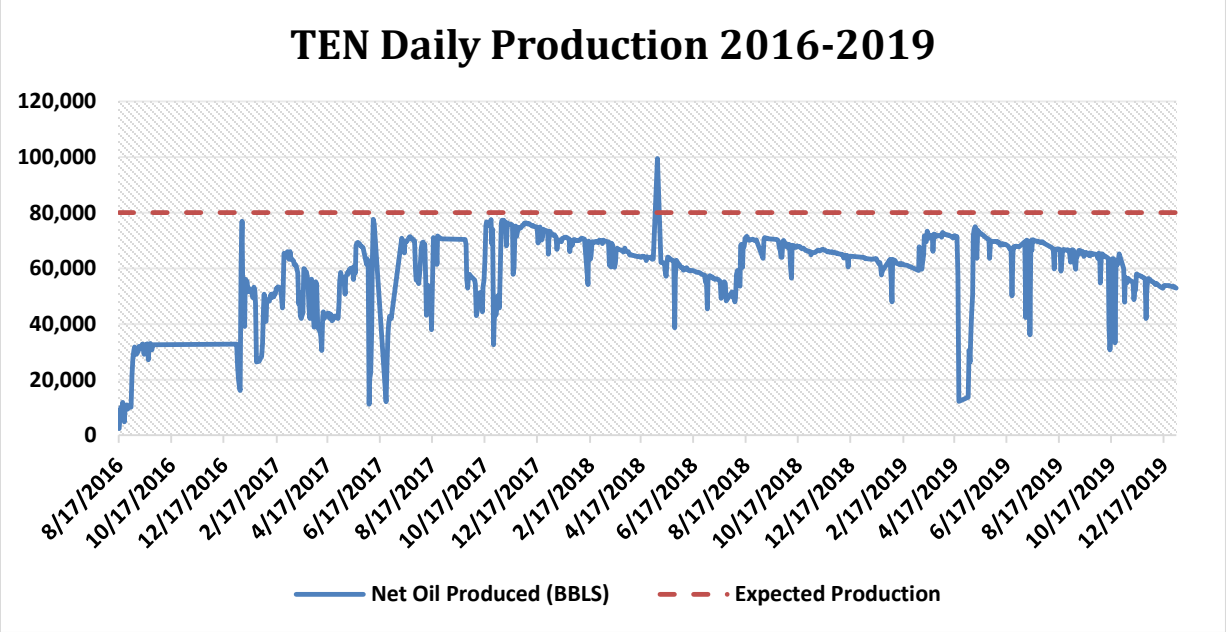

Figure 13: TEN field daily oil production trend, 2016-2019

2.1.1.4 Sankofa-Gye Nyame field

First oil from the Sankofa-Gye Nyame field[38] occurred in May, 2017. Total production for that year stood at about 5.5 million barrels. The field witnessed its first full year of production in 2018 nearly doubling output to about 10 million barrels. Production increased by about 70% to 17.2

[38] Also called OCTP (Offshore Cape Three Point) field

million barrels in 2019. Daily production in the first quarter of 2019 increased significantly from the previous year's average production of 27,000 barrels starting from an average of about 34,800 barrels in the first quarter and increased to about 44,000 barrels in the second quarter, further increasing in the 3rd quarter to about 54,000 barrels to round up the year with 55,000 barrels in the last quarter. The average production in 2019 fell within the average daily production target of 45,000-50,000 barrels per day[39] *(Figure 14)*.

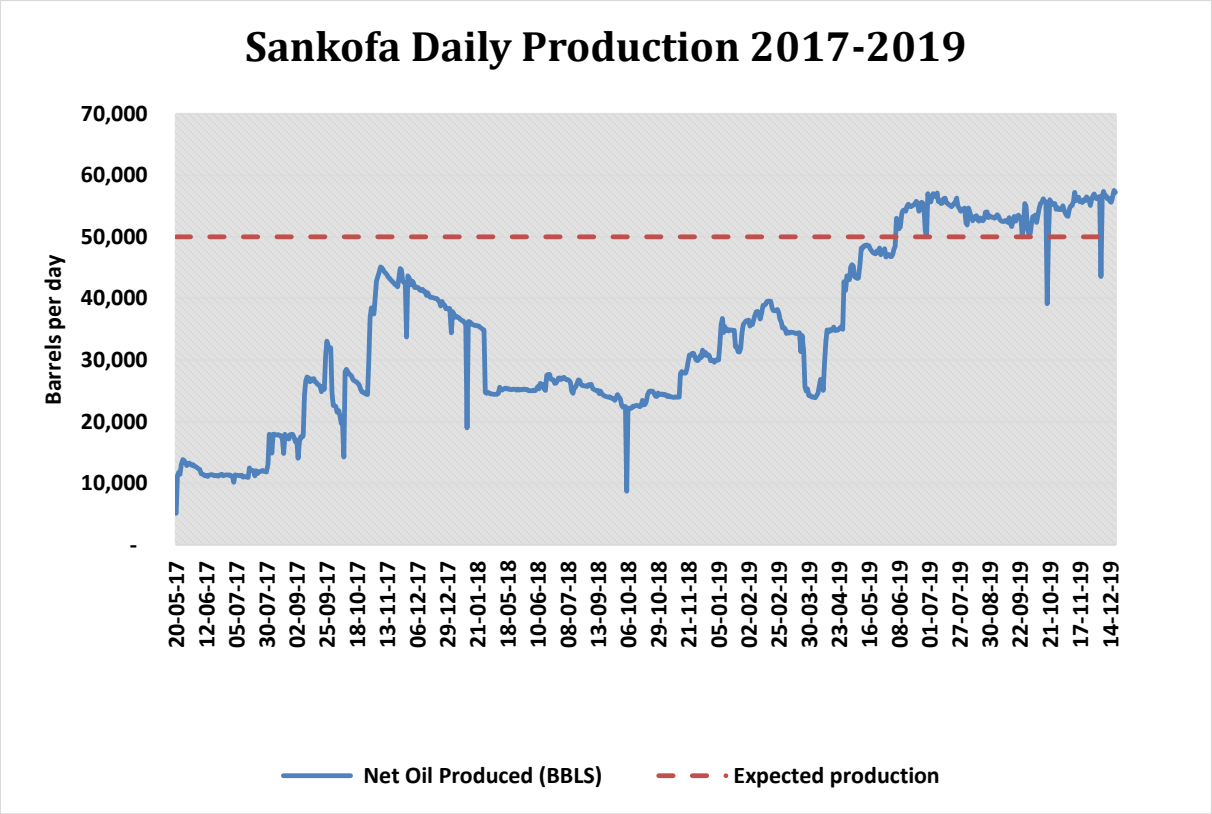

Figure 14: Sankofa-Gye Nyame field daily oil production trend 2017-2019

2.1.2 Crude Oil Prices

In 2019, the average price of crude oil for refinery operations was about $64.19 per barrel compared with $71.5 per barrel in 2018 and $54.6 in 2017 (*see Table 17*).

In 2019, Ghana's crude oil was sold for $60 per barrel representing a 12% reduction from $68.3 per barrel in 2018.

[39] http://www.oilviewafrica.com/exploration/ghana-sankofa-field; https://ghanatalksbusiness.com/first-oil-flow-sankofa/

The average price of Jubilee oil over the period was about $63.8 per barrel compared with $70.6 per barrel in 2018. TEN oil achieved an average price of about $60.6 per barrel compared with $71.6 per barrel in 2018. In 2017, TEN oil was sold at $49.3 per barrel. The first lifting of Sankofa oil was sold at $70.22 per barrel compared to the Benchmark Revenue price of US$66.8 per barrel[40] but declined up to average $65.3 per barrel for 2019 compared to the 2018 average of $72 per barrel.

Also, the price of Brent crude oil, the international benchmark, averaged $64 per barrel in 2019, $7 per barrel lower than its 2018 average. The price of West Texas Intermediate (WTI) crude oil, the U.S. benchmark, averaged $57 per barrel in 2019, $7 per barrel lower than in 2018.

Table 18 compares the prices of Ghana sourced oil to those of West Texas Intermediate (WTI) representing the United States and the London Brent representing Europe.

Table 17: Average Crude Oil prices in Ghana, United States (Gulf Coast), and Europe (the North Sea) from 2010-2019

Year	Ghana	WTI Gulf Coast/ United States	Brent Crude North Sea/ United Kingdom
	U.S dollars per barrel		
2010	80	79.4	70
2011	111	94.9	111
2012	113	93.3	112
2013	109	97.9	109
2014	99	93.3	99
2015	54.5 (60*)	48.7	52
2016	46.5 (55*)	43.3	43.7
2017	54.6 (63*)	49.7	52.4
2018	71.5 (80*)	65.06	71.19
2019	64.19	57.02	64.37

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

2.1.3 Domestic Consumption and Stocks in 2019

Crude oil imported for domestic consumption went sky-high from 197,000 tonnes (~1.4 million barrels) in 2018 to 830,000 tonnes (~5.8 million barrels) in 2019. Out of which primary refinery operations accounted for about 84% whilst the remaining 16% (*compared to 28% in 2018*) was used for electricity generation by the power plant.

[40] https://www.mofep.gov.gh/sites/default/files/reports/petroleum/2019-Annual-Petroleum-Report.pdf

Crude oil for power generation reduced by 64% due to improvement in natural gas supply as the preferred and cheaper fuel. The crude oil is mainly used as backup fuel for some power plants.

Total petroleum products supplied increased from about 3.9 million tonnes in 2018 to 4.1 million tonnes in 2019. The great product movers, as usual, were **RFO**, **LPG**, **ATK** and **Premix** (*see Table 19*).

The LPG supplied came largely from the Atuabo Gas Processing Plant (20%) and imports (80%) since the Tema Oil Refinery was virtually shut down. About 93% of the LPG produced locally came from the Atuabo gas processing plant; is a by-product of processing wet/rich associated gas to dry/lean gas for power production (*see Table 20*).

Table 18: Petroleum products supplied to the Economy from 2016-2019

PETROLEUM PRODUCT	2016	2017	2018	2019	CHANGE			
					b/n 2015 & 2016	*b/n 2016 & 2017*	*b/n 2017 & 2018*	*b/n 2018 & 2019*
	1000 tonnes				*Percentage*			
LPG	281.5	358.9	396.8	340.2	*0.9*	*27.5*	10.6	-14.3
Gasoline	1,069.20	1,072.60	1,256.50	1,350.6	*-8.1*	*0.3*	17.1	7.5
Premix	56	68.8	55.3	54.4	*18.6*	*22.9*	-19.6	-1.7
Kerosene	8.1	5.6	5	3.8	*17.4*	*-30.9*	-10.7	-23.8
ATK	132.2	166.6	200.3	231.7	*18*	*26*	20.2	15.7
Gas oil/diesel	1,765.00	1,661.50	1,836.70	1,905.6	*-7.2*	*-5.9*	10.5	3.6
RFO	12.9	129	139.1	174.4	*-3.7*	*900*	7.8	25.4
Total	**3,324.80**	**3,462.90**	**3,889.70**	**4,060.7**	***-5.7***	***4.2***	***12.3***	***4.40***

Table 19: Petroleum Products produced Locally, Imported and Exported from 2016-2019

Petrol Product	2016			2017			2018			2019		
	1000 tonnes											
	Pro	Imp	Exp	Pro	Imp	Exp	Pro	Imp	Exp	Pro	Imp	Exp
LPG	114	177.9	25.1	114	202.4	40.3	87.9	306.2	4.8	70.2	275.2	**0.77**
Gasolines	244	1,235.7	271.6	6.5	1,304.1	184	101.6	1326	63.2	125	1265	**108.2**
Kerosene	24.5	0	0	2	0	0	33.1	0	0	12.1	0	**0**
ATK	37.6	112.7	115	0.1	181.4	150	21.5	183.9	184.8	79.7	180.7	**0**
Gas oil	255	2,161	170.1	6.1	1,780.9	190	113	1753	45.4	198.1	1,741.6	**117.4**
RFO	64	20.6	69.8	1.3	248.8	53	31.5	111.6	41.5	203.8	0	**66.21**
Total	**739**	**3266.7**	**651.6**	**129.9**	**3717.6**	**618**	**388.7**	**3680**	**339.7**	**688.7**	**3462.5**	**292.58**

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

There was also about 366,355 metric tonnes of heavy fuel oil (HFO)[41] imported for power production in 2019 but not accounted for in Table 20.

2.1.4 2019 Forecast and Actuals

Average Brent crude price for refinery operations was $64.19 per barrel. Average prices in other regions also fell within forecast for the year (*see Table 21).*

Table 20: 2019 Average Crude Oil Prices in Ghana, United States and Europe - Forecast and Actuals

	Ghana		WTI & NYMEX Gulf Coast/ United States	Brent Crude North Sea/ Europe
	Brent	LCOs*	LCOs	Brent
Forecast	65.67	59-61	57.87	64-66
Actual	64.19	57.02	57.02	64.37

**Other light crudes /U.S refinery*
 # power generation requirements
Source: Bank of Ghana, U.S EIA Short Term Energy Outlook, 2019, 2020

Tema Oil Refinery (TOR) was virtually shut down throughout the year, operating just about 20% of its production capacity, even though, thrice that of 2017 operations. This was largely due to management and financial challenges.

The supply of all petroleum products were slightly higher than the 2019 projections with the exception of Kerosene and ATK which were largely within the 2019 projections. The consumption however was equivalent to operating 75,000-80,000 barrels per stream day refinery (*see Table 22*).

ATK supply started increasing in 2016. ATK consumption had dropped consistently since 2012 until 2016 which was attributed to its relatively high cost in the country. However, ATK consumption had been increasing marginally since 2016. The consumption of ATK mainly by planes engaging in international aviation was 231,000 tonnes in 2019.

The shortfall in kerosene consumption has largely been due to the shift from its usage as fuel for lighting and cooking to better options such as solar lanterns for lighting and LPG for cooking.

[41] HFO is different from RFO (Residual Fuel Oil) by its higher Sulphur content. HFO consumption will be incorporated in future releases.

Table 21: Forecast and Actual Petroleum Products Consumption in 2019

Product	Products Supplied to the Economy	
	Requirement (Forecast)	Consumption (Actual)
	1000 Tonnes	
	For economic growth	Economic growth
Total Gasolines[42]	1,350 – 1,400	1,405.0
Total Diesel	1,850 – 1,900	1,905.6
Kerosene	4 – 5	3.8
ATK	200 – 250	231.7
LPG	416 - 455	340.2
RFO	140 - 150	174.4
Total	***3,950-4,160***	***4,060.8***
Equivalent refinery capacity	***75-80 per day***	***78 per day***

2.3 Forecast for 2020

After a strong economic growth of over 3% in 2017. The global growth experienced a downward revision from 3.6% in 2018 to 2.4%-2.9% in 2019[43]. The global economic growth is projected to rise from an estimated 2.9% in 2019 to 2.5-3.3%[44] for 2020. However, the global oil industry is experiencing a shock like no other in its history. The global economic growth is expected to slow down, due as markets, companies and entire economies reel from the effects of the COVID-19 and trade war between Russia and Saudi Arabia, oil prices have crumbled.

Growth among emerging market and developing economies is projected to increase to 4.4% in 2020 from an estimated 3.7% in 2019 compared to the forecasted average of 4%.

Africa's economic growth remains uneven with East Africa out-pacing the rest of the continent. East Africa maintained its lead as the continent's fastest-growing region, with average growth estimated at 5% in 2019. The continent's economic growth remained stable in 2019 at 3.4% and

[42] Includes Premix.
[43] IMF, 2020 World Economic Outlook Report. The World is on the low-side
[44] IMF, 2020 World Economic Outlook Report. The World is on the low-side.

estimated to increase to 3.9% in 2020[45]. Most of the growth is expected to come from the continent's the largest economies – Algeria, Egypt, Morocco, South Africa and Nigeria whose joint growth rate was averaged at 3.1%, compared with the average of 4% for the rest of the continent[46].

The slow global economic growth is expected to result in drop in energy requirements. Average prices of crude oil are also projected to decline from the average of $64 per barrel to around $57 per barrel for Brent and from the $64 to $55-57 per barrel for other light crudes[47].

Crude oil prices have been largely stable after falling in the last quarter of 2018 due to the crisis in the Middle East and the trade war between the United States and the other economic giants; EU and China. This resulted in lower oil production as members of the Organization of the Petroleum Exporting Countries (OPEC) reduce supply quantities and the attacks on Saudi Arabia's oil infrastructure, were offset by increased production by the United States and other non-OPEC countries, keeping oil prices around $60[48] a barrel in 2019.

The U.S EIA projects average world crude oil prices to drop in 2020; from $64 per barrel to $43 per barrel for Brent and from $57 to $38 per barrel for the other light crudes[49].

The IMF and the World Bank forecast an average of $58 per barrel for 2020. The downward revision reflects the weaker outlook for global growth and therefore for oil demand.

2.3.1 Forecast for Ghana

Despite recent discoveries and the ongoing expansion of its upstream infrastructure, Ghana remains an importer of energy. Though Ghana's oil supplies are largely derived from Nigeria and Equatorial Guinea all in West Africa, we expect significant drop from last year's average global oil prices. This is due to the global oil price war between Saudi Arabia and Russia, triggering a major fall in the price of oil.

For economic reasons, the country has traditionally preferred to export its crude oil from the local

[45] African Economic Outlook 2020.
[46] African Economic Outlook 2020.
[47] tradingnrg.com; www.eia.gov.
[48] African Economic Outlook, 2020.
[49] US Energy Information Administration, 2019, https://www.eia.gov › outlooks › steo

indigenous fields which are of high premium brands[50] and import lower-grade oil. Rather, it sounds more convenient for the Government to use part of the readily available foreign currency proceeds from sales to support other commitments. However, as a result of the price war between Saudi Arabia and Russia, Ghana's petroleum revenue from the export of crude oil is expected to decline in 2020 due to the fact that Ghana exports oil from the three production fields, albeit relatively lower compared to other oil-producing and exporting countries. Although the estimated crude oil price was programmed at an average of US$58 per barrel for 2020, it is expected to decline to an average crude oil price of US$30 per barrel due to the outbreak of coronavirus resulting in the continuous decrease in global crude oil price.

We, therefore, forecast that the Brent price would fall within the range of **$30-32** per barrel. For other light crudes for refinery operations, it is expected to decrease from the average of **$57.02** per barrel in 2019 to within **$37-55** per barrel (*see Table 23*). Average delivery price of light crudes for power production is expected to be around $43 per barrel..

With the global oil demand plunging due to the COVID19 pandemic, crude oil prices are in tailspin. We expect these prices to drop well below their projected values if global production and storage continue to outwit demand. It provides the opportunity for the government to explore ways of taking advantage of the historic fall in oil prices as a short-term financial squeeze to stock strategic crude oil reserve for the country. The strategic crude oil reserves are meant to cushion the country against supply and price shocks; however, crude oil strategic stock is non-existent in the country.

Table 22: Forecast for Average Crude Oil Prices for Ghana, United States and Europe for 2020

Fuel Brand	Ghana	United States EIA (WTI And NYMEX)	Europe[51] (UK & Holland)
	US dollars per barrel		
Brent crude	30-32	43.30	61-63
Other light crudes/ U.S refinery	38-55	38.19	55-57

In 2019, Jubilee field oil was sold at an average price of $63.8 per barrel whilst those of TEN and

[50] With API equal or greater than 37
[51] London and Rotterdam trading forecast for Brent averaged $65-68 for 2019. www.tradingeconomics.com The IMF and World Bank forecast average range of $63-65 per barrel respectively for all crudes for 2019

Sankofa fields were sold at $61.6 and $65.3 per barrel respectively[52]. Crude oil prices have remained relatively stable, while output has marginally increased, mainly as a result of increased production from the SGN Field in 2019. However, daily production levels could not exceed the expected minimum for the year.

With stable oil price forecast for 2019, Ghana's total production increased from the average of 173,000 barrels per day in 2018 to between 190,000 – 196,000 barrels per day as projected (*see Table 23*).

A further drop in the price per barrel of crude oil is expected in 2020 from the three fields before a possible recovery in 2021 due to the global influence following the coronavirus outbreak; falling within **$38-55** per barrel[53]. With no new oil production expected to come on stream in 2020, the oil sector is expected to be relatively flat in terms of growth. Expected average daily production levels are likely to either remain the same or increase marginally (*see Table 24*).

Table 23: Forecast for Ghana's Crude Oil Prices and Production for 2020

Source of oil	Fuel Prices US$ per barrel			Average Daily Production Range '000 barrels		
	2019		Forecast for 2020	2019		Forecast for 2020
	Actual	Forecast		Actual	Forecast	
Jubilee field	63.8	66-68	57-60	87.44	90-92	90-95
TEN field	61.6	68-69	52-57	61.15	70-71	65-90
Sankofa field	65.3	68-70	60-65	47.10	30-33	48-50
Total				***196***	***190-196***	***203-235***

To meet the Government economic growth rate target of **6.8%** and particularly **6.7%** (***non-oil growth)*** for the country in **2020,** the total petroleum products required is expected to decrease from 4 million tonnes to about 3.8 million tonnes, with gasoline and diesel, as usual, having the most significant shares (*see Table 24).*

[52] GNPC, Data on crude oil and gas production for 2019
[53] U.S. Energy Information Administration

Table 24: Forecast for Petroleum Products requirements for 2020

Product	National supply requirement
	'000 Tonnes
	For economic growth target 6.8% (oil); 6.7% (non-oil)
Total Gasolines	1,250.5 - 1,333.8
Total Diesel	1,653 - 1,754.5
Kerosene	2.5 - 3.3
ATK	206.2 - 242.1
LPG	294.1 - 313.2
RFO	154.9 - 196.2
Total	***3,561 – 3,843***
Equivalent refinery capacity ('000 bbl)	***68 - 74 per day***

The expected decline in crude oil prices due to the decrease in demand would lead to a decline in petroleum revenue as well as total petroleum and liquid fuels demand. However, consumers of petroleum products are likely to benefit from crude oil price collapse leading to a reduction in ex-pump price.

The requirement for diesel (gas oil) includes demand by the mining and the petroleum upstream industries. Though the demand for petroleum products is expected to fall, gasoline demand would continue to increase but marginally.

For LPG, at least about a third of the total LPG requirement is still expected to come from local production. To achieve government's objective of 50% nationwide penetration of LPG, the consumption would require supply of at least 450,000 tonnes by 2020 based on an estimated population of 30 million by the end of the decade, but this is not achievable. This is evident since the LPG supplied in 2019 was 340,000 tonnes, and the estimated supply for 2020 is at 313,200 tonnes. The target year, therefore, has now been extended.

The estimated consumption of petroleum product is equivalent to operating 68,000-74,000 barrels per stream day refinery (see Table 24).

3.0 Petroleum Subsector: Natural Gas

3.1 Overview of Natural Gas Supply in 2019

The total wet gas production in 2019 was about 140,853.67 mmscf coming from the three main commercial fields, Jubilee, TEN and Sankofa Gye-Nyame compared to about 91,459 mmscf in 2018[54], representing an increase of about 54% over the previous year.

The Jubilee Field accounted for 51,282.67 mmscf (36.4%) and exported 20,689.05 mmscf of it to Ghana Gas, while the TEN and Sankofa Gye-Nyame (SGN) Fields produced 48,387 mmscf (about 34.4%) and 41,184 mmscf (about 29.2%) respectively[55]. Both fields also exported 694 and 32,670 mmscf of their gas respectively to Ghana Gas[56] for processing.

Thus, total raw gas receipt at Atuabo gas processing plant (Ghana Gas) was 54,053.83 mmscf; 38.3% from Jubilee, about 1.3% from TEN and the remaining 60.4% from SGN fields. About 95% (i.e. 56,118,413 mmBTU) of the resulting processed (also called dry or lean) gas was shipped for power production whilst the remaining 5% (i.e. 2,928,439 mmBTU) was transmitted for non-power activities.

In 2019 total gas flow to consuming facilities in Ghana was 75,798.75 mmscf. About 28.7% was from Nigeria via the WAGP and the remaining 71.3% coming from indigenous sources through the Atuabo gas processing plant. About 42% of the gas was supplied to the thermal plants in the Tema power enclave, 54% went to the Takoradi power enclave and the remaining 4% went for non-power activities.

3.1.1 Domestic Gas Production

3.1.1.1 Jubilee field

The total associated gas from the Jubilee field operations in 2019 was about 51,282.67 mmscf compared to 44,842 mmscf in 2018. There was no gas export to the Atuabo Gas Processing Plant in February due to a 24-day shutdown of the Jubilee FPSO compressor for maintenance from 8th

[54] Associated gas is produced from the Jubilee and TEN Fields and non-associated gas from Sankofa Gye-Nyame (SGN) Field
[55] Annual Report on the Management and Use of Petroleum Revenues for the Period 2018, Public Interest Accountability Committee, Publication, 2019
[56] Ghana National Gas Company

February 2019 to 3rd March 2019. About 20,689.05 mmscf of the gas produced from the field was exported to the Atuabo Processing Plant for processing with about 23,074.5 mmscf and 4,049.47 mmscf being reinjected and flared respectively[57]. This is about a 7% increase in the quantity of gas exported to Ghana Gas against 19,330.18 mmscf in 2018.

Average daily production of the raw gas decreased from 137mmscfd in 2018 to about 65 mmscfd in 2019 (*see Figure 15*). The Sankofa take-or-pay obligations have ensured that gas from the Sankofa Field is the first to be dispatched. This makes gas supply from the Jubilee Field interruptible. In effect, the associated gas in this field is reinjected to accommodate Sankofa production.

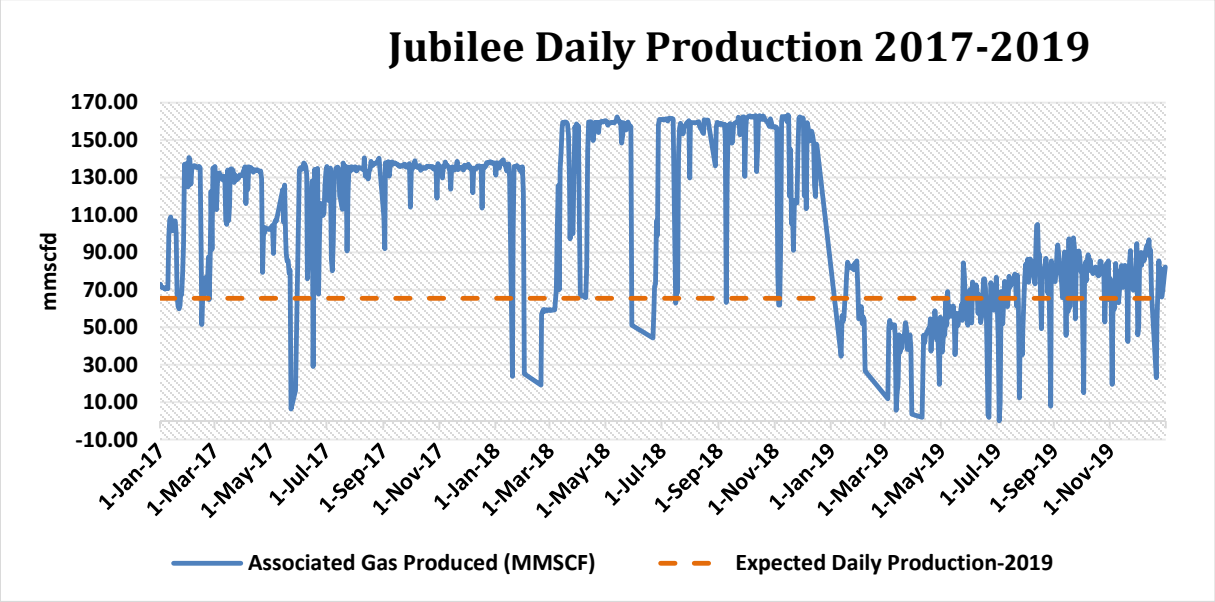

Figure 15: Comparison of Jubilee field daily gas yield; 2017 and 2019

[57] Petroleum Commission, Production volumes, 2019

3.1.1.2 TEN field

The first gas produced from the TEN field occurred in August 2016 with a total production of 6,531.86 mmscf. Total production rose to 26,818.33 mmscf in 2017 and further increased in 2018 to 39,472.78 mmscf.

In 2019, TEN field produced a total of about 48,387 mmscf of wet gas, representing an increase of about 23% more than the production in 2018. The raw gas export from the TEN field to GNGC Atuabo Gas Processing Plant (GPP) experienced a 91.73% decline from 8,391 mmscf in 2018 to 694 mmscf in 2019. The main challenge on the TEN Field was due to the lack of market for the gas and, more recently, the hydrate blockage on the gas export pipeline which led to the increase in gas reinjection into the reservoir. Daily production of the raw gas decreased from about 93.7 mmscfd in 2018 to about 21 mmscfd in 2019 (*see Figure 16*). Just like Jubilee Field, the Sankofa take-or-pay obligations have ensured that gas from the Sankofa Field is the first to be dispatched, which makes gas supply from the TEN Field interruptible. As a result, the associated gas in this field is reinjected to accommodate Sankofa production.

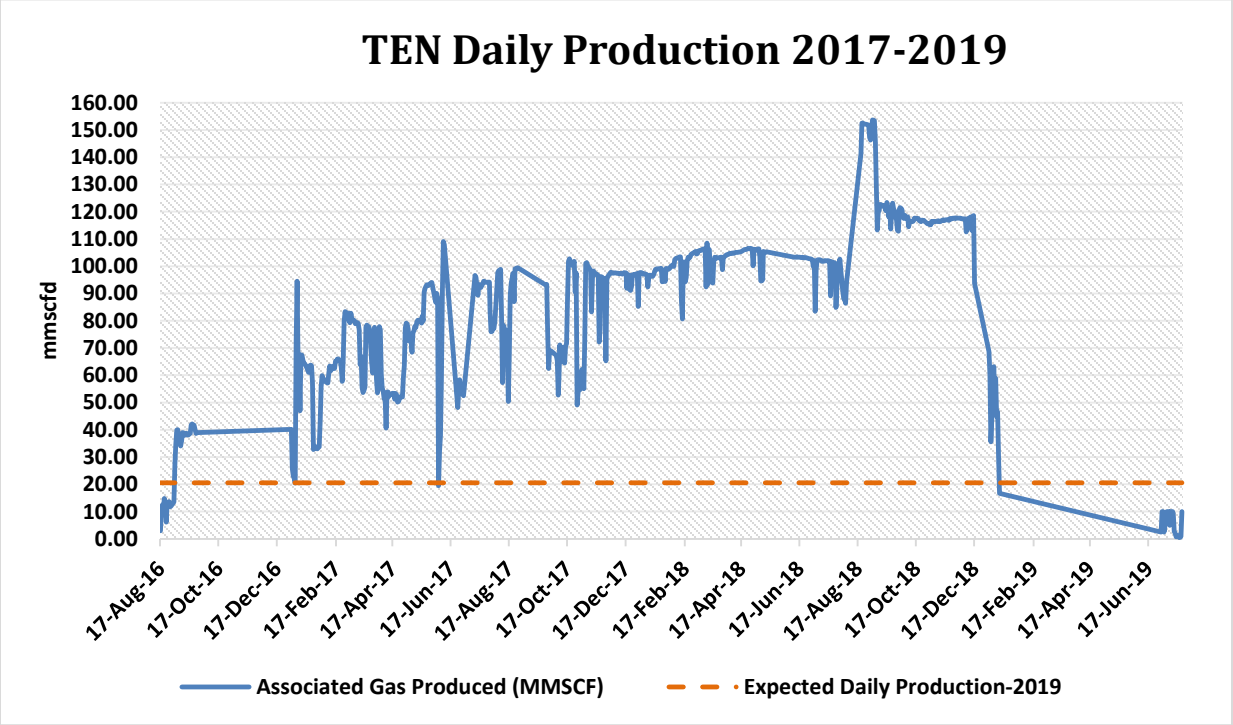

Figure 16: TEN field daily gas yield from 2016-2019

3.1.1.3 Sankofa-Gye Nyame field

The first gas from the Sankofa-Gye Nyame field[58] was in the year 2017 in May but at non-commercial levels, i.e. for operator's own production use

In 2019, total gas production from Sankofa-Gye Nyame (SGN) field (combination of associated and non-associated gas) amounts to about 69,942 mmscf. This represents an increase of about 186% over the volume of raw gas (24,420 MMscf) produced for 2018. This is mainly attributable to the addition of two (2) new producing wells (OP-9 ST and OP-10 ST) on 27th April and 6th June 2019 respectively, to eight (8) already producing wells on the SGN Field[59].

Over 79.3% of the raw gas (non-associated gas) of 41,184 mmscf produced and processed translating to 32,670 mmscf were exported through the Onshore Receiving Facility (ORF) to the GNGC pipeline to comingled with the other indigenous sources for power generation in Aboadze by VRA .

Daily production increased from about 40 mmscfd in 2018 to over 88 mmscfd in 2019 *(see Figure 17*).

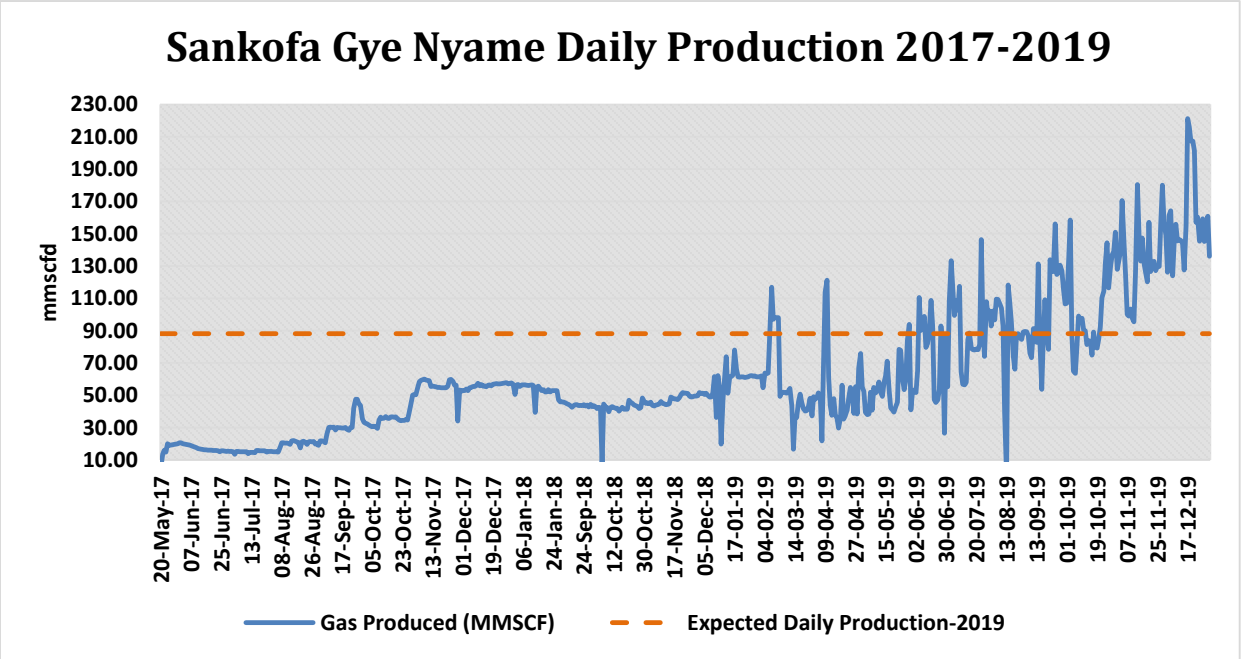

Figure 17: Sankofa-Gye Nyame field daily gas yield in 2019

[58] Also called OCTP (Offshore Cape Three Point) field
[59] PIAC, 2019 semi-annual report

3.1.2 2019 Forecast and Actuals

Average gas flow from the WAGP was about 60 mmscfd falling short of the projected average gas flow target of 110-120 mmscfd for the year. The average flow from Ghana Gas about 40.29 mmscfd compared with the projected range of 120-160 mmscfd.

In terms of fuel for power generation, the WAGP average delivery gas price averaged $8.71/mmbtu compared to the weighted average natural gas price of US$7.29/mmbtu for 2018. However, in 2019, WAGP average delivery gas price averaged $7.14/mmbtu compared to the weighted average natural gas price of US$6.08/mmbtu. For domestic gas, in 2019, the average delivery price of Ghana Gas was sold at $6.08/mmbtu same as the weighted average natural gas price compared to $7.53/mmBTU about $0.24/mmbtu above the weighted average natural gas price in 2018.

The delivered wet gas price from Jubilee field to Ghana Gas was $2.90/mmbtu. Also, the delivered wet gas from TEN was sold at the same price to Ghana Gas. This is in line with the forecast made in the 2019 Energy Outlook. While Sankofa Gye Nyame gas was delivered to the Ghana Gas pipeline system to VRA and Genser at $7.29/mmbtu until June 2019 after which the price decrease to $6.08/mmbtu (same as the weighted average natural gas price).

Table 25 compares the prices of **Ghana (WAGP)** natural gas to those of Henry Hub spot price representing the United States and the North Sea representing Europe.

Table 24: Average Delivery Gas Prices in Ghana (WAGP), United States (Henry Hub), and Europe (North Sea); 2016-2019

Year	WAGP+local/ Ghana	Henry Hub/ United States	Northsea/ Europe
	U.S dollars per mmbtu		
2016	7.9-8.84	2.52	4.56
2017	8.6-8.8	2.99	5.65
2018	7.53-8.71	3.15	7.68
2019	6.08-7.14	2.56	4.81

Sources: Bank of Ghana, LondonGasPrice.com, tradingnrg.com, US EIA STEO for 2020

3.2 Forecast for 2020 and beyond

The gas processing at the Jubilee Field is expected to increase in 2020 due to maintenance at the Jubilee field and the tie-in of the J-54 water injector well. At TEN, the drilling of a production well on the Ntomme field has commenced and the well is expected to be tied-in by the end of the first quarter[60]. The expected volumes of gas from OCTP and Jubilee fields are 180-200 mmscf/day and 100-120 mmscf/day for the year 2020.

Following the successful completion of the WAGP Reverse Flow Project, it is expected that a total of about 60 mmscf/day of gas can be transported from the Western Region of Ghana to the Eastern part through WAGP up to April 2020. This has made it possible for Ghana to supply the Tema Generation Enclave with natural gas to power plants. With the ongoing expansion works at Tema it is expected that the capacity of the gas infrastructure would increase to 235 mmscf/day. This could make it possible for Ghana to increase its supply to about 120 mmscf/day from the West to the East by April 2020.

On the global scene, the average US spot price[61] for gas is expected to reach about $2.7/mmbtu in 2020 from $2.56/mmbtu in 2019[62]. For the EU, the average natural gas import price would decline from $4.81/mmbtu in 2019 to about 4.5/mmbtu in 2020.

For **2020**, average wet gas prices from the Jubilee and TEN are expected to remain about the same as last year, i.e. at **$2.90/mmbtu** being associated gas. For SGN gas, a non-associated gas and feeds into the Ghana Gas pipeline, the average price is expected to be same as the weighted average natural gas price which is **$6.08/mmBTU** *(see Table 26).*

Table 25: Projected delivered gas prices in Ghana (WAGP), United States (Henry Hub), and Europe (North Sea) for 2020

Year	WAGP+local/ Ghana	Henry Hub/ United States	Northsea/Europe
	U.S dollars per mmBTU		
2020	6.08-8.30	2.10-2.7	4.5

Given the availability of domestic gas, in 2020 priority will be given to usage of gas from the Ghana fields. Therefore, gas from Ghana fields will be preferred for power generation followed

[60] Tullow Oil plc – Trading Statement & Operational Update
[61] Spot prices usually do not include transportation cost
[62] https://www.statista.com

by gas from Nigeria. A daily average of 60 mmscf of gas supply from Nigeria is expected in the year 2020. In relation to Ghana gas supply, we expect about 73 mmscf/day, 24 mmscf/day and 180-200 mmscf/day from the Jubilee, TEN and Sankofa Fields respectively. The only limitation to the comingled flow would be the intake point at the metering station. Table 27 summarises the projected monthly gas delivery profile of the Jubilee, TEN and ENI fields.

Table 26: 2020 Projected Monthly Gas Delivery Profile in mmscfd by GNGC

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OCTP	128	128	128	130	130	130	130	130	130	130	130	130
Jubilee /TEN	87	87	87	125	125	125	125	125	125	125	25	125
Total	**215**	**215**	**215**	**255**	**255**	**255**	**255**	**255**	**255**	**255**	**155**	**255**

Source: Ghana Gas, 2020.

Table 28 shows forecasts for local gas and WAGP supply.

Table 27: Forecast for Ghana's fields Gas export and WAGP Gas Supply for 2020

SOURCE OF GAS	Average Export Prices US$ per mmBTU			Average Daily Export Range mmscfd		
	2019		Forecast for 2020	2019		Forecast for 2020
	Forecast	Actual		Forecast	Actual	
Raw/Wet Gas export						
Jubilee field	2.9	2.9	2.9	92-95	56.69	67-73
TEN field	2.9	2.9	2.9	30-35	1.90	20-24
lean/Dry Gas export						
Sankofa field	7.29	7.29	6.08	133-135	89.51	175-180
WAGP	8.41	7.14	7.01	110-120	59.6	60-70
			Total	***365-385****		***322-347***

**Wet gas export volumes would reduce marginally after processing*

3.2.1 Gas Supply Challenges

On the average, gas still remains the most sustainable and relatively cost-competitive fuel supply to produce affordable power in the country. The key challenges hampering reliability of gas supply however still remain about the same as in the previous years, though with some significant improvements such as the drop in the gas tariff since 2018, namely:

i. inadequate supply, particularly from Nigeria through the WAGP (*see Annex 4*); and
ii. finance - domestic and international payment deficits.

3.2.1.1 Adequacy of gas supply

The demand for natural gas in Ghana is totally driven by the power sector. The power sector accounts for almost all gas consumption. In addition to domestic production, gas is imported through the West Africa Gas Pipeline (WAGP) which is an offshore gas pipeline serving plants in the Tema area in the East.

WAPG is supposed to supply Ghana with 123.2 mmscfd of gas under the contractual obligations. However, since the inception of WAGP in 2009, gas flows to Ghana from Nigeria have never reached the fully contracted volume of 123 million standard cubic feet per day (mmscfd).

Further, the embarkment of the cleaning and inspection exercise on the offshore pipeline of the West African Gas Pipeline (WAGP) referred to as "pigging" sometime in 2020 would result in the curtailment of the reverse flow of gas from Takoradi to Tema as well as the supply of gas to facilities in Tema.

3.2.1.2 Finance – domestic and international payment deficits

Both the Power and the Petroleum subsectors of the Energy Sector are still bedevilled with financial challenges.

The energy sector is still crippled with a debt of over US$2 billion as at mid-2019.[63] Most of the debt have been due to short term loan contracted by the power producers culminating in the 'take or pay' and the distribution utilities' inability to collect adequate revenue to cover their operations.

With regard to the operations of the Ghana National Gas Company, the gas commercialisation phase of the Ghana Gas Infrastructure project has continued and progressed well, with gas transportation infrastructure extended to the mining enclave of Tarkwa, Damang, and Prestea, and off-takers secured for gas supplies[64]. However, persistent untimely and insufficient payments for gas delivered are also contributing to the huge debt burdens of the gas off-takers most of the public entities. For instance, untimely and inadequate payments still contribute to the reasons for the unreliable and interruptions in gas supply from Nigeria through the WAGP. On the domestic side,

[63] https://www.ghanaweb.com/GhanaHomePage/business/The-continuous-rise-of-Ghana-s-energy-sector-debt-and-its-implications-762724
[64] PIAC 2019 Semi-Annual Report

VRA still owes Ghana Gas Company about $150 million[65] for gas supplied and as of June 2019, Ghana Gas' indebtedness to GNPC stood at about US$97 million and ECG's, at about US$12 million.

VRA consumes 90 percent of the lean gas produced from Ghana Gas for the purposes of power production. Therefore, the former's inability to pay for this gas has grave financial implications on Ghana Gas' ability to produce lean gas for electricity generation[66].

Total indebtedness of VRA to Ghana Gas stood at almost US$735 million as at the end of 2018 of which the Government of Ghana in 2019 settled US$230 million of the debt.[67]

A total of GHc4.78 billion out of over GHc6 billion of the legacy debt owed by VRA, representing 80 percent of the amount has been paid by government.[10] However, this payment only reflects on the total debts accumulated by the VRA alone and not the total sector debts. In order to address the chronic debt challenges and to facilitate equitable distribution of all cash collected in the power sector value chain using the end-user tariff as a basis, the Cash Waterfall Mechanism (CWM) concept was instituted in 2016. It was to be implemented in a way that all suppliers of goods and services to companies in the energy sector are paid by a third-party and not directly by the company, thereby avoiding the situation wherein companies mount-up debts and pay as they wish. However, the CWM is expected to commence from April 2020.

To resolve the Energy Sector debts due to banks and trade creditors, the Government has set up E.S.L.A. PLC, a Special Purpose Vehicle (SPV) incorporated as a public limited liability company to issue long-term bonds. The securities issued are backed by a component of the Energy Sector Levy Act (ESLA) receivables which has been assigned to the company for the settlement of coupons and principal repayments arising under the securities that are issued.

ESLA Plc has, since inception, issued bonds worth GHS6.664 billion. Significantly, a buy-back and subsequent cancellation of bonds worth GHS664 million in June 2019 brought the total outstanding bond under the programme to GHS6 billion[68].

[65] https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Parliament-approves-PIAC-Report-769207
[66] https://www.graphic.com.gh/news/general-news/vra-depth-will-not-halt-power-supply-in-ghana-emmanuel-essiel.html
[67] https://goldstreetbusiness.com/business/govt-settles-us-230m-vra-debt-to-ghana-gas/
[68] https://www.ghanaweb.com/GhanaHomePage/NewsArchive/ESLA-plc-to-issue-GHC260m-bond-Monday-

Further, the Energy Sector Recovery Program (ESRP)[69] has outlined more actions that Government must take to improve the financial health of the energy sector. The ESRP is a roadmap of immediate, near-term, and medium-term actions needed to achieve Government's aim to bring the sector into balance by the end of 2023, and a commitment by Government to fund the Annual Sector Shortfall (with Sector Stabilization Payments) from 2020 onwards until the sector is in balance to prevent further accumulation of arrears. The identified actions are classified into three phases: Phase I, II and III. Phase I actions are to be taken immediately while Phase II actions will be initiated within twelve months. Phase I and Phase II actions are expected to reduce the annual sector shortfall and prevent future imbalances, thereby minimizing needed increases in electricity tariffs and/or Sector Stabilization Payments by Government. Finally, Phase III actions will be required in the next two years to reduce further the shortfall until no Sector Stabilization Payments are required by 2023.

Key actions in Phase I include:

- ✓ Make full and timely payment of MDA electricity bills;
- ✓ Institute a least-cost fuel procurement strategy;
- ✓ Adopt a competitive procurement policy for Energy Supply and Service Contracts, including placing a moratorium on unsolicited proposals; and
- ✓ Establish an Energy Sector Task Force (ESTF) to further develop, implement, and monitor the impact of the ESRP.

According to the ESRP, Phase II will lead to full cost recovery for gas and electricity, address overcapacity in the electricity subsector, oversupply in the gas subsector, and the accumulated Sector Arrears.

Key actions in Phase II include:

- ✓ Address excess take-or-pay generation capacity payments;
- ✓ Address the oversupply of gas by matching supply and demand;
- ✓ Complete gas infrastructure, pricing, and policy actions to reduce the gas tariff to the power sector;

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[69] Energy Sector Recovery Programme, Ministry of Energy report published on 7th May 2019

- ✓ Support the technical and operational performance of the electricity transmission infrastructure;
- ✓ Adoption of the cash waterfall and any other appropriate mechanism to ensure equity and transparency in disbursement of energy revenues;
- ✓ Institute tariffs and regulations on street lighting; and
- ✓ Adopt a funding plan for ongoing Sector Arrears.

Key actions for Phase III will be developed by the Energy Sector Task Force (ESTF) within 18 months of the commencement of the ESRP for review and approval of Cabinet sub-committee.

3.2.2 Progress of Planned LNG projects

Two major LNG projects so far and one is expected in the country by 2020. They are:

- ✓ the Tema LNG Terminal Company, and
- ✓ a small-scale virtual LNG pipeline project.

The **Tema LNG Terminal Company** project which is currently under construction is a **Floating Storage and Floating Regasification Unit** with expected capacity of **250 mmscfd** (1.7 mmtpa[70]) expected to be completed in 2020**.** The company secured a Construction Permit from the regulator in 2018[71]. GNPC has signed a 12-year agreement with Rosneft of Russia for the supply of the LNG.

GNPC earlier in 2017 signed an agreement with a private company, Quantum Power for the latter to construct and operate a 500 mmscfd[72] floating LNG storage, regasification and delivery facility moored offshore Kpone.

The estimated US$550 million facility signed with Quantum Power which was supposed to be operational in 2018 apparently fell through and has been replaced with the Rosneft facility.

In addition, the Tema LNG Project is expected to commence supply by the fourth quarter of 2020. Expected volumes from Tema LNG in 2020 is 75MMscfd. This would help meet Ghana's growing energy demand and would also provide the domestic power generation industry with reliable and

[70] https://www.hydrocarbons-technology.com/projects/tema-liquefied-natural-gas-lng-terminal/.
[71] The natural gas transport and use regulator is the Energy Commission
[72] https://www.hydrocarbons-technology.com/projects/tema-liquefied-natural-gas-lng-terminal/

clean fuel supply diversity of gas sources and significantly improve gas supply reliability.

The **small-scale virtual LNG pipeline** is a virtual pipeline project to supply gas to Sunon-Asogli and Trojan power plants. It is a stop-gap short-to-medium term measure to meet the fuel requirements of the said power plants. It would comprise seventeen '52-cubic-metre' LNG trucks ferrying LNG from small-scale LNG ships berthed at the Tema port; eight (8) trucks at the loading gantry at a time and additional eight (8) trucks moving every night to deliver the fuel to the 560 MW gas-fired Sunon-Asogli Power Plant thermal plants. Loading is estimated to take an average of an hour. Each LNG truck would take an average of 45 minutes to reach the Sunon-Asogli Power Plant where instant regasification is expected, taking advantage of the relatively high ambient temperatures. Initial contract quantity is said to be 60 mmscfd. This project is currently on hold if not cancelled facing challenges with the supply of the LNG for the project

Unlike the GNPC-Rosneft/Gazprom agreement, the source of LNG for the small-scale project is the **LNG2Africa initiative;** an Equatorial Guinea[7373] initiative to sell small-scale LNG for utilisation in Africa. Initial target countries are Togo, Burkina Faso and Ghana.

The LNG aspect of the project was apparently not well negotiated during the contracting process. The major shareholder of the LNG company in Equatorial Guinea, Shell International has blocked the deal ostensibly for not involving them right from the beginning.

[73] Equatorial Guinea has been an LNG producer since 2007 with production of 24,000-25,000 cu m per day (151,000 bpd LNG). Proven reserve estimated in 2010 was 4.5 Tcf. Target countries are Togo LNG project (MoU, April) 2018; Burkina (MoU,2017); and Faso LNG project Ghana LNG project (15-yr MoU) 150 mmscfd equivalent

4.0 The Regulatory Regime

4.1 The Electricity Supply Industry

The electricity industry in Ghana has been unbundled with separate jurisdictions into Generation, Transmission and Distribution. Generation and wholesale supply of electricity are liberalized and is undertaken by both state (VRA and BPA) and privately owned entities usually referred to as Independent Power Producers (IPPs).

The transmission system covers all the regions of the country. It connects all the major generation plants to Bulk Supply Points (BSPs) across the country. GRIDCo is the operator of the National Interconnected Trasmission System (NITS) and is responsible for the real-time dispatch (monitoring, coordination and control) of power system operations as well as cross-border power exchanges with neighbouring countries.

There are three power distribution entities in the country comprising two state-owned utilities: Electricity Company of Ghana (ECG) and Northern Electrification Distribution Company (NEDCo). The only private distributor, Enclave Power Company, operates in the Free-Zone Enclave and industrial estates in the Greater Accra region.

4.1.1 Licensing and Permitting

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

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

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

i. Number of power generation companies with Operation Licenses increased from 17 in 2016 to 18 at the end of 2019. The total capacity had also expanded from 4,562 MW in

2018 to about 4,990 MW as at the end of 2019.

ii. Electricity Embedded Generation license issued to Genser Power Limited[74], stood at two just as in 2016; 30 MW at Chirano and a 23 MW plant at Damang all in the Western Region. The 5 MW at Tema, however, has been decommissioned and the license withdrawn.

iii. Construction permits have been issued to the following two power companies with installed capacity totalling 740 MW:

a) Rotan Power Limited 660 MW Combined Cycle at Aboadze in the Western Region has renewed their construction permit. It was first issued in 2016.

b) 80 MW Simple Cycle Marinus Energy Power Plant at Anochie near Atuabo in the Western Region.

Sunon-Asogli has been issued with an export license to export excess power.

Enclave Power Company was issued with distribution and sale license to distribute and sell electricity to customers in Dawa Power Enclave (under-construction) besides its existing operations at Tema.

Bulk Customers of electricity operating in the deregulated Wholesale Electricity Market increased from 43 in 2017 to 50 as at the end of 2018.

4.1.2 Codes of Practices and Regulations

The Commission developed and launched the ***National Electricity Grid Code*** in 2012 to govern the operation of the National Interconnected Transmission System (NITS). The Grid Code specifies in detail the technical operational rules, codes and procedures as well as obligations and liabilities of all players in the market. Complementary to the National Electricity Grid Code, the Energy Commission Board approved the ***National Electricity Distribution Code*** that sets in detail, the minimum acceptable technical standards for the development of the electricity distribution networks, provides guidelines and technical requirements for interconnection and evacuation of embedded generation and other relevant issues related to the safe and reliable management and operation of the Electricity Distribution Network in accordance with LI 1816 and LI 1935.

[74] an IPP to distribute electricity to specific consumers in the distribution network

Both the **Grid Code** and the **National Electricity Distribution Code** are currently being updated to cover **Renewable energy and embedded generation**.

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

Pursuant to the above, a certification guideline has been developed. Furthermore, a curriculum for the certification examination was developed in conjunction with the Technical/Vocational Education Directorate of the Ghana Education Service in 2013.

In 2014, The Energy Commission in collaboration with the Technical Examinations Unit, of the Ghana Education Service conducted the first certification examination for potential and practicing electrician for certification as Certified Electrical Wiring Professionals (CEWPs).

Number of examinations conducted increased from nine (9) in 2017 to 13 as the end of 2019.

Full implementation of the wiring law came into effect in October, 2017. Under the full implementation, non-certified persons would not be allowed to practice. Also, CEWP persons are expected to invite certified inspectors to inspect their wiring jobs when complete. The certification is being expanded to cover solar infrastructural installations and technicians.

Also, EWR, 2011 LI 2008 mandates the Energy Commission to register all electrical contractors in the country. The exercise started last year. Also, the LI requires all buildings ten (10) years and older to be inspected to ascertain the integrity of its wiring installations. The Energy Commission also commenced this exercise in 2018, and about twenty (20) buildings have so far been inspected as at the end of the year.

As at November 2019, about 9,769 electricians had been certified as CEWPs and 154 as Certified Electrical Wiring Inspectors. The examinations are conducted twice in a year at 4 centres (Accra, Takoradi, Kumasi and Tamale).

The Commission continues to carry out public sensitization activities to create awareness in the general public on the provisions of the Regulations. In addition, the Commission has conducted training programmes in all the regional capitals for the CEWPs.

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

4.1.3 Establishment of Wholesale Electricity Market

The Power Sector Reform embarked on by Ghana in the 1990s adopted a Competitive Wholesale Electricity Market mechanism for Ghana and set out structures and frameworks to remove monopolistic tendencies and market dominance in the Power Sector. The reforms resulted in the unbundling of the Electricity Supply Industry, leading to the establishment of an independent Transmission Utility (GRIDCo).

The enactment of the Electricity Transmission (Technical, Operational and Standards of Performance) Rules, 2008, L.1934, defined the National Interconnected Transmission System (NITS)[75] and provided the legal framework for open, fair and non-discriminatory access to electricity transmission network for all industry players. The quest for a competitive power sector was further boosted by the enactment of Electricity Regulations 2008 (L.I.1937) which establishes a Wholesale Electricity Market (WEM) to facilitate provision of ancillary services in the National Interconnected Transmission System (NITS)[76].the wholesale electricity trading and the

The Ghana Wholesale Electricity Market is structured to consist of Bilateral Contracts between wholesale suppliers and other Market Participants for electricity supply, and a Spot Market to provide for additional electricity requirement by Market Participants beyond contracted capacity to make up for shortfalls and balances. The Electricity Regulations 2008 provides that the Electricity Market Rules are the primary guidelines that should govern operations in the Wholesale Electricity Market and is administered by GRIDCo, the Electricity Transmission Utility.

In accordance with Regulation 8(1) of L.I. 1937, no entity shall participate in trading in the Wholesale Electricity Market unless that entity has:

(a) An operating licence or permit issued by Energy Commission;

(b) Registered with the Electricity Transmission Utility; and

(c) Entered into a contractual arrangement with the Electricity Transmission Utility.

The operating licenses or permits issued by the Energy Commission are in the following

[75] The NITS consist of plants and equipment operated at high voltages including the 69kV, 161kV and 330kV infrastructure as well as the 225kV interconnection with La Cote D'Ivoire power system.

[76] The NITS is exclusive of embedded generation assets and infrastructure consisting of plants and equipment within the distribution network which are operated below 69kV and consisting of low voltage 33kV,11kV and 415V lines serving industrial and residential customers.

categories:

i. Electricity Wholesale Supply;

ii. Electricity Distribution;

iii. Electricity Brokerage; and

iv. Bulk Customer.

The administration and operation of the Wholesale Electricity Market by GRIDCo as per the Electricity Regulations 2008, is to be supervised by the Electricity Market Oversight Panel (EMOP) which advises the Energy Commission accordingly.

The EMOP was thus set up in 2015, and members of the panel had been nominated by the appropriate institutions and had since been approved by the Ministry. The EMOP was inaugurated in 2017, has been working and publishing a monthly bulletin which is available on the Commission's website[77].

4.2 The Natural Gas Supply Industry

Natural gas supply from Nigeria through the West African Gas Pipeline (WAGP) has now been improving though still unreliable primarily due to Ghana's indebtedness to WAGP as well N-Gas supply limitations[78] *(see Annex 4).* Gas from the indigenous fields is, therefore, mitigating the supply situation.

The key natural infrastructure include the Gas Processing Plant, the 20-inch natural gas pipeline from Atuabo through Essiama to Takoradi and also the lateral pipeline from Essiama to Prestea. In addition to the above, Genser Ghana Limited, is currently operating a 20-inch -158km pipeline from Prestea to Nyinahin in the Western Region. The pipeline is currently evacuating an average of 25 mmscfd to Genser power plants in Tarkwa, Damang and Chirano, all in the Western Region. ENI Ghana operates the Offshore Receiving Facility (ORF) at Sanzule. The ORF transports the ENI gas to the Atuabo or Ghana Gas pipeline network.

4.2.1 Licensing and Permitting

[77] http://www.energycom.gov.gh/index.php/planning/ghana-wholesale-electricity-market-watch-monthly-bulletin
[78] owners of the commodity

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

In 2017, BOST ceded the Natural Gas Transmission Utility License to operate the Natural Gas Interconnected Transmission System (NGITS) to the Ghana National Gas Company (GNGC) is The Energy Commission has thus further issued the following licenses to players in the Natural Gas industry.

i. Ghana National Gas Company (GNGC) holds a Gas Processing License.
ii. Two Natural Gas Bulk Customer Permits were issued in 2016 for downstream off-takers.
iii. Tema LNG Terminal Ghana limited currently holds a Construction Permit for the construction of an LNG facility.
iv. Volta River Authority (VRA) and Ghana National Petroleum Corporation (GNPC) both hold Natural Gas Wholesale Supply license.
v. Three companies currently hold a Provisional Natural Gas Wholesale Supply License.

4.2.2 Codes of Practices and Regulations

Since the natural gas industry is still new in Ghana and like any other energy industry, it is important that developers satisfy some basic requirements and comply with established regulation before the construction of facilities takes place. It is in this respect that the Energy Commission has developed the following Legislative Instruments (L.I.) with adopted Ghanaian Standards and which have been approved by Parliament:

i. Natural Gas Pipeline Safety (Construction, Operation and Maintenance) Regulation (L.I. 2189)
ii. Natural Gas Distribution And Sale(Technical And Operational) Rules, 2007(LI 1911)
iii. Natural Gas Distribution And Sale (Standard of Performance) Regulations, 2007(LI 1912)

iv. Natural Gas Transmission Utility(Technical And Operational) Rules, 2007(LI 1913)
v. Natural Gas Transmission Utility (Standards of Performance) Regulations, 2008(LI 1936)

A ***Natural Gas Transmission Access Code*** to establish conditions for Natural Gas Service Providers to have fair, transparent and safe access to the Natural Gas Transmission Network in Ghana, Access Code has also been developed in accordance with Sections 24, 27 and 28 of the Energy Commission Act, 1997 (Act 541). The Commission, however, has still not finalised the ***Occupational Health and Safety Regulation*** with adopted Ghanaian Standards.

4.3 Renewable Energy Update

As at the end of 2019, about 130 Provisional Wholesale Electricity Supply Licences had been issued to potential Independent Power Producers (IPPs) who proposed to develop a total of 7,030.6 MW of electricity from various renewable energy sources. Out of these, 63.8% are for solar photovoltaic (PV) generation.

About 40 licensees have moved to the Siting Permit stage of the licensing process of which about 30 are for solar PV. However, only 13 companies have been issued with Construction Permits with 11 being issued for the development of solar PV projects.

Four (4) Operational Wholesale Electricity Supply Licenses have been granted to the following companies:

i. BXC (Ghana) Company Limited (20MW solar PV plant located at Gomoa Onyadze in the Central Region.)
ii. Safi Sana Ghana Limited (100kW waste-to-energy plant located at Ashaiman in the Greater Accra Region).
iii. Meinergy Technology Company Limited (20MW solar PV plant located at Gomoa Onyadze in the Central Region).
iv. Crossboundary Energy Ghana Limited (400kWp rooftop solar PV plant at Kasapreko Company Limited located at Spintex Road, Accra.

However, in view of the excess grid generation capacity, the over-subscription of Power Purchase Agreements (PPAs) for solar and wind projects, the Energy Commission has placed a temporary

suspension of the issuance of Provisional Licenses for utility-scale solar PV and wind energy projects. This directive, however, does not apply to Bulk customers and the off-shore market. The Ministry of Energy has also issued a policy directive that effective 1st July 2019, all power (conventional and renewable) to be procured by any Government agency should be done through a competitive tendering process.

For 2019, Bui Power Authority's 45kW mini-hydro power plant located at Tsatsadu in the Volta Region, was commissioned. One (1) Provisional Licence was also issued to Volta River Authority for a proposed 120MW hybrid hydro-solar PV multipurpose dam at Pwalugu. Two (2) Construction Permits have been issued to CrossBoundary Energy Ghana Limited for their projects of 1.0MW each at Coca-Cola Bottling Company and Unilever Ghana Limited.

The Energy Commission, as part of the 5th Ghana Renewable Energy Fair and Energy Symposium held 7th – 11th October, 2019, organised the maiden edition of the High School Renewable Energy Challenge. The objectives of the Challenge include developing the research skills of Senior High School students and promoting technical innovation in renewable energy and instill in students a passion for solving renewable energy efficiency and climate challenges through innovation and research. 30 schools participated in the qualifying stages out of which 6 participated in the grand finale.

ANNEXES

Annex1 – Schematic Overview of Ghana Energy Demand and Supply System

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

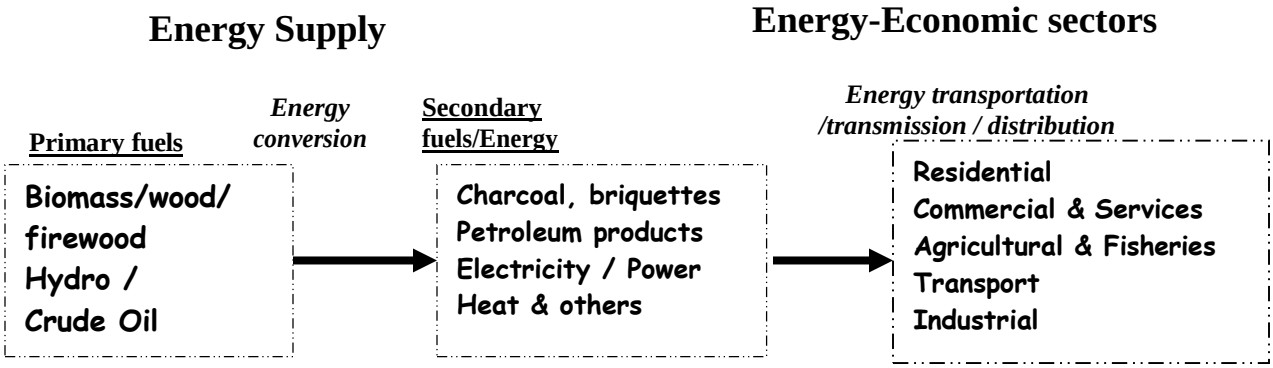
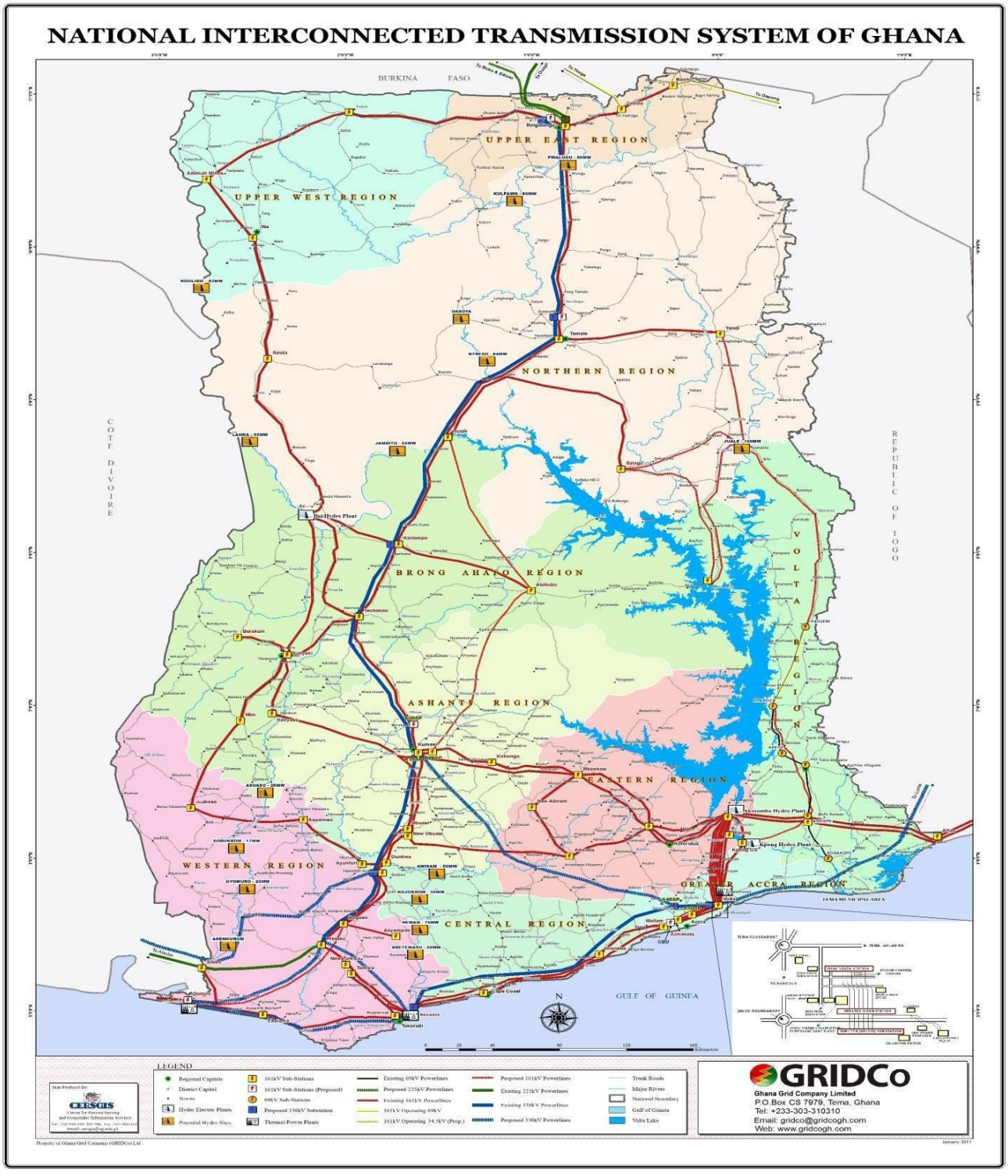


Figure Annex A1. Energy supply continuum

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

Figure A2. Energy supply continuum

Annex 2 – National Grid Transmission Map



Source: GRIDCo, 2018 Electricity Supply Plan

Annex 3 – Liquefied Natural Gas Regas Terminal Technologies

The normal way to transport natural gas is through pipelines, but pipelines aren't considered economical for transoceanic shipments of natural gas. Liquefied natural gas, or LNG, has been cooled so that it can be shipped more efficiently as a liquid in specially designed cargo ships. Transporting natural gas this way requires specialized facilities at both ends of the voyage.

LNG could be delivered through the following terminal technologies:

Temporary or stop-gap through "Energy Bridge Re-gasification Vessels" (EBRVs)

Floating Re-gasification plants using grounded LNG vessels which have retired from services.

- Permanent LNG re-gasification plants. Energy Bridge Regasification Vessels

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

Through the EBRV's connection with subsea buoy in the hull of the ship; and

through a high pressure gas manifold located in front of the vessel's LNG loading arms.

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

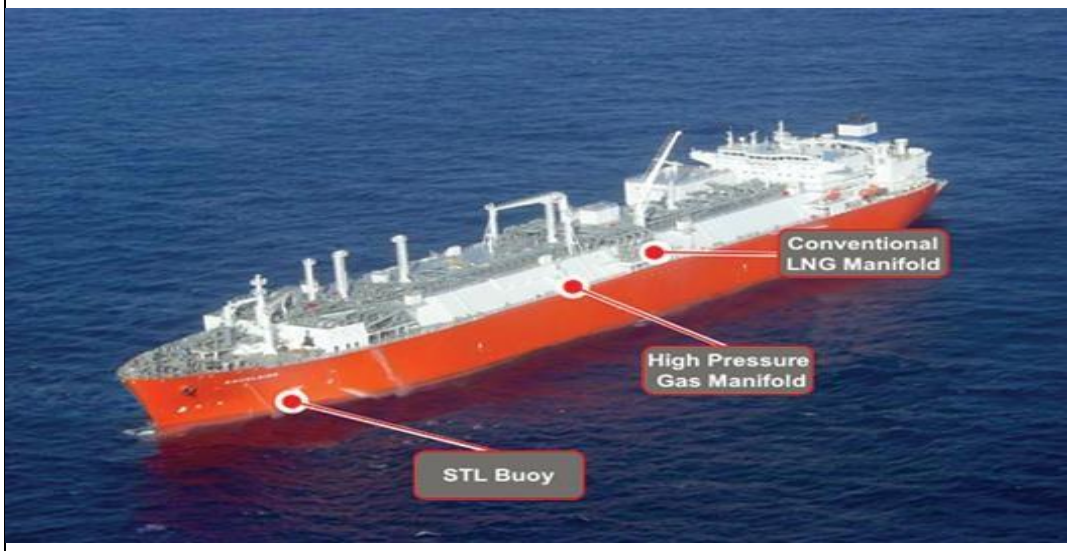


Figure A3. LNG Energy Bridge Regasification Vessel

LNG Floating, Storage and Re-gasification (FSRU) plants

Average lifetime of most LNG vessels is 25 years. This means LNG vessels built more than 25 years ago have become less competitive for transport services. Such an LNG ship is retired and reconfigured as floating storage LNG re-gasification unit or facility (FSRU). Typical LNG ship has capacity of 120,000-125,000 liquid cubic metres (lm^3). The larger the containment the greater the application for floating storage and regasification applications[80]. Construction of floating regas terminals has rapidly increased since 2005 when the first one was built in Louisiana, USA.

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

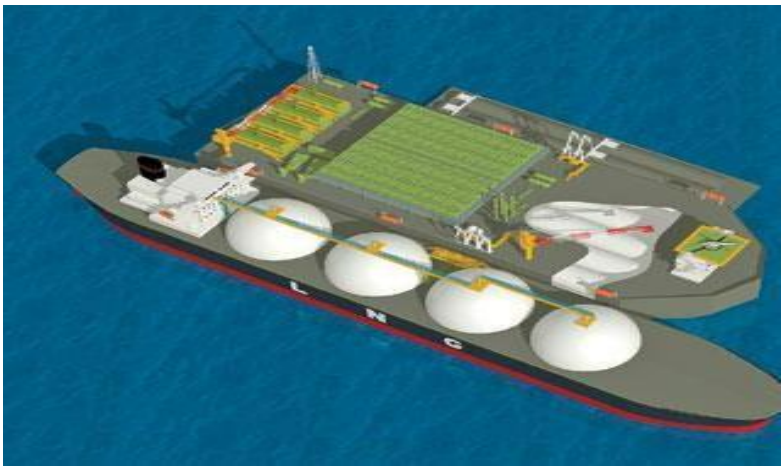


Figure A4. LNG Floating, Storage And Re-Gasification Plant

Permanent LNG discharge/re-gasification terminal

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

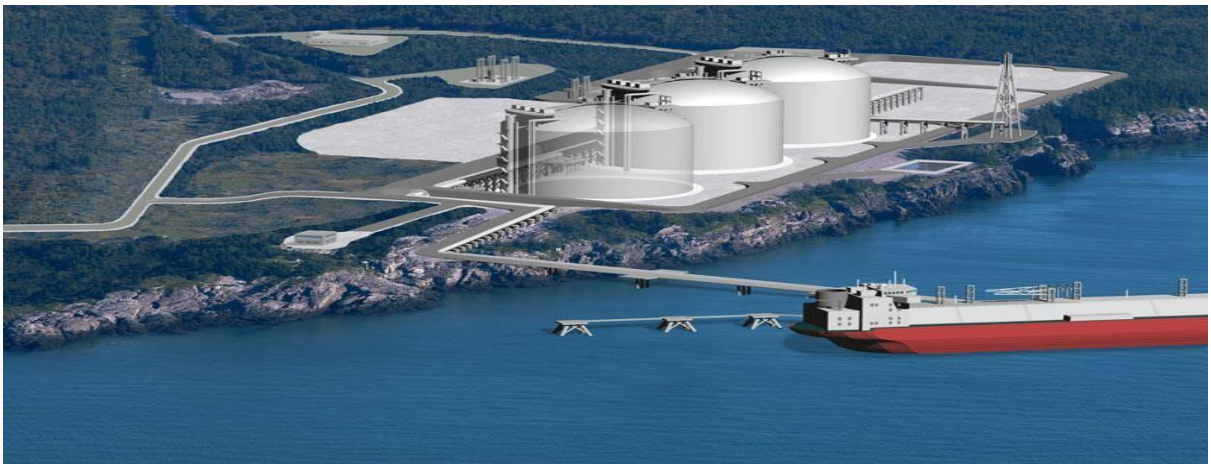


Figure A5: Permanent LNG Re-Gasification Terminal

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

Annex 4 – Nigeria Gas Supply Challenges

Ghana has been expecting much of its natural gas to come from Nigeria. However, there are over 25 grid-connected generating plants in operation in the Nigerian Electricity Supply Industry (NESI), with a total installed capacity of about **12,500 MW** and dependable capacity of about **6,800 MW**. Most generation is thermal based of total installed capacity of about 12,000 MW from 9000 MW in early 2018 [81]. Available capacity has however ranged between 3,500-5,000 MW. The target is to hit 15,000 MW by 2020 against an estimated demand of 26,651 MW by the end of the decade[82].

Nigeria estimates that it would require 40,000 MW of additional capacity to address the energy needs.

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

The current policy of the Nigerian government somehow seems to be to meet local gas demand first before considering exports to neighbouring countries. For this reason, there is a policy in place compelling all major gas shippers including N-Gas that ship gas to Ghana through the West African Gas Pipeline (WAGP) to meet local supply quota first before export. As at the end of 2013, most shippers were finding it difficult to meet the local quota obligation. Besides, the sabotaging of oil and gas facilities in the Delta region still remains a challenge[83]. These are contributing to the relatively low average supplies to the WAGP, aside untimely payments by off-takers particularly in Ghana for gas supplied.

The country has done well in reducing gas flaring over the years from 2 bcfd in 2015 to about 750 mmscfd, this still equates to burning $700 million annually or wasting fuel that could have been used to generate nearly 3,000MW of electricity.

Thus for N-Gas of Nigeria to limit gas supply to WAGP at the contracted volume of 123 mmscfd instead of the full capacity of 440 mmscfd as originally agreed in the supply contract is of concern but not hopeless[84]. The supply balance of 312 mmscfd reinforces the opportunity for the development of a viable alternative supply option such as an LNG terminal along Ghana's coast.

[81] http://www.nipptransactions.com, 2017
[82] Power Generation: Status and Outlook, a presentation by Presidential Task Force on Power, at Electric Power Investors ' Forum by Bureau of Public Enterprises,
[83] Orient Energy Review, Vol.5 No. 02/03 Feb-March, 2018.
[84] Energy Commission source