2020-2022 REPORT

REVIEW OF THE PERFORMANCE OF THE GHANA WHOLESALE ELECTRICITY MARKET FROM 2020 TO 2022

ELECTRICITY MARKET OVERSIGHT PANEL
EMOP
ENERGY COMMISSION

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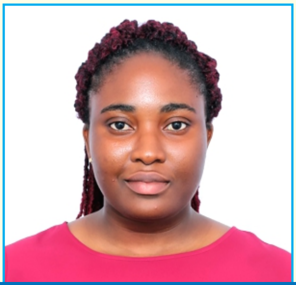

Maame Serwaa Tuffour

FOREWORD

The Electricity Market Oversight Panel (EMOP) is established by the Energy Commission to supervise the administration and operation of the Ghana Wholesale Electricity Market (GWEM). The EMOP is also to advise the Energy Commission on the operation and administration of the GWEM. The mandate of EMOP entails monitoring, settling disputes and ensuring transparency in the GWEM.

Transparency in the GWEM is essential in ensuring confidence in the market. One way to ensure transparency is the dissemination of market information that is, making market information available to every stakeholder. This would enable Market Participants, potential Market Participants and other Stakeholders to make informed decisions in the market.

To this end, the EMOP has been publishing market information on a weekly, monthly and yearly basis. The weekly data provides daily information and is published in the 'Weekly Statistics'. Publication of the Weekly Statistics commenced in 2018. The monthly data is published in the 'Market Watch', which commenced in January 2016.
In the year 2020, the EMOP commenced the publication of the 'Annual Report, A Review of the Ghana Wholesale Electricity Market (WEM)'. The 2019 Report was published in September 2020. The document contained the functions and achievements of EMOP, major happenings in the year, the performance of the WEM in 2019 and recommendations of EMOP on the proper functioning of the market.

Due to logistical constraints and the end of the tenure of the then members of the EMOP in 2020, the 2020 and 2021 Annual Reports were not published. The EMOP therefore decided to consolidate the 2020 to 2022 annual reports into a single report to be published in 2023.

The 2020 – 2022 report entails the major happenings in the GWEM for 2020, 2021 and 2022, the performance of the market and recommendations. This includes the state of the power market during the COVID-19 period, a review of the scheduling and dispatch process and natural gas dependency and its attending challenges.

This report is also in fulfilment of the EMOP reporting requirement in the Electricity Regulations, 2008, L.I. 1937.

This report has been published under my authority as Chairman of the EMOP of Ghana.

Ebo. B. Quagrainie
Chairman, EMOP

ACKNOWLEDGEMENTS

I would also like to thank the Ministry of Energy, Energy Commission, Public Utilities Regulatory Commission, Ghana Grid Company Limited, Market Participants and all other stakeholders for their support. I would like to express my profound appreciation to the Members of the EMOP and the Secretariat for their devotion and hard work towards the achievement of EMOP's mandates. I urge all stakeholders to continue to assist the EMOP in its desire to ensure that the Ghana Wholesale Electricity Market is fully functional for Ghana and the Regional Market to realize its full benefit.

DISCLAIMER

The graphs, tables and any other information incorporated into this report is intended for informative purposes only. It is also subject to change without notice to users of the report. The EMOP disavows any liability be it financial or legal, resulting from the use of the whole or any part of the information contained in this report.

The contents of this report provide a subjective valuation of what prevailed in the Wholesale Electricity Market from 2020 to 2022. The recommendations and some analyses made in this report are based on assumptions, expertise and possible prognoses, which may be tentative. No representation or guarantee which are made or implied in this report, is made as to the accuracy or completeness of the information contained in the report. Any view or recommendation presented in this document is subject to change without notice to any person or entity.

Table of **CONTENT**

Table Of **FIGURES**

List of **TABLES**

ACRONYMS / ABBREVIATIONS

GPP	–	Atuabo Gas Processing Plant
AMCS	–	Anokyi Mainline Compressor Station
bbl	–	barrels
BCM	–	Bilateral Contract Market
BPA	–	Bui Power Authority
BSP	–	Bulk Supply Point
Btu	–	British thermal unit
CBGC	–	Composite Bulk Generation Charge
CEB	–	Communauté Électrique du Bénin
CIE	–	Compagnie Ivoirienne d'Electricité
DFO	–	Diesel Fuel Oil
EC	–	Energy Commission
ECG	–	Electricity Company of Ghana
EMOP	–	Electricity Market Oversight Panel
EPC	–	Enclave Power Company
ESP	–	Electricity Supply Plan
GDP	–	Gross Domestic Produce
GHp	–	Ghana Pesewa
GNGC	–	Ghana National Gas Company
GoG	–	Government of Ghana
GPP	–	Gas Processing plant
GRIDCo	–	Ghana Grid Company
GSA	–	Gas Supply Agreement
GWEM	–	Ghana Wholesale Electricity Market
GWh	–	Gigawatt hours
HEP	–	Hydro Electric Plant
HFO	–	Heavy Fuel Oil
IPPs	–	Independent Power Producers
KTPP	–	Kpone Thermal Power Plant
kV	–	Kilovolts
kWh	–	Kilowatt-hour
LBCS	–	Lagos Beach Compressor Station
LCO	–	Light Crude Oil
LPG	–	Liquefied Petroleum Gas
MGHS	–	Million Ghana Cedis

MW	–	Mega Watt
MMBtu	–	Million British thermal unit
MMScf	–	Million Standard Cubic Feet
NEDCo	–	Northern Electricity Distribution Company
NITS	–	National Interconnected Transmission System
PPA	–	Power Purchase Agreement
PURC	–	Public Utility Regulatory Commission
SAPP	–	Sunon Asogli Power Plant
SONABEL	–	Société Nationale d'électricité du Burkina Faso
TAPCO	–	Takoradi Power Company
TICO	–	Takoradi International Company
TT1PP	–	Tema Thermal 1 Power Plant
TT2PP	–	Tema Thermal 2 Power Plant
TRMS	–	Takoradi Regulating and Metering Station
TWh	–	Terawatt Hours
US$	–	United States Dollar
US cents	–	United States Cent
VALCO	–	Volta Aluminum Company
VRA	–	Volta River Authority
WACoG	–	Weighted Average Cost of Gas
WAGP	–	West African Gas Pipeline
WAPCo	–	West African Gas Pipeline Company
WEM	–	Wholesale Electricity Market
WHO	–	World Health Organization

EXECUTIVE SUMMARY

System Peak Load between 2020 to 2022, grew by an annual average of 11.2% from 2,804 MW in 2020 to 3,246.1 MW in 2021 and 3,469.4 MW in 2022. On average, 60% of the System Peak Load from 2020 to 2022 was supplied by thermal power plants. Electricity supply also grew by an average of 6.8% annually from 19.72 TWh in 2020 to 22.48 TWh in 2022.

Similarly, electricity consumption grew by 7% annually from 2021 to 2022. Out of the total electricity consumed in GWEM from 2020 to 2022, an average of 78.6% and 8.1% was consumed in the Regulated and De-regulated Market respectively.

In 2020, a total of 111.98 trillion Btu of fossil fuel was used by thermal power plants for electricity generation. A total of 117.4 trillion Btu of fuel was used in 2021, 4.8% higher than the fuel consumed in 2020. Fuel consumption increased by 8% in 2022 compared to 2021. It increased from 117.4 trillion Btu in 2021 to 126.8 trillion Btu in 2022,

The price of natural gas sold to the power plants for electricity generation in Ghana is approved by the PURC through the Weighted Average Cost of Gas (WACoG). Natural gas price was 6.08 US$/MMBtu in 2020, 2021 to July 2022. Natural gas prices were reduced to 5.91 US$/MMBtu in September 2022.

The cost of electricity supply increased from an estimated GHS9.1 billion in 2020, GHS10.1 billion in 2021 to GHS14.96 billion in 2022. This translates to 5.49%, 5.76% and 8.32% of GDP in 2020, 2021 and 2022 respectively. The value of bilateral contract trade also increased from GHS8.33 billion in 2020, GHS9.17 billion in 2021 to GHS13.68 billion in 2022. The cost of supply by IPPs was GHS5.03 billion in 2020, GHS7.02 billion in 2021 to GHS8.68 billion in 2022. These represent 3.03%, 4.02% and 4.82% of GDP in 2020, 2021 and 2022 respectively.

The total transmission system losses reduced from 4.7% in 2019 to 4.5% in 2020 due to the energization of the 330 kV Aboadze – Anwomaso and, the 330 kV Kintampo – Adubiyili – Nayagnia line circuits in the last quarter of 2019. Losses in 2021 increased to 5% due to the conservative dispatch of the Bui hydro plant as a result of the low reservoir level in the first half of the year, causing poor voltages in Kumasi and the Northern parts of the grid.

The reinforcement of the grid that took place in the last quarter of 2021 resulted in a significant reduction in losses in 2022 to 4.1%.

The West African Gas Pipeline Company Limited (WAPCo), operators of the West African Gas Pipeline (WAGP) in consultation with its stakeholders in Ghana, Togo, Benin and Nigeria embarked on a cleaning and inspection of its offshore pipeline from Nigeria to Ghana from 20th January 2020 and ended on 27th February 2020.

In 2020, a worldwide pandemic was declared by the World Health Organization (WHO) known as COVID-19. The mode of transmission of the virus and its unknown dangers such as treatment necessitated the periods of lockdown and closure of all borders in the country including the airport. To ensure continues supply of electricity, the GoG gave special dispensation to expatriate workers providing power supply-related services or activities to enter the country during the closure of all airports in the country.

The membership of the EMOP was reconstituted on the 25th of November, 2021 by the Minister for Energy. There were five new members in the reconstituted EMOP. The Chairman, Mr Michael Opam was replaced by Mr Ebo B. Quagrainie, and the representatives of Wholesale Suppliers, Mr Abubakari Obuama Addy and Nana Osae Nyampong VI were replaced by Ing. Emmanuel Antwi-Darkwa and Ing. Richard Badger respectively. Ing Jonathan Amoako-Baah, CEO of GRIDCo was replaced by Ing Ebenezer Essienyi. The Executive Secretary of PURC, Mrs Maame Dufie Ofori was replaced by Dr. Ishmael Ackah.

In November 2021, GRIDCo, in consultation with the major off-takers on the National Interconnected Transmission System (NITS), developed a new dispatch protocol manual under the guidance and supervision of the Energy Commission.

Natural gas consumption in the Ghana Wholesale Electricity market has increased over the years from 94.4%% of the total thermal power plant fuel consumption to 97.7% in 2022. The future of electricity supply is from thermal sources using natural gas as the primary fuel supply. There is, therefore the need to ensure diversity and reliability of natural gas supply. This may be achieved through broad stakeholder engagement to fashion out the most cost-effective and efficient solution to Ghana's natural gas security dilemma.

The power market requires a balance between demand and supply especially since electric energy cannot be stored in large quantities. A balance between supply and demand is needed to maintain the integrity of the National Interconnected Transmission System (NITS). To achieve this, a robust ancillary services market including the reserves market needs to be in place to adequately compensate for services provided and also ensure standards services been provided. A well-functioning ancillary service market is therefore essential to maintaining the reliability of the NITS and improving the viability of the market.

INTRODUCTION

THE ELECTRICITY MARKET OVERSIGHT PANEL - ITS CONSTITUTION AND FUNCTIONS

The Electricity Market Oversight Panel (EMOP) is established by regulation 16 (1) of the Electricity Regulations, 2008 (L.I. 2008) to supervise the administration and operation of the wholesale electricity market. The EMOP is empowered to discharge its functions and operations independently of the Utility as well as advise the Energy Commission regarding the operations and administration of the wholesale electricity market.

The Electricity Market Oversight Panel EMOP is an 11 - member panel consisting of:

(a) The Chairperson;
(b) The Executive Secretary of the Energy Commission;
(c) The Executive Secretary of the Public Utilities Regulatory Commission (PURC);
(d) The Chief Executive Officer of Ghana Grid Company Limited (GRIDCo);
(e) The Head of System Operations and Control of GRIDCo;
(f) One representative nominated by;
    a. the Distribution Licensees, and
    b. the Bulk Customers
(g) Two representatives nominated by the Wholesale Suppliers;
(h) One person responsible for the administration of the Electricity Market Oversight Panel; and
(i) One other person with knowledge and experience in matters relevant to the wholesale electricity market.

The functions of EMOP are to:

(a) Monitor the general performance of the market administration functions of the Utility;
(b) Ensure the smooth operation of the wholesale electricity market;
(c) Review the operations of the wholesale electricity market and studies related to the development of the market;
(d) Procedures, manuals, and electricity market rules for the operation of the wholesale electricity market;
(e) Monitor pre-dispatch schedules;
(f) Resolve disputes referred to it by Market Participants in respect of transactions in the wholesale electricity market; and
(g) ensure the long-term optimisation of the hydroelectric supply sources in the country.

This report on the Ghana Wholesale Electricity Market (GWEM) is presented by the EMOP in compliance with Electricity Regulations 2008 (L.I. 1937) and makes information on the GWEM available to stakeholders.

The report consists of the following four (4) Chapters:

Chapter One contains a review of the 2020 to 2022 performance of the GWEM concerning the electricity demand and supply in the market. It includes the performance of the transmission system, fuel supply and prices of liquid fuel. The chapter further outlines the structure and applicable pricing principles in the GWEM and provides a succinct review of commercial and financial transactions as well as the outcomes of prices in the GWEM in 2020, 2021 and 2022.

Chapter Two presents some developments in the GWEM from 2020 to 2022 including the reconstitution of the EMOP and the 2020 to 2022 Legacy Hydro allocation.

Chapter Three (3) provides discussions on some pertinent issues in the GWEM.

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Chapter Four (4) contains key recommendations required to ensure the smooth operation of the GWEM.

CHAPTER 1

GHANA WHOLESALE ELECTRICITY MARKET TRADING

1 Estimated Value of Electricity Traded from 2020 to 2022

Table 1: **Summary of trading in the GWEM from 2020 to 2022**

GWEM	2020	2021	2022
Total Traded (GWh)	19,574.70	21,378.85	22,478.46
Total Value (MGHS)	9,116.70	10,053.50	14,976.57
% of GDP	5.49%[1]	5.76 %[2]	8.32%[3]
Bilateral Contract Market			
Total Traded (GWh)	13,551	14,849	15,761
Total Value (MGHS)	8,334.60	9,166.86	13,695.73
% of GDP	5.02%	5.25%	7.61%
Spot Market[4]			
Total Traded (GWh)	6,023.70	6,529.61	6,717.56
Total Value (MGHS)	782.1	886.64	1,280.84
% of GDP	0.47%	0.51%	0.71%

The estimated value of electricity traded increased by 10.3% from 2020 to 2021. That is, the value of electricity increased from GHS 9.1 billion to GHS10.1 billion. Correspondingly, the value of electricity traded as a percentage of Gross Domestic Product (GDP) increased from 5.49% in 2020 to 5.76% in 2021.

The estimated value of electricity traded increased from GHS9.1 billion in 2020 by 10.3% to GHS10.1 billion in 2021. Consequently, the value of electricity traded as a percentage of Gross Domestic Product (GDP) increased from 5.49% in 2020 to 5.76% in 2021.

In 2022, the estimated value of electricity traded increased from its 2021 value by 48.8% to GHS14.96 billion, representing 8.32% of GDP.

The value of Bilateral Contracts accounted for an average of 91% of the total electricity traded between 2020 to 2022 while the Spot Market accounted for the remaining 9%. The estimated value of electricity traded through bilateral contracts increased from GHS8.3 billion in 2020 to GHS13.7 billion in 2022. Likewise, electricity traded in the Spot Market increased from GHS0.78 billion in 2020 to GHS1.28 billion in 2022.

The estimated values of electricity supplied by IPP's were GHS5.04 billion in 2020, GHS7.02 billion in 2021 and GHS8.68 billion in 2022. As a percentage of GDP, this accounted for 3.03%, 4.02% and 4.82% in 2020, 2021 and 2022 respectively.

[1] Source from 2024 Budget Statement, 2020 GDP of GHS 166,157 Million constant 2013 prices
[2] Source from 2024 Budget Statement, Provisional 2021 GDP of GHS 174,592 Million constant 2013 prices
[3] Source from 2024 Budget Statement, Projected 2022 GDP of GHS 179,966 Million constant 2013 prices
[4] Currently only Akosombo and Kpong power plants are traded in the spot market. These plants are traded in the spot market due to restriction to bilateral contracts in the L.I. 1937.

2 Electricity Demand

System Demand Overview

The System Peak Load comprises the Domestic Peak Load and Export Loads. The System Peak Load witnessed an average annual growth rate of 7.7% from 2015 to 2019. Between 2020 to 2022, the System Peak load grew by an annual average of 11.2% from 2,804 MW in 2020 to 3,246.1 MW in 2021 and 3,469.4 MW in 2022. This growth rate was higher than the projected annual growth of 6.7% in the 2020, 2021 and 2022 Electricity Supply Plant (ESP). The System Peak Load recorded in 2020 compares satisfactorily with the reviewed projected System Peak Load of 3,115.2 MW for that year. The System Peak load recorded in 2021 was 1.7% lower than projected in the 2021 ESP. Likewise, the System Peak Load recorded in 2022 was 2.7% lower than the projected 3,545.3 MW projected in 2022 ESP.

In 2020, 40.7% of the System Peak load, that is, 1,256.4 MW was from the hydroelectric power stations. The remaining 1,833.1 MW was generated by the thermal power plants, constituting 59.3% of the System Peak Load. In 2021, the thermal share of the System Peak Load was 58.9%, lower than its share in 2020. Thermal share however increased to 63% in 2022.

The Ghana Peak Load in 2020 witnessed an increase of 11.9% to 2,775.5 MW from 2,480 MW. It continued to increase by 7.4% in 2021 to 2,980 MW. The Ghana Peak Load further increased to 3,224.2 MW in 2022 by 8.2%. Between 2020 to 2022, Ghana's Peak demand has increased by 16.2%. This growth corresponds to 448 MW.

Electricity consumption in the GWEM increased by 9.7% from 17,034.6 GWh in 2019 to 18,693.51 GWh in 2020. Similarly, electricity consumption increased by 8.3% in 2021 compared to 2020, from 18,693.51 GWh to 20,429.29 GWh. Consumption also increased by 5.8% in 2022 from 20,249.29 GWh in 2021 to 21,421.2 Gwh.

Out of the total electricity consumed in GWEM in 2020, 14,468.67 GWh was consumed in the Regulated Market, representing 77.4%. Likewise, 16,180.31 GWh and 16,796.66 GWh were consumed in the regulated market in 2021 and 2022.

Electricity export reduced from 2,576.68 GWh in 2020 to 2,505.74 GWh in 2021 due to a reduction in export to our neighbouring countries in 2021. Electricity exports to CIE, CEB and SONABEL reduced from 1,855.12 GWh in 2020 to 1,733.98 GWh in 2021. Export to the neighbouring countries however increased by 28% from 2021 to 2022.

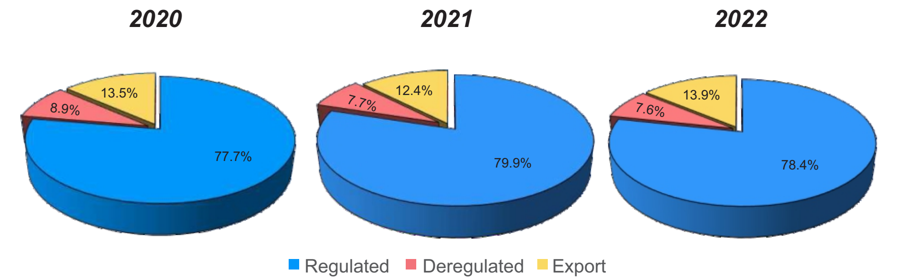
Export to CIE, CEB and SONABEL increased from 1,733.98 GWh in 2021 to 2,214.99 GWh in 2022. This resulted in an increase in electricity consumption in the export from 2,505.74 GWh in 2021 to 2,987.28 GWh in 2022.

Electricity consumed in the Deregulated Market reduced from 1,648.16 GWh in 2020 to 1,563.25 GWh in 2021, representing a 5.2% reduction. There was an increase in consumption by 4.7% in 2022 compared to 2021.

The Regulated Market accounted for between 77.4% and 79.9% of the total electricity consumed in the GWEM between 2020 and 2022. The Export Market accounted for about 13% of the electricity consumed in the GWEM from 2020 to 2022.

Figure 1 shows the proportions of electricity consumed in the GWEM by the various markets in 2020, 2021 and 2022 respectively.

Figure 1: **Proportion of the Electricity consumed in various Market in 2020 to 2022**



Regulated Market Demand

The players in the Regulated Market are the Distribution Companies, namely, the Electricity Company of Ghana (ECG), the Northern Electricity Distribution Company (NEDCo), and the Enclave Power Company (EPC).

The average electricity demand for the Regulated Market increased from 1,569.9 MW in 2019 to 1,999.42 MW in 2022, representing 8.4% average growth.

On a year-on-year basis, average electricity demand increased from 1,569.9 MW in 2019 to 1,729.5 MW in 2020 by 10.2%. 2021 also saw an increase of 12.4% to 1,944.7 MW. There was a marginal increase of 2.8% in 2022 to 1,999.4MW. The slowdown in the growth in 2022 can be attributed to the slowdown in the growth of the economy in 2022.

Cumulated electricity consumption by the Regulated Market was 14,468.67 GWh in 2020 higher than the 13,133.3 GWh recorded in 2019. This increased to 16,180.31 GWh in 2021 and to 16,796.66 GWh in 2022.

The electricity consumed by ECG customers in 2020 grew by 10.2%, from 11,487.2 GWh in 2019 to 12,653.33 GWh. In 2021, ECG's consumption increased to 14,194.9 GWh, a growth of 12.2%. The Year 2022 saw a marginal growth in ECG's customer consumption by only 4% to 14,755.7 Gwh.

NEDCo in 2020 recorded a growth of 11.5% in the total electricity consumed by its customers from 1,410.5 GWh in 2019 to 1,573.2 GWh. Electricity consumption grew by

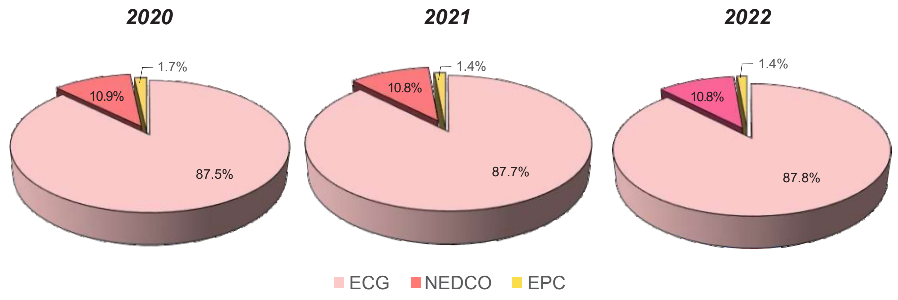
11.4% in 2021 to 1,752.9 GWh. Electricity consumption by NEDCo's customers increased in 2021. Similar to the trend in ECG's customer consumption, NEDCo's consumption grew by only 3.4% in 2022 to 1,813 Gwh.

The EPC's customer electricity consumption increased from 235.5 GWh in 2019 to 242.1 GWh in 2020, an increase of 2.8%. EPC's consumption however decreased by 4% in 2021 and further reduced by 1.9% in 2022 to 227.9 Gwh.

ECG, NEDCo and EPC accounted for an average of 87.7%, 10.8% and 1.5% respectively of the total electricity consumed in the regulated market for 2020, 2021 and 2022.

Figure 2 shows the proportion of electricity consumed in the Regulated Market for 2020, 2021 and 2022 respectively.

Figure 2: **Proportion of Electricity consumed in the Regulated Market for 2020 to 2022**



Deregulated Market Demand

The Deregulated Market in Ghana is made up of Bulk Customers whose consumption is above a threshold determined by the EC and who also purchase electricity directly from wholesale suppliers for their own consumption and are granted permits by the EC. HVThe Bulk Customers operating in the Deregulated Market include mining companies and large industrial customers. It is important to note that some Bulk Customers embedded within the distribution networks purchase their needs from the Distribution Companies but do not operate in the Deregulated Market. Currently, of the fifty-one (51) registered Bulk Customers, twenty-three (23) operate in the deregulated market.

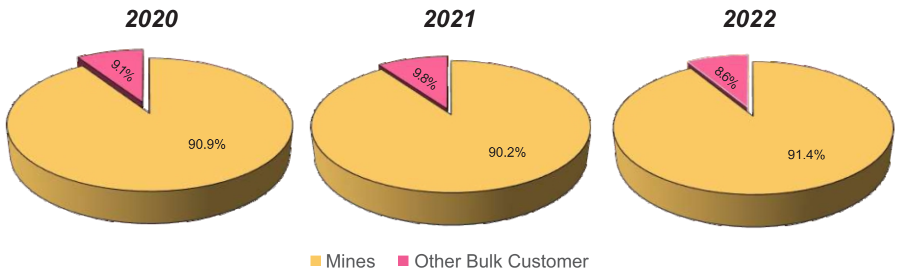
The average electricity demand of Bulk Customers grew by 4.2%, from 188.7 MW in 2019 to 196.6 MW in 2020. Electricity demand however decreased by 4.9% in 2021 to 186.9MW. There was a 4.5% increase in demand in 2022 to 194.9MW.

Electricity consumption in the Deregulated Market showed a decline of about 1.4% from 2020 to 2022. Electricity consumption reduced from 1,648.2 GWh in 2020 to 1,563.2 GWh in 2021. Electricity consumption increased by 4.7% in 2022 compared to 2021 but lower than the consumption in 2020. This increase can be attributed to the increased consumption of Newmont Ghana Gold limited and AngloGold in New Obuasi by 10.8% and 36.5% respectively.

The reduced trend in consumption in the Deregulated Market could be attributed to reduced consumption by the mines mainly as a result of Golden Star in Wassa resorting to the use of a Captive Generator. Consequently, the consumption of Golden Star reduced from 91.89 GWh in 2020 to 8.06 GWh in 2021. Similarly, Perseus Gold Mine's shift to captive generation resulted in reductions in its consumption from 132.4 GWh in 2020 to 123.3 GWh in 2021 and 54.47 GWh in 2022.

Figure 3 shows the proportion of electricity consumed by customer category in the Deregulated Market in 2020, 2021 and 2022 respectively.

Figure 3: **Proportion of the Electricity consumed by customer category in the De-regulated Market 2020 to 2022**



Export Market Demand

Ghana exports electricity on contractual arrangements to its neighbouring countries: Togo and Benin through Communauté Electrique du Bénin (CEB) and Burkina Faso through La Société Nationale d'Electricité du Burkina (SONABEL). In addition, there is a power exchange arrangement with Compagnie Ivoirienne d'Electricité (CIE) of La Côte d'Ivoire. Electricity supply to VALCO aluminum smelter, located in Tema, is also considered as part of the export market.

Export demand to the neighbouring countries, Togo, Benin, Burkina Faso and La Côte d'Ivoire grew by an average of 9.3% annually from 211.8 MW in 2020 to 252.85 MW in 2022.

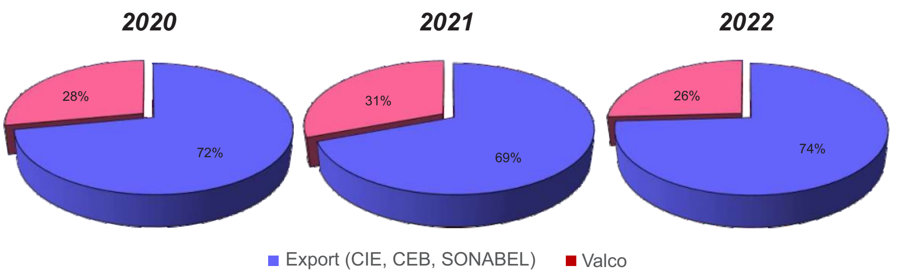
VALCO had an average demand of 90 MW from 2019 to 2022.

The electricity exported to the neighbouring countries increased from 1,855.12 GWh in 2019 to 2,214.8 GWh in 2022.

All exports to CIE from the beginning of 2020 to June 2021 were inadvertent. From July 2021, scheduled export to CIE commenced. A total of 106 GWh was exported from July 2021 to December 2021. A total of 267.2 GWh was exported in 2022 to CIE. An average of 744.7 GWh was supplied to CEB annually from 2020 to 2022. Electricity exported to SONABEL witnessed a significant growth of 60.8% from 627.5 GWh in 2019 to 1,008.8 GWh in 2020. There was a drop of 4.6% in electricity exported to SONABEL between 2020 and 2021. Exports to SONABEL increased by 25.2% from 962 GWh in 2021 to 1,204.2 GWh in 2022.

Figure 4 shows the proportion of electricity consumed by customer category in the Export Market in 2020, 2021 and 2022 respectively.

Figure 4: **Proportion of the Electricity consumed by customer category in the Export Market for 2020 to 2022**



[5] According to the PURC Act, Act 538

3 Electricity Supply

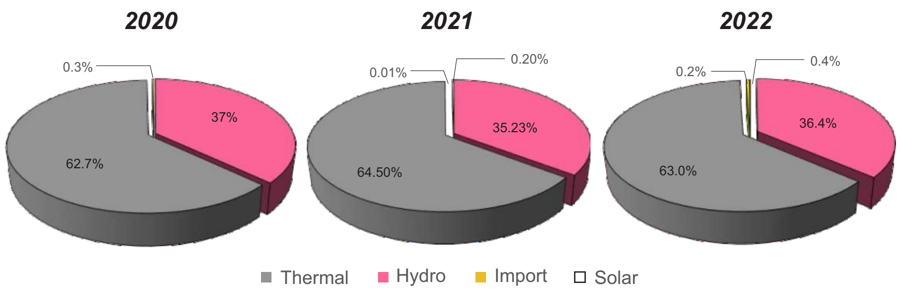
The total electricity supplied to the GWEM from 2020 to 2022 grew by an annual average of 6.9%, from 19,574.8 GWh in 2020 to 22,365.5 GWh in 2022. Electricity supply in 2021 was 21,317.7 GWh. Out of the total electricity supplied in 2020, 2021 and 2022, over 99.6% was from domestic sources whilst the remaining 0.4% was from inadvertent imports via the La Cote D'Ivoire intertie.

Thermal / Hydro Mix

The proportion of the electricity supplied from thermal sources increased in 2020 to 62.7%, from 59.7% recorded in 2019. The thermal proportion further increased to 64.5% in 2021 but reduced to 62.9% in 2022. Correspondingly, the hydro share decreased from 39.6% in 2019 to 37% in 2020. Hydro share further reduced to 35.3% in 2021. Hydro share however increased to 36.9% in 2022.

Figure 5 shows the proportion of electricity supply by sources for 2020, 2021 and 2022 respectively.

Figure 5: **Proportion of supply sources in the total Electricity supplied in 2020 to 2022.**

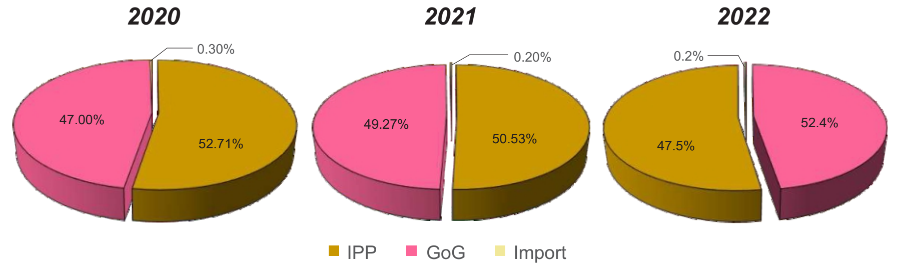


IPP and SoE Generation Mix

The proportion of IPPs in the total electricity supply decreased gradually from 2020 to 2022. The proportion reduced from 52.7% in 2020 to 50.5% in 2021 to 47.5% in 2022. GoG-owned power plants' share in the total electricity supply increased from 47% in 2020 to 49.3% in 2021 and to 52.4% in 2022. The share of imports decreased from 0.3% in 2020 to 0.2% in 2021 and 2022.

Figure 6 shows the proportion of IPP, GoG and import share in the total electricity supply for 2020, 2021 and 2022.

Figure 6: **Proportion of Electricity supply from IPP, GoG and import in 2020 to 2022.**

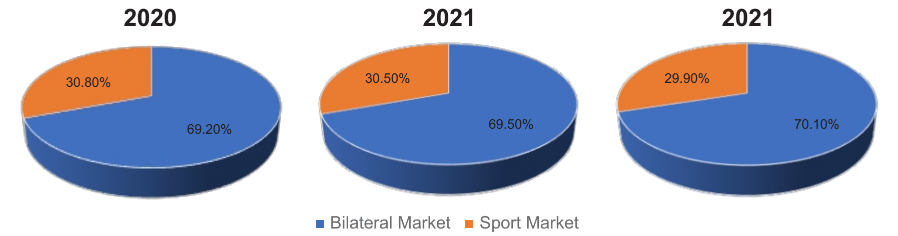


Bilateral / Spot Markets Proportions

The electricity supplied to the GWEM was either through the Spot Market or the Bilateral Contract Market (BCM). The share of bilateral contracts in the total electricity supply from 2020 to 2022 increased from 69.5% in 2020 to 70.1% in 2022. This is despite the increase in the volume of trade in the spot market from 6,023.7 GWh in 2020 to 6,717 GWh in 2022.

Figure 7 shows the proportion of bilateral and spot market trading in the WEM from 2020 to 2022

Figure 7: **Proportion of Bilateral and spot market trading in the WEM from 2020 to 2022**



4 Fuel Supply and Prices

Major events in 2020

The fuel for electricity generation by thermal power plants is natural gas, Heavy Fuel Oil (HFO), Light Crude Oil (LCO), and a small amount of distillate fuel oil (DFO) used primarily for starting and stopping gas turbines. The sources of natural gas supply are i) domestic oil and gas fields and ii) imports from Nigeria through the West African Gas Pipeline (WAGP). All liquid fuels for power generation are imported.

The West African Gas Pipeline Company Limited (WAPCo) operators of the West African Gas Pipeline (WAGP) in consultation with its stakeholders in Ghana, Togo, Benin and Nigeria embarked on a cleaning and inspection of its offshore pipeline from Nigeria to Ghana to protect the integrity of WAPCo's offshore pipeline which forms part of its regulatory requirement. The pipeline transports natural gas within the four (4) West African States of Nigeria, Benin, Togo and Ghana.

The exercise commenced on 20th January 2020 and ended in March 2020. The pig was launched from Lagos Beach Compressor Station (LBCS) in Badagry, Nigeria and received at our Takoradi Regulating & Metering Station (TRMS) in Ghana.

As a result of the pigging exercise, reverse flow of gas from Takoradi to Tema as well as the supply of gas through the laterals to the various gas processing facilities in Tema, Lome and Cotonou was curtailed. Natural gas was however supplied in sufficient quantities from the east to Takoradi to facilitate the pigging process.

Major event in 2021

In January and February 2021, GNPC successfully undertook a 45-day High Flow Test required to end the Run-in Period (ended on 22nd February 2021) under the Sankofa/OCTP Gas Supply Agreement (GSA). This helped to reduce GNPC's monthly offtake obligation and liability.

Jubilee and TEN oil fields, together with GNGC (Ghana National Gas Company), also successfully conducted a 12-hour high gas flow test during the first half of the year. This test was conducted to assess the maximum export capacity of the Jubilee offshore facilities and Atuabo Gas Processing Plant (AGPP) and improve the reliability of the facilities along the gas supply corridor.

The Atuabo Gas Processing Plant (AGPP) underwent planned maintenance in the month of October 2021 lasting fourteen (14) days, starting from the 4th to the 18th of October, 2021. There were no Jubilee/TEN gas exports for the period. In the same month of October 2021, GNGC commissioned the Anokyi Mainline Compressor Station (AMCS).

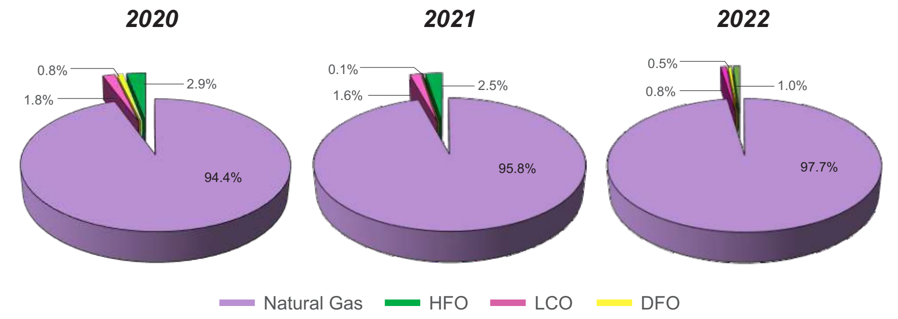
There were some challenges across the natural gas value chain, including offshore outages and shutdowns at the AGPP which affected gas supply during the period under review.

Fuel Supply

In 2020, a total of 111.98 trillion Btu of fossil fuel was used by thermal power plants for electricity generation in the Market. Of this total, 105.8 trillion Btu of natural gas was consumed, representing 94.4% and 3.2 Trillion Btu of HFO was consumed, representing 2.9%. The consumption figures for LCO and DFO were 2.1 trillion Btu and 0.8 trillion Btu, representing 1.8% and 0.8% respectively.

Figure 8 shows the proportion of the various types of fuel consumed in the GWEM for 2020 to 2022.

Figure 8: **Shows the proportion of fuel consumed for 2020 to 2022.**



A total of 117.4 trillion Btu of fuel was used in 2021, 4.8% higher than the fuel consumed in 2020. Natural gas consumption increased to 112.4 trillion Btu accounting for 95.8% of the total fuel used by thermal power plants in 2021. Liquid fuels accounted for 4.2% of the total fuel consumed by power plants in 2021. HFO, LCO and DFO accounted for 2.5%, 1.6% and 0.1% respectively of the total fuel consumed in 2021. This translates to 2.9 trillion Btu for HFO, 1.9 trillion Btu for LCO and 0.1 trillion Btu for DFO.

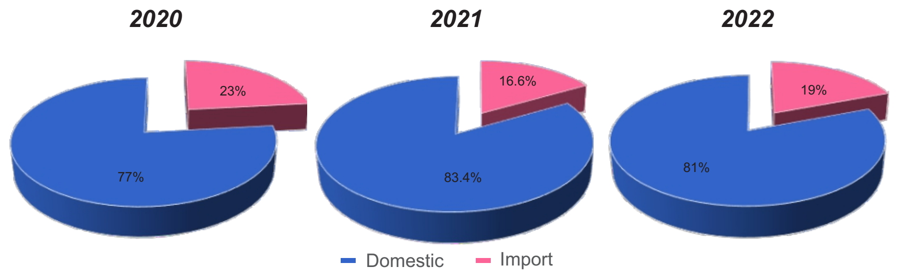
Fuel consumption increased to 126.8 trillion Btu in 2022, an increase of 4.9% from 2021. Liquid fuel was rarely used in 2022 as natural gas continued to dominate the fuel supply mix, accounting for 97.8% of the total fuel consumed. A total of 1.2 trillion Btu HFO, 0.98 trillion Btu LCO and 0.6 trillion Btu DFO were used in 2022.

6 Source: WAPCo
7 Source: 2022 Electricity Supply Plan

Natural Gas Consumption

Natural gas imports from Nigeria in 2020 accounted for 23% of the total natural gas consumed in 2020. A total of 24.7 trillion Btu of natural gas was imported in 2020. Domestic supply accounted for 77% of the total natural gas supply, that is, 81.3 trillion Btu.

Figure 9: **Shows the proportion of Natural Gas from the various supply sources in 2020 to 2022**



Domestic supply increased to 83.9 trillion Btu accounting for 83% of the total natural gas supply in 2021 whiles import was 17.2 trillion Btu accounting for 17% of the total natural gas supply.

Domestic supply reduced marginally in 2022 to 83.5 trillion Btu. Compared to 2021, imports increased to 19.8 trillion Btu in 2022.

HFO Consumption

HFO consumption decreased from 3.25 trillion Btu in 2020 to 1.21 trillion Btu in 2022. The reduction was due to the conversion of AKSA and Karpowership generating units to run on natural gas. Karpowership converted all of its generating units to run on natural gas while AKSA only converted 144 MW out of its 370MW to operate on natural gas.

LCO Consumption

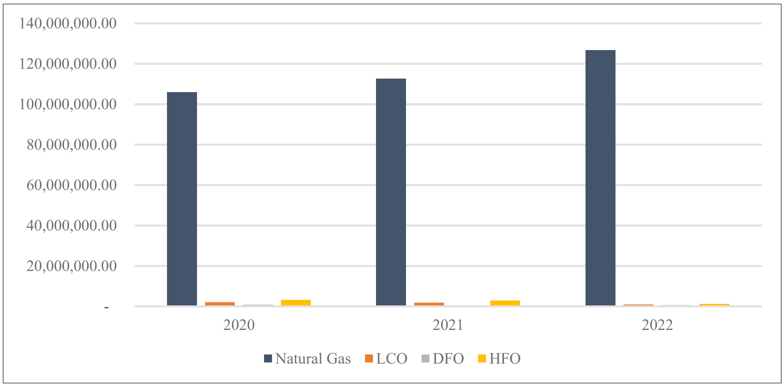
LCO was used in electricity generation during the periods when natural gas supply was reduced due to maintenance work or other technical challenges associated with the gas supply facilities. A total of 2.06 trillion Btu of LCO was consumed in 2020 during the WAPCo pigging period by Cenpower and TICO. LCO consumption decreased to 0.98 trillion Btu in 2022.

DFO Consumption

DFO consumption is used largely for starting and stopping the gas turbines. It is sometimes used by KTPP for electricity generation during system emergencies. A total of 0.92 trillion Btu of DFO was consumed in 2020. Out of the total, 0.76 trillion Btu was consumed during the period of the WAPCo pigging by KTPP. KTPP consumed 0.58 trillion Btu of DFO in February 2022 and June 2022 due to shortfalls in natural gas supply.

Figure 13 shows the trends in monthly fuel consumption from 2020 to 2022.

Figure 10: **Annual Fuel Consumption from 2020 to 2022.**



Fuel Prices

Natural Gas Prices

The price of natural gas sold to the power plants in Ghana is approved by the PURC using the Weighted Average Cost of Gas (WACoG). Natural gas price was US$/MMBtu6.08 from 2020 to July 2022 which reduced to US$/MMBtu5.91 from September 2022.

Liquid Fuel Prices

The prices of liquid fuel were affected by the COVID-19 pandemic and the Russian-

Ukraine war during the years under review, 2020 to 2022. The pandemic contributed to the reduction in liquid fuel prices whiles the Russian-Ukraine war contributed to an increase in the global prices of liquid fuels.

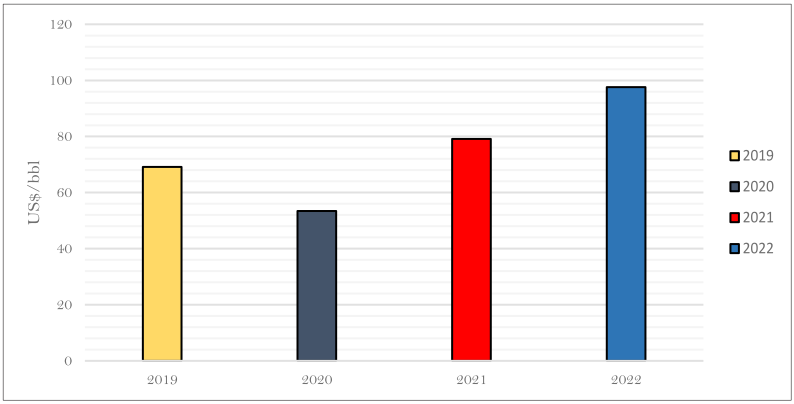
HFO Prices

The average price of HFO reduced by 22.7%, from an average of US$/bbl69.15 in 2019 to US$/bbl53.43 in 2020 with prices going as low as US$/bbl39.44. HFO prices ranged between US$/bbl61.37 to US$/bbl 94.58 in 2021.

In 2022, HFO prices soared to an average of US$/bbl97.6 and reached a peak of US$/bbl123.29 as a result of the Russian-Ukraine war.

Figure 15 shows the trend of HFO prices from 2019 to 2022.

Figure 11: **Trend of HFO prices from 2019 to 2022.**



LCO Prices

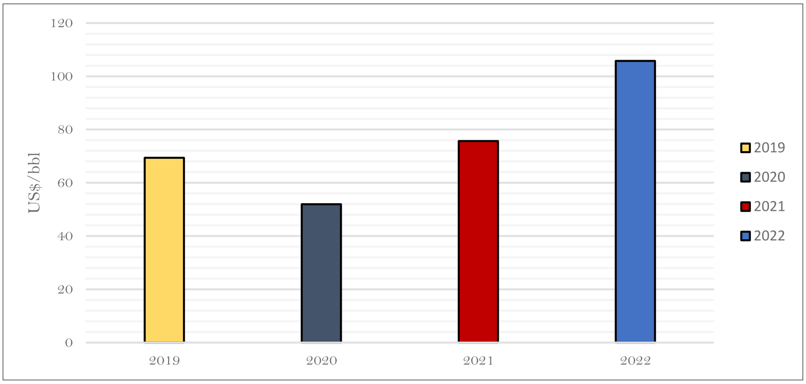
LCO prices reduced in 2020 by 25.4%, from an average of US$/bbl69.4 in 2019 to US$/bbl51.76. Prices plummeted from US$/bbl73.65 in January 2020 to US$/bbl28.38 in April 2020 due to the effect of the COVID-19 pandemic. Prices of LCO averaged US$/bbl75.68 in 2021.

The impact of the Russian-Ukraine war was also felt in 2022 as average LCO price in January of US$/bbl86.5 rose to US$/bbl122.71 by June and then reduced to US$/bbl80.92 in December 2022.

Figure 15 shows the trend of LCO prices from 2019 to 2022.

[8] Calculated based data from https://www.theice.com
[9] Data sources from https://www.eia.gov/dnav/pet/hist/rbrteD.htm

Figure 12: **Trend of LCO prices from 2019 to 2022**

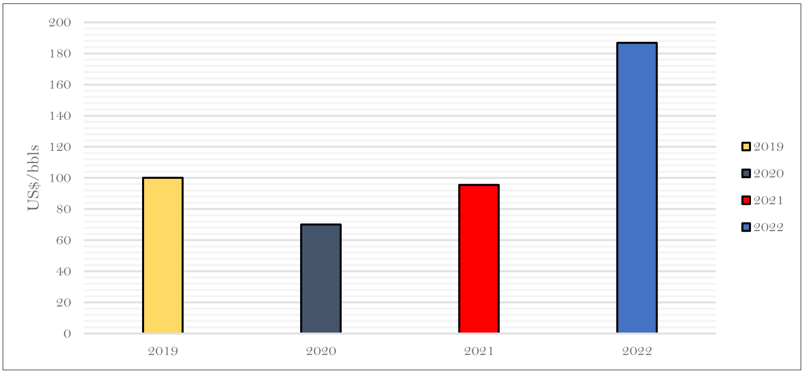


DFO Prices

DFO prices as other liquid fuel prices showed the same trend with prices at their minimum in 2020 and peaking in 2022. The price of DFO reached a maximum of US$/bbl186.81 in 2022 and had a minimum of US$/bbl70.09 in 2020.

Figure 17 shows the trend of DFO prices from 2019 to 2022.

Figure 13: **Trend of DFO prices from 2019 to 2022**



[10] Calculated from NPA data

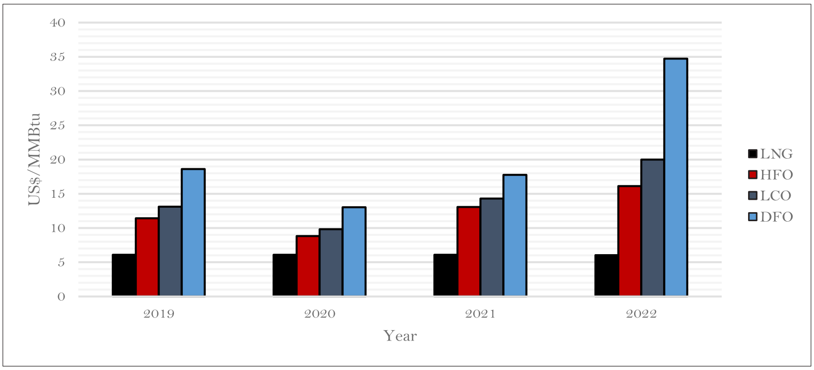
Price Comparison

Comparatively, the gazetted price of US$/MMBtu6.08 for natural gas was the cheapest source of fossil fuel for power generation even with the reduced prices of LCO and HFO in 2020. In September 2022, natural gas prices were reduced to US$/MMBtu5.95 during the major tariff review. The average natural gas price for 2022 was US$/MMBtu6.04.

HFO prices were relatively cheaper than all the other liquid fuels but was at least 45% higher than natural gas prices.

Figure 18 shows the price comparison between the fuels used by thermal power plants from 2019 to 2022.

Figure 14: **Average Annual Fuel prices from 2019 to 2022**



5 Performance of the National Interconnected Transmission System (NITS)

NITS performance in 2020

The natural gas supply outages in 2020, from mid-January 2020 to March 2020 resulted in reduced power generation in the Eastern Enclave. This resulted in low system voltages. The transmission system experienced some disturbances from 2020 to 2022 mostly on the Western to Northern transmission corridor.

Voltages at Achimota, Takoradi and Tamale were within the normal range for over 86% of the period while voltages in Mallam, New Tema and Kumasi were, over 60% of the time, within the normal range. The system frequency was within the prescribed band of 49.8Hz to 50.2Hz 78.5 % of the time.

The NITS registered an average availability of 99.85% as against the approved PURC 95% benchmark. ECG, NEDCO and other bulk customers recorded average feeder availability of 99.81%, 99.84% and 99.84% respectively.

[11] Sourced from 2021 Electricity Supply Plan

NITS performance in 2021

System frequency was within the normal range for 79.67% of the period in 2021 as compared to 78.5% recorded in 2020.

Voltages at peak for Mallam and Kumasi substations Bulk Supply Points were poor. The low voltages observed at Mallam were due to upgrade works on the 161 kV Accra Central – Mallam and Achimota – Mallam transmission lines. During this period, the two lines were taken out of service leading to low voltages at the Mallam substation.

The Bui HEP was shutdown during offpeak for some period in 2021 due to low water levels which resulted in low voltages in Kumasi.

The Achimota, Takoradi, Tamale and New Tema substations were however largely within the normal voltage limits.

NITS performance in 2022

The system frequency was within the normal range for 77.17%, marginally lower than the 79.67% recorded in 2021. The NITS registered an average feeder availability of 99.79% for the year. The transmission lines recorded an average availability of 99.26% for the period.

Transmission System Losses

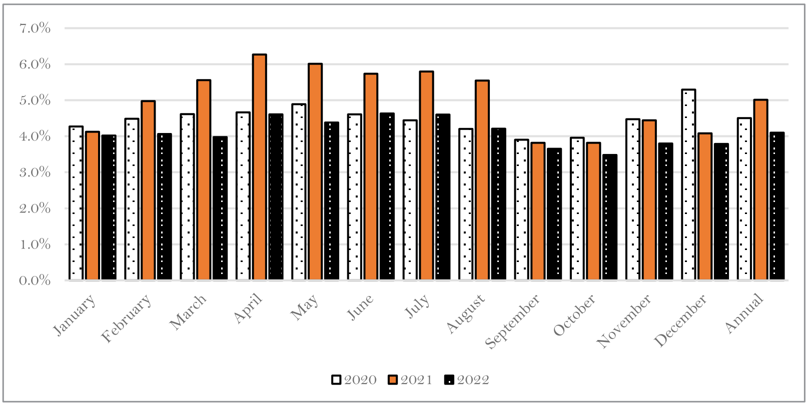
The total transmission system losses reduced from 4.7% in 2019 to 4.5% in 2020 due to the energization of the 330 kV Aboadze – Anwomaso and, the 330 kV Kintampo – Adubiyili – Nayagnia line circuits in the last quarter of 2019 . Further to the energization of the line, the Bui plant was dispatched one unit off-peak and two units during peak continuously due to the high reservoir elevation. This dispatch scenario improved the poor voltages normally experienced in the northern part of the grid which resulted in a reduction in losses. However, losses increased in the last quarter of 2020 which was attributed to increased energy transmitted to SONABEL and poor reactive power compensation across the NITS.

Losses in 2021 increased to 5% from 4.5% recorded in 2020. This could be attributed to the conservative dispatch of Bui HEP due to the low reservoir level in the first half of the year. The conservative dispatch of Bui HEP caused poor voltages in Kumasi and the Northern parts of the grid. The voltage situation improved in the fourth quarter of the year after the inflow season when the dispatch of the Bui hydro plant was increased. In addition, the 330 kV Anwomaso – Kintampo transmission line was completed and commissioned into service. Also, the first phase of the upgrade of the Volta-Achimota-Mallam line corridor and the addition of a third 161/34.5 kV 50/66 MVA transformer at Anwomaso contributed to reduce the losses in the last quarter of the year.

The reinforcement undertaken in the last quarter of 2021 resulted in a significant reduction in losses in 2022 to 4.1% from 5% in 2021.

Figure 19 shows the monthly electricity transmission losses from 2020 to 2022.

Figure 15: **Transmission Losses from 2020 to 2022**



6 Cost of Electricity traded in the WEM

Overview

The Electricity Regulations 2008, L.I. 1937 stipulates that electricity can be traded either through bilateral contracts or the Spot Market. Currently, electricity is traded mainly through bilateral contracts because the Spot Market is not yet developed. This notwithstanding, the L.I. 1937 mandates the sale of electricity from the Akosombo and Kpong hydroelectric power plants to be sold on the Spot Market. As a result, the EMOP has on an annual basis allocated the electricity supplied by the Akosombo and Kpong hydroelectric power plants to the Market Participants and Export.

In this report, prices in the GWEM have been calculated based on the following four (4) pricing methodologies. Using data on the actual monthly electricity dispatch for 2020, 2021 and 2022, the cost of electricity has been calculated in the various market segments of the GWEM using the following methods:

[12] Sourced from 2022 Electricity Supply Plan
[13] Sourced from 2023 Electricity Supply Plan

a) Average Total Costs (ATC) – equivalent to the total costs of electricity supplied (based on prices executed in the bilateral contracts and price of Akosombo and Kpong hydroelectric power plants as approved by PURC) divided by the total electricity supplied;
b) Spot Market Cost (SMC) – using the System Short-Run Marginal Cost (SSRMC) principles and per L.I. 1937;
c) PURC Gazetted Tariffs: Regulated Market – it is derived by converting the Composite Bulk Generation Charge (CBGC) contained in the PURC Gazette (denominated in GHp/kWh) into US$/MWh using the monthly average exchange rates between the Ghana cedi and the United States Dollar as determined by the Bank of Ghana; and
d) Estimated Regulated Market Price (ERMP) – it is the average total cost of electricity supplied to the Regulated Market based on the actual contract prices for the power plants and the accounting costs of the Akosombo and Kpong hydroelectric power plants.

Table 2 shows the monthly prices based on the methodologies discussed above for 2020.

Table 2: **Estimated Prices for Different Scenarios from 2020 to 2022**

	Average Total Cost (ATC)	**Spot Market Cost (SMC)**	**PURC Gazetted Tariffs**	**Estimated Regulated Market Price (ERMP)**
	US$/MWh	**US$/MWh**	**US$/MWh**	**US$/MWh**
2020	83.51	120.46	82.47	93.45
2021	80.96	106.29	77.28	94.58
2022	80.92	117.90	62.12	85.20

The ATC showed a downward trend from USD/MWh83.51 in 2020 to USD/MWh80.92 in 2022. This may be attributed to the increase in the use of cheaper natural gas as compared to liquid fuels. Natural gas share of the total fuel mix increased from 94.4% in 2020 to 97.7% in 2022. Liquid fuel was rarely used in 2021 and 2022.

The SMC also showed a downward trend from USD/MWh120.5 in 2020 to USD/MWh117.9 in 2022. The high SMC was due to the use of liquid fuel predominately during periods when natural gas was unavailable.

CHAPTER 2

DEVELOPMENT IN T HE WEM FROM 2020 - 2022

1 Impact of COVID-19 on Electricity Generation in 2020

Ghana recorded its first case of COVID-19 on 12th March 2020. Government response to limiting and stopping the importation of the virus into the country led to the closure of all borders on 22nd March 2020.

The government placed restrictions on public gatherings and on the 30th March 2020 placed a ban on movements in Greater Accra and Kumasi. Persons working in the energy sector were exempted from these restrictions. The ban on movement in these areas were lifted on the 22nd of April 2020 but other measures were introduced to limit the spread of the virus.

Electricity demand during the lockdown period reduced by 4.4% from 2,956.1 MW in March 2020 to 2,824.4 MW in April 2020. Likewise, electricity demand for April 2020 was 8.7% lower than projected in the 2020 ESP. Also, electricity supply reduced by 4.8% in April 2020 and was 1.5% lower than projected in the 2020 ESP. The reduction in electricity supply may be attributed to the lockdown as some companies and institutions closed down or reduced workforce and production to achieve the required social distancing to prevent the spread of the virus. The COVID-19 pandemic and its consequent lockdown did not lead to any load curtailment.

The Electricity Market Oversight Panel in March 2020 initiated a study on the impact of COVID-19 on the electricity supply industry especially power generators during the lockdown period. The study was to assess the impact of the restrictions on power generators and GRIDCo, taking cognizance of the fact that these institutions rely on the services of some foreign experts to undertake major maintenance and installation activities.

The study also considered activities that could be impaired by COVID-19 restrictions including planned maintenance work, forced maintenance work, fuel supply and staff availability.

A total of thirteen (13) generations of plants responded to EMOP's questionnaire, comprising eight (8) Government of Ghana (GoG) plants and five (5) IPPs. Four power plants had planned maintenance from March 2020 to April 2020. These included run-time hours, borescope inspection, hot gas path inspection, other repair works, and five (5) yearly level 'A' maintenance. Three (3) out of the four (4) power plants were unable to undertake these maintenance works due to COVID-19 restrictions. This they explained was due to the inability of expatriate consultants and engineers to either leave their countries or enter Ghana due to the closure of the borders.

Two (2) power plants had forced maintenance work to be undertaken within the period. One was unable to undertake the forced maintenance work due to the closure of the borders. To ensure appropriate social distancing, stations had to reduce their workforce, with some on rotation and others working from home.

Mandatory or forced maintenance works are important in maintaining the efficiency and reliability of the power plant. Therefore, power plant operators make it imperative not to miss any maintenance work as it can have dire consequences on the power supply and their contractual obligation.

For this reason, the GoG gave special dispensation to expatriate workers providing power supply-related services or activities in the country during the closure of all airports in the country. The Ministry of Energy representing the GoG, therefore, request stakeholders (power plant operators) to inform the Ministry of Energy in writing ahead of time to allow the Ministry to make the necessary preparations to facilitate travel.

2 EMOP Membership Reconstituted

The members of the EMOP are appointed by the Minister of Energy. Other than an ex-officio member, EMOP members shall hold office for a period not exceeding three years and is eligible for reappointment but a member shall not be appointed for more than two terms.

The tenure of the first panel members came to an end on the 21st of December, 2020. The Panel was reconstituted on the 25th of November, 2021 by the Minister for Energy. There were five new members in the reconstituted EMOP. The Chairman, Mr. Michael Opam was replaced by Mr. Ebo Bakers Quagrainie, and the representatives of Wholesale Suppliers, Mr. Abubakari Obuama Addy and Nana Osae Nyampong VI were replaced by Ing. Emmanuel Antwi-Darkwa and Ing. Richard Badger respectively. Ing. Jonathan Amoako-Baah, CEO of GRIDCo was replaced by the CEO, Ing. Ebenezer Essienyi. The Executive Secretary of PURC, Mrs. Maame Dufie Ofori was replaced by the Executive Secretary Dr. Ishmael Ackah.

At the inauguration, the newly sworn-in Chairman reiterated the commitment of the Panel to ensure that the wholesale electricity market of Ghana is fully operational to benefit the sector and the country at large.

Dispatch Protocol developed to guide the dispatch of power plants in the Wholesale Electricity Market

In November 2021, GRIDCo, in consultation with the major off-takers on the National Interconnected Transmission System (NITS) developed a Dispatch Protocol manual under the guide and supervision of the Energy Commission and in accordance with Electricity Regulations, 2008, (L.I. 1937).

The Electricity Regulations, 2008, (L.I. 1937) provides for the establishment of a Wholesale Electricity Market which shall consist of a bilateral contract and a spot market. However, the current framework of Ghana's Wholesale Electricity Market (WEM) is typically a bilateral contract one. Under many forms of bilateral contract markets, the off-taker is responsible for the commercial risks associated with the contracts.

Section 26 (1) of L.I. 1934 mandates Ghana Grid Company (GRIDCo) as the Electricity Transmission Utility to establish transparent Scheduling and Dispatch processes in carrying out its responsibility as the operator of the National Interconnected Transmission System (NITS). In line with this mandate, GRIDCo performs operational planning, pre-dispatch and real-time dispatch.

To consolidate the need for off-takers to be able to control their commercial risk and also to achieve the mandate of the L.I. 1937 and GRIDCo's operational mandate, the Dispatch Protocol was developed. The document provides a guide to the dispatch processes and gives clear instructions on decision-making to resolve real-time dispatch challenges on the NITS. The Dispatch Protocol was approved by all parties on 1st November 2021.

A copy of the dispatch protocol can be downloaded on the EC website:

The dispatch protocol manual is an important step in the development of Ghana's wholesale electricity market as it is geared towards allowing the off-takers to control their commercial risks while ensuring operational independence of the system operation functions of GRIDCo.

3 GRIDCo submits Market Rules for approval

The Ghana Grid Company completed and submitted the Draft Market Rules to the Energy Commission for approval in accordance with Regulation 15 (a) of the L.I. 1937 in October 2022. The Market Rules governs the operations and administration of the GWEM.

The Market Rules follow from the development of the market design which serves as the framework for the development of the rules.

The market rules provide for the following:

1. Wholesale market procedures, including invoicing, payments, adjustment of payments with interest for late or overpayments, and monetary penalties;
2. The market manuals; and
3. Procedures for settling complaints and disputes among market participants.

The Energy Commission referred the Market Rules to the EMOP for advice.

4 Legacy Hydro Allocation Framework

Guiding Principles

The allocation of the legacy hydro-electricity supplies is guided by the following principles:

a) Government of Ghana (GoG) policy directives (adequate supply for VALCO and Ghana Water Company Limited);

b) Ensure that the cost of electricity supply to the export market is competitive in terms of pricing; and
c) Equitable allocation to all other consumers in the electricity market.

Allocation Timelines

Electricity generation from the legacy hydroelectric power plants is forecasted on a five-year rolling time scale by VRA and submitted to EMOP by the end of October each year. EMOP decides on the allocation of the hydro generation by the end of November of each year and submits it to the Ministry of Energy, EC, VRA, GRIDCo and PURC.

Modelling

The model used for the allocation of electricity generated from the Akosombo and Kpong hydroelectric power plants is contained in Appendix 6 of this document.

Tables 3, 4 and 5 show the hydro allocation for the years under review.

Table 3: **Legacy Hydro Allocation for 2020**

Customers	Allocation (GWh)	Percentages (%)
VALCO	1,287.3	21.46
Export	864.68	14.41
GWCL	70.37	1.17
Subtotal	2,222.35	37.04
Distribution Utilities	3,296.01	54.93
Bulk Customers	481.64	8.03
Subtotal	3,777.65	62.96
Total	**6,000.00**	**100**

Table 4: **Legacy Hydro Allocation for 2021**

Consumers	Allocation (GWh)	Percentages (%)
VALCO	824.27	12.68
Export	903.26	13.90
GWCL	70.51	1.08
Subtotal	***1,798.04***	**27.66**
Distribution Utilities	4,169.34	64.14
Bulk Customers	532.62	8.19
Subtotal	***4,702***	**72.34**
Total	**6,500.00**	**100.00**

Table 5: **Legacy Hydro Allocation for 2022**

Consumer	Allocation (GWh)	Percentage (%)
VALCO	771.46	11.87
Export	1,022.62	15.73
GWCL	65.65	1.01
Subtotal	***1,859.73***	***28.61***
Distribution Companies	*4,317.01*	66.42
Bulk Customers	*323.26*	4.97
Subtotal	***4,640.27***	***71.39***
Total Generation	**6,500.00**	**100**

CHAPTER 3

CONCLUSIONS

Natural Gas dependency and its effect on the Wholesale Electricity Market

Electricity supply from thermal sources in the WEM of Ghana has increased over the years and now accounts for more than half of Ghana's electricity supply. Electricity supply from thermal power plants increased from 55.2% of the total supply in 2016 to 58.9% in 2017 and 63.4% as of the end of 2020. As of October 2021, the thermal share of the total electricity supply stood at 65.6%. Natural gas consumption in the Ghana Wholesale Electricity Market (GWEM) has correspondingly increased over the years from 54.6% of the total thermal power plant fuel consumption in 2017 to 97.8% in 2022.

In energy terms, natural gas consumption increased from 75.5 trillion Btu in 2019 to 106 trillion Btu in 2020, 112.4 trillion Btu in 2021 to 124.01 trillion Btu in 2022.

Natural gas is the preferred fuel for thermal power generation. It is a cleaner fuel compared to liquid fuels and is also domestically available. The price of natural gas is regulated in Ghana. From July 2019 to July 2022 natural gas prices were USD/MMBtu6.08 and USD/MMBtu5.95 from September to December 2022 while LCO and HFO prices averaged between USD/MMBtu9.82 to USD/MMBtu19.99 and USD/MMBtu8.83 to USD/MMBtu16.12 respectively. The increasing dependency on thermal power plants and the corresponding increase in natural gas consumption has brought to the fore the need to ensure natural gas supply security. A combination of any of the following can adversely affect supply of natural gas and have dire consequences on Ghana's electricity supply;

a. a shutdown in the natural gas processing plant.
b. a trip in the compressor of the FPSOs.
c. a shutdown in WAGPCo supply.
d. a shutdown in the WAGPCo pipeline.
e. a shutdown in the GNGC pipeline.

The issue of natural gas supply diversity and reliability need to be addressed to ensure the achievement of the needed security of supply. The addition of LNG at Tema to the supply sources will help improve supply diversification. Also, the construction of a gas pipeline from the West to the East will ensure greater reliability of the supply of domestic natural gas from the West to the East.

The future of electricity supply is from thermal sources using natural gas as the primary fuel supply. There is therefore the need to ensure the diversity and reliability of natural gas supply. This may be achieved through broad stakeholder engagements to fashion out the most cost-effective and efficient solution to Ghana's natural gas security dilemma.

Balancing in the GWEM

The power market requires a balance between demand and supply to maintain the integrity of the NITS. Balancing in the power market begins with the planning process, that is, pre-dispatch processes.

In Ghana, the pre-dispatch processes include monthly pre-dispatch, weekly pre-dispatch and daily pre-dispatch schedules. The pre-dispatch processes are meant to ensure that a balance between demand and supply is maintained. All these schedules are prepared by the System and Market Operator (SMO) with inputs from Market Participants (wholesale suppliers and off-takers).

In real-time, the balancing of supply and demand is the sole responsibility of the SMO. The SMO relies on ancillary services to undertake real-time balancing. Specifically, the SMO uses the operating reserves to undertake upward and downward regulation. The reserves available to the SMO include; spinning reserves and non-spinning reserves.

Spinning reserves are automatically activated. This is usually compulsory and is either paid for or provided for free. Non-spinning reserves are provided through contractual commitment with the SMO by a Wholesale Supplier.

Aside the operating reserves, the SMO has at its disposal the load (demand response) in balancing supply and demand. This provides frequency response through interruption of the demand of customers and this service is mainly provided based on a contract between the SMO and the customer providing the service.

The Ghana Grid Code provides for the provision of spinning and non-spinning reserves but not for demand response. The Grid Code is undergoing review to include other ancillary services like demand response.

Operationally, the SMO relies on the Akosombo Dam to provide the spinning reserves needed by the NITS. There is however no formal laid-down process for the SMO to procure reserves in Ghana, both spinning and non-spinning. This has left a situation where providers of spinning reserves (VRA) are not appropriately compensated. The SMO does not have any contract for non-spinning reserves and hence does not rely on any non-spinning reserves. These issues are however addressed in the yet-to-be approved Market Rules.

To have a well-functioning power system, a robust ancillary services market including the reserves market needs to be in place to adequately compensate for services provided and standards for the services being provided. The establishment of a well-functioning ancillary service is essential for maintaining the reliability of the NITS and improving the viability of the market.

CHAPTER 4

RECOMMENDATIONS

1 Fuel supply Security

Ghana depended solely on hydro generation in the mid 90's and in reforming the energy sector, introduced thermal generation to increase its electricity supply security. Over time, Ghana has experienced a significant shift in its primary source of electricity supply, transitioning from hydroelectric power to thermal power. The increasing dependence on thermal power means the need to have sufficient fossil fuel, especially natural gas, to prevent any power generation shortage. In 2019, the Ministry of Energy issued a directive on the use of fossil fuel for electricity generation in a document titled 'Policy Guidelines for Least Cost Fuel Procurement and Competitive Procurement of Energy Supply and Services." This directive specified among others that, natural gas is the primary fuel for thermal generation. Currently, over 90% of thermal power generation uses natural gas as fuel.

Throughout the years, the EMOP noticed that ensuring natural gas insufficiency and reliability has presented a challenge. The Panel thus recommends the following measures in addressing insufficient fuel in the short to long run.

Short term

a. Contracting additional gas from NGAS in Nigeria: This provides a quick solution to immediate gas shortages by sourcing additional supply from a neighbouring country.
b. Stocking strategic volumes of liquid fuels in the eastern and western power enclaves: This serves as a backup plan to mitigate any short-term disruptions in gas supply, ensuring continued power generation

Medium-term

a. Completion and bringing into commercial operation the Tema LNG project

Long term

a. Speeding up the development of domestic oil and gas fields and constructing a second Gas Processing Plant (GPP): Investing in domestic production infrastructure will enhance energy security and reduce dependency on imports.
b. Constructing an onshore natural gas pipeline from west to east: Building an alternative pipeline infrastructure ensures redundancy and minimizes the risk of supply disruptions, especially in cases where offshore pipelines may face challenges.

Implementing these recommendations requires careful consideration of factors such as cost-effectiveness, environmental impact, and long-term sustainability. It's essential for Ghana to strike a balance between meeting immediate energy needs and laying the foundation for a resilient and sustainable energy future.

GLOSSARY

In this report, unless the context otherwise requires:

Act - means the Energy Commission Act, 1997, (Act 541);

Bilateral contract - means a contract of financial settlement between two parties for a transaction in the wholesale electricity market;

Bulk Customer - means a customer that purchases or receives electric power of an amount or level that the Commission may specify;

Bulk Supply Point - This means any point at which electricity is delivered from a transmission system to any distribution system.

Commission - means the Energy Commission established under the Act;

Composite Bulk Generation Charge - is the weighted average rate at which electricity distribution companies, shall procure electricity from generation sources in respect of their operations in the regulated.

Distribution Utility - means a person licensed under the Act to distribute and sell electricity without discrimination to consumers in an area or zone designated by the Commission;

Electricity Market Rules - means the published document developed and adopted by the Utility and Market Participants and approved by the Commission to govern the operation of the market for the wholesale supply of electricity by the National Interconnected Transmission System;

Market Manual - means a published document that is created and adopted by the Utility that contains requirements to be followed, met or performed by one or more of the Market Participants and the Utility in support of the obligations contained in the electricity market rules relating to the operation of the wholesale electricity market;

Market Participants - includes a wholesale electricity supplier, a distribution utility and a bulk customer;

National Interconnected Transmission System - means all electricity plants and equipment within the borders of the country that function or are operated at any voltage higher than 36 Kilovolts and any associated figure or supply equipment that is shared for common use;

Person - includes a body corporate, whether corporation aggregate

Public Utilities Regulatory Commission (PURC) - means the Public Utilities Regulatory Commission established by Public Utilities Regulatory Commission Act, 1997 (Act 538);

Spot Market - means the real-time market that comprises an hourly auction of electricity by a generator to meet the projected demand;

Spot Market Price - means the real-time price of electricity on the spot market as determined by the Utility;

System Marginal Cost - means the additional cost of producing one more unit of electricity in the National Interconnected Transmission System;

Transmission Service - means the safe and reliable operation of high-voltage electrical circuits, transformers and substations to ensure the cost-effective dispatch and movement of electricity from the facility of a wholesale supplier to a Bulk Customer or distribution company;

Utility - means the public utility granted a license under section 23 (5) of the Energy Commission Act, 1997 (Act 541) for the transmission of electricity throughout the country;

Wholesale Electricity Market - means an electricity market established by market rules approved by the Commission for bulk trading of electricity, ancillary services or any other related electricity supply product or service;

Wholesale Supplier - means a Person licensed under the Act to install and operate a facility to procure or produce electricity for sale to a Bulk Customer or a distribution company

APPENDICES

Appendix 1 – Supply

Table 6: **Electricity Generation by power plants in 2020**

Generation (GWh)													
Power Plants	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
BUI	81.31	122.62	124.98	104.87	107.80	92.88	92.93	108.78	128.74	101.02	102.61	100.98	**1,269.52**
TAPCO	90.82	104.48	110.68	104.79	110.02	107.50	117.23	93.39	12.56	29.99	81.63	124.41	**1,087.48**
TICO	100.25	91.76	124.97	156.39	153.14	106.32	52.58	15.68	71.50	141.90	81.99	96.84	**1,193.31**
T3	-	-	-	-	-	-	-	-	-	-	-	-	
SAPP	149.07	-	179.97	249.74	262.13	349.74	366.32	354.59	304.35	230.82	188.53	269.95	**2,905.22**
MRP	-	-	-	-	-	-	-	-	-	-	-	-	**-**
TT2PP	5.32	-	4.74	15.74	8.94	8.68	5.84	7.94	13.28	16.37	2.90	0.34	**90.06**
AKOSOMBO	495.44	566.25	530.71	385.83	431.12	326.47	320.45	366.58	398.27	421.31	477.01	442.02	**5,161.45**
KPONG	62.53	71.61	77.04	72.10	77.33	63.40	63.37	68.83	73.03	73.42	81.75	77.84	**862.25**
TT1PP	38.46	-	6.36	36.54	51.81	6.38	71.96	41.58	6.33	73.20	25.01	69.64	**427.26**
CENIT	45.84	-	24.69	68.44	78.35	74.85	78.09	78.21	61.88	58.37	63.11	79.03	**710.86**
KARPOWERSHIP	247.89	294.49	272.13	233.72	246.35	262.12	276.91	255.11	224.42	265.68	264.00	285.30	**3,128.12**
AMERI	134.30	126.67	127.19	116.08	117.80	116.15	107.97	76.02	51.35	97.40	106.50	105.63	**1,283.07**
KPONE THERMAL	9.61	21.54	28.26	31.34	14.48	63.31	0.67	35.58	67.08	4.39	70.93	21.22	**368.43**
CENPOWER	60.69	121.02	65.84	-	0.85	-	-	-	-	115.25	93.82	110.24	**567.71**
AKSA ENERGY	93.46	90.21	47.48	17.39	22.50	11.34	13.76	17.06	21.71	20.01	26.71	16.12	**397.76**
Twin City	14.35	2.28	10.31	4.85	32.60	-	-	3.72	39.49	-	34.85	53.54	**195.99**
Bridge Power	3.58	6.06	0.01	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.15	**9.81**
Domestic Supply	*1,632.93*	*1,618.99*	*1,735.36*	*1,597.82*	*1,715.22*	*1,589.14*	*1,568.06*	*1,523.07*	*1,473.99*	*1,649.14*	*1,701.36*	*1,853.24*	*19,658.31*
Import	3.50	5.66	3.51	4.58	6.91	5.50	6.09	8.56	7.63	5.39	0.65	0.28	*58.27*
Grand -Total	**1,636.43**	**1,624.65**	**1,738.88**	**1,602.40**	**1,722.14**	**1,594.63**	**1,574.15**	**1,531.62**	**1,481.63**	**1,654.54**	**1,702.01**	**1,853.52**	**19,716.59**

Table 7: Electricity Generation by power plants in 2021

Generation (GWh)													
Power Plants	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
BUI	98.81	76.28	42.00	21.60	25.76	27.15	28.45	32.72	211.18	188.51	166.07	122.58	**1,041.12**
TAPCO	194.07	156.81	130.65	154.66	187.39	220.27	227.44	237.76	221.12	157.92	33.90	208.27	**2,130.27**
TICO	26.86	87.62	227.59	218.77	215.39	217.35	193.61	228.71	222.27	109.43	97.55	152.50	**1,997.66**
T3	-	-	-	-	-	-	-	-	-	-	-	-	**-**
SAPP	346.07	284.81	353.76	291.08	219.64	257.99	260.95	234.81	86.73	262.19	236.43	149.77	**2,984.23**
MRP	-	-	-	-	-	-	-	-	-	-	-	-	**-**
TT2PP	6.26	8.54	12.23	17.19	15.44	17.25	9.81	2.93	0.03	-	-	-	**89.68**
AKOSOMBO	396.41	404.89	418.42	434.00	517.75	464.21	443.09	429.80	411.25	548.78	544.58	543.97	**5,557.15**
KPONG	71.59	69.07	74.43	75.92	90.09	83.83	82.32	80.08	74.66	93.53	89.24	87.71	**972.47**
TT1PP	77.20	1.32	48.41	11.33	20.59	68.74	79.66	4.55	3.04	41.07	47.82	-	**403.72**
CENIT	58.39	39.45	56.96	70.30	77.05	22.52	11.69	7.50	0.30	14.93	60.04	50.57	**469.69**
KARPOWERSHIP	264.22	250.17	281.39	265.52	166.23	145.82	216.50	84.57	53.22	188.68	73.87	142.08	**2,132.26**
AMERI PLANT	66.07	-	-	0.75	-	-	-	-	-	-	-	-	**66.82**
KPONE THERMAL	-	61.11	33.99	71.12	73.96	5.84	-	48.90	-	0.93	25.44	57.21	**378.49**
CENPOWER	134.20	115.25	116.55	123.27	128.19	130.34	132.99	130.38	237.72	26.41	235.26	233.40	**1,743.96**
AKSA ENERGY	19.55	27.64	21.51	30.89	33.36	25.80	18.91	25.73	8.46	38.41	58.58	47.08	**355.92**
Twin City	81.25	122.78	23.59	56.62	89.13	33.53	-	130.95	138.81	132.76	132.57	139.80	**1,081.80**
Bridge Power	2.01	0.97	4.03	1.57	0.89	3.45	1.48	0.14	0.00	0.00	0.00	0.00	**14.53**
Kaleo	-	-	-	-	-	-	-	-	-	0.03	1.57	1.24	**2.85**
Domestic Supply (NITS)	*1,842.95*	*1,706.70*	*1,845.53*	*1,844.58*	*1,860.86*	*1,724.07*	*1,706.90*	*1,679.53*	*1,668.79*	*1,803.58*	*1,802.92*	*1,936.18*	*21,422.60*
Import	1.11	1.98	4.87	3.06	4.60	5.38	6.24	3.94	3.66	3.37	4.22	1.22	**43.65**
Grand Total	**1,844.06**	**1,708.68**	**1,850.40**	**1,847.64**	**1,865.46**	**1,729.45**	**1,713.13**	**1,683.47**	**1,672.45**	**1,806.95**	**1,807.15**	**1,937.40**	**21,466.25**

Table 8: Electricity Generation by power plants in 2022

Generation (GWh)													
Power Plants	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
BUI	81.98	109.71	133.84	62.49	89.21	48.48	66.47	84.48	216.12	302.15	199.52	156.59	**1,551.04**
TAPCO	232.60	201.25	222.02	198.22	155.57	211.91	235.59	209.72	219.73	173.00	198.18	222.46	**2,480.24**
TICO	226.00	195.84	74.73	178.68	214.09	223.96	246.24	220.64	199.60	218.27	225.00	221.13	**2,444.20**
T3	-	-	-	-	-	-	-	-	-	-	-	-	**-**
SAPP	202.98	239.20	315.08	207.51	160.10	235.31	229.61	136.11	134.68	347.43	366.71	380.70	**2,955.43**
MRP	-	-	-	-	-	-	-	-	-	-	-	-	**-**
TT2PP	-	-	0.06	11.99	16.93	14.60	12.86	4.35	6.85	6.88	2.04	7.96	**84.52**
AKOSOMBO	493.70	493.20	556.09	515.32	556.62	470.36	467.74	405.99	401.44	436.36	464.36	487.00	**5,748.17**
KPONG	78.07	80.33	92.69	86.30	86.80	83.04	82.63	76.26	74.94	73.92	77.43	76.98	**969.39**
TT1PP	0.00	55.22	35.76	76.61	15.05	73.75	15.73	70.25	2.00	25.63	1.56	66.43	**437.98**
CENIT	30.83	47.65	72.50	31.04	41.33	72.57	76.76	67.46	16.97	-	4.67	5.21	**466.99**
KARPOWERSHIP	123.42	69.04	78.20	168.96	168.36	82.67	97.42	62.51	34.22	61.89	45.96	51.71	**1,044.38**
AMERI PLANT	-	-	-	-	-	-	-	-	-	-	-	-	**-**
KPONE THERMAL	60.24	19.87	64.77	14.98	68.22	52.17	75.10	4.46	53.34	1.15	60.90	5.44	**480.64**
CENPOWER	250.20	174.91	253.07	241.58	258.47	115.05	84.39	245.40	205.58	27.14	47.69	93.02	**1,996.51**
AKSA ENERGY	51.55	48.04	50.12	8.83	15.58	10.69	10.47	10.55	11.39	21.08	23.78	21.42	**283.50**
Twin City	103.33	92.03	129.04	137.44	115.29	110.40	130.02	142.93	120.24	140.24	127.17	131.51	**1,479.64**
Bridge Power	-	-	0.00	0.00	0.00	0.00	0.00	-	-	-	0.01	-	**0.01**
Kaleo	0.93	1.48	1.63	1.71	1.73	1.69	1.42	1.41	1.41	1.85	1.64	1.54	**18.45**
Domestic Supply (NITS)	***1,934.91***	***1,826.30***	***2,077.96***	***1,939.96***	***1,961.62***	***1,804.95***	***1,831.04***	***1,741.11***	***1,697.11***	***1,835.14***	***1,844.97***	***1,927.57***	***22,422.63***
Import	1.43	2.11	2.18	3.12	4.12	3.77	2.45	4.21	5.78	4.71	1.33	2.15	37.37
Total Supply	**1,936.34**	**1,828.41**	**2,080.14**	**1,943.08**	**1,965.74**	**1,808.71**	**1,833.49**	**1,745.32**	**1,702.89**	**1,839.85**	**1,846.30**	**1,929.72**	**22,459.99**

Appendix 2 - Electricity Demand

Table 9: **Electricity Demand for 2020**

	Demand for 2020 (MW)		
	System Peak	**Ghana Peak**	**Average Demand**
January	2,900.00	2,818.20	2,090.13
February	2,892.90	2,881.20	2,291.26
March	2,956.10	2,902.95	2,213.09
April	2,824.40	2,955.90	2,106.01
May	2,950.23	2,920.32	2,184.99
June	2,870.27	2,886.70	2,097.02
July	2,652.54	2,730.90	2,005.94
August	2,637.40	2,700.20	1,955.94
September	2,676.70	2,758.80	1,964.20
October	2,881.60	2,857.00	2,122.38
November	2,995.00	2,775.50	2,243.06
December	3,089.50	2,980.00	2,344.71
Annual	**3,089.50**	**2,980.00**	**2,344.71**

Table 10: **Electricity Demand for 2021**

	Demand for 2021 (MW)		
	System Peak	**Ghana Peak**	**Average Demand**
January	3,070.20	2,818.20	2,462.13
February	3,087.90	2,881.20	2,526.04
March	3,171.95	2,902.95	2,469.92
April	3,206.60	2,955.90	2,548.75
May	3,072.32	2,920.32	2,488.70
June	3,097.90	2,886.70	2,382.22
July	2,903.90	2,730.90	2,282.70
August	2,867.20	2,700.20	2,245.32
September	3,049.40	2,758.80	2,308.27
October	3,152.30	2,857.00	2,411.89
November	3,134.70	2,887.20	2,497.03
December	3,246.10	2,980.00	2,588.34
Annual	**3,246.10**	**2,980.00**	**2,588.34**

Table 11: **Electricity Demand for 2022**

	Demand for 2022 (MW)		
	System Peak	Ghana Peak	Average Demand
January	3,323.50	3,055.50	2,483.51
February	3,417.90	3,224.20	2,596.42
March	3,469.40	3,197.70	2,669.56
April	3,415.50	3,149.00	2,561.15
May	3,378.00	3,068.00	2,513.48
June	3,309.30	3,062.30	2,382.01
July	3,177.60	2,830.10	2,336.92
August	3,052.25	2,781.20	2,233.84
September	3,135.30	2,817.30	2,265.97
October	3,203.40	2,910.00	2,376.41
November	3,256.10	2,928.40	2,453.72
December	3,370.80	3,049.80	2,482.11
Annual	**3,469.40**	**3,224.20**	**2,445.36**

Table 12: **Average Electricity Demand by power consumers for 2020**

	Average demand by power consumers (MW)						
	ECG	NEDCo	Enclave Power	Mines	VALCO	Bulk Customers	Export
January	1,409.02	152.90	25.80	164.92	62.87	15.94	258.69
February	1,551.43	178.77	27.00	169.06	78.11	16.89	270.00
March	1,483.44	188.49	28.84	170.57	84.12	16.15	241.49
April	1,411.13	189.42	18.62	168.80	81.27	15.89	220.89
May	1,472.25	193.72	29.82	173.64	81.08	17.65	216.83
June	1,410.18	176.02	32.37	169.75	84.41	18.36	205.93
July	1,329.13	168.13	31.11	177.19	85.88	17.37	197.14
August	1,319.76	165.53	29.07	172.79	85.59	18.37	164.84
September	1,363.22	168.29	27.04	169.42	85.76	17.32	133.15
October	1,453.08	182.40	27.77	168.03	85.84	17.40	187.86
November	1,562.79	195.51	30.32	172.72	87.04	17.24	177.44
December	1,577.27	196.17	23.81	174.77	86.37	17.20	269.11
Annual	**1,577.27**	**196.17**	**32.37**	**177.19**	**87.04**	**18.37**	**270.00**

Table 13: **Electricity Demand by power consumers for 2021**

	Average demand by power consumers (MW)						
	ECG	**NEDCo**	**Enclave Power**	**Mines**	**VALCO**	**Bulk Customers**	**Export**
January	1,620.12	197.32	25.97	169.11	86.05	17.67	244.36
February	1,681.36	210.94	28.55	162.06	85.53	18.20	213.66
March	1,639.90	217.17	29.75	160.52	83.97	18.34	183.07
April	1,690.60	218.26	26.78	160.07	86.30	19.36	187.70
May	1,673.49	205.57	25.99	160.01	88.58	18.05	167.36
June	1,599.17	195.14	26.70	149.89	88.12	18.38	168.22
July	1,508.01	187.53	26.35	161.09	83.30	16.95	167.12
August	1,489.37	178.10	23.42	156.94	89.74	17.38	165.86
September	1,533.76	183.59	25.51	163.60	91.97	16.91	204.88
October	1,610.67	204.48	26.48	161.82	88.58	16.57	211.17
November	1,658.54	208.05	26.76	159.11	90.03	16.02	227.53
December	1,745.99	196.32	26.37	166.84	94.92	16.40	235.82
Annual	**1,745.99**	**218.26**	**29.75**	**169.11**	**94.92**	**19.36**	**244.36**

Table 14: **Electricity demand by power consumers for 2022**

	Average demand by power consumers (MW)						
	ECG	**NEDCo**	**Enclave Power**	**Mines**	**VALCO**	**Bulk Customers**	**Export**
January	1,740.56	187.08	26.08	170.61	97.37	17.42	244.38
February	1,823.60	217.01	28.73	169.45	99.82	17.99	239.82
March	1,843.57	235.08	28.11	178.51	101.79	17.95	264.55
April	1,745.36	228.22	26.42	175.92	100.42	16.28	268.53
May	1,732.26	220.91	25.63	170.99	98.35	16.21	249.12
June	1,629.13	204.99	25.80	172.97	98.21	15.51	235.40
July	1,553.14	196.60	23.18	174.54	100.56	15.74	273.17
August	1,495.32	187.86	29.91	161.36	94.50	15.86	249.02
September	1,523.61	185.07	25.79	170.38	94.37	15.50	251.25
October	1,619.03	204.32	21.73	163.55	94.83	15.49	257.46
November	1,762.27	216.78	27.90	171.49	14.29	14.93	246.04
December	1,756.45	200.90	23.20	169.52	63.08	15.05	253.92
Annual	**1,843.57**	**235.08**	**29.91**	**178.51**	**101.79**	**17.99**	**273.17**

Appendix 3 - Consumption

Table 15: Electricity Consumption by market participants 2020

	Electricity Consumption (GWh) - 2020						
	ECG	NEDCo	Enclave Power	Mines	VALCO	Others	Export
January	1,048.31	113.76	19.19	122.70	46.77	11.86	192.47
February	1,042.56	120.14	18.14	113.60	52.49	11.35	181.44
March	1,103.68	140.23	21.46	126.90	62.58	12.01	179.67
April	1,016.01	136.38	13.41	121.54	58.52	11.44	159.04
May	1,095.36	144.13	22.19	129.19	60.32	13.13	161.32
June	1,015.33	126.74	23.31	122.22	60.77	13.22	148.27
July	988.87	125.09	23.14	131.83	63.89	12.92	146.67
August	981.90	123.15	21.62	128.56	63.68	13.66	122.64
September	981.52	121.17	19.47	121.98	61.75	12.47	95.87
October	1,081.09	135.70	20.66	125.01	63.86	12.95	139.77
November	1,125.21	140.77	21.83	124.36	62.67	12.42	127.75
December	1,173.49	145.95	17.72	130.03	64.26	12.80	200.21
Total	**12,653.33**	**1,573.19**	**242.15**	**1,497.92**	**721.56**	**150.23**	**1,855.12**

Table 16: Electricity consumption by market participants 2021

	Electricity Purchases (GWh) - 2021						
	ECG	NEDCo	Enclave Power	Mines	VALCO	Others	Export
January	1,205.37	146.81	19.33	125.82	64.02	13.14	181.81
February	1,129.87	141.75	19.19	108.90	57.48	12.23	143.58
March	1,220.09	161.58	22.14	119.43	62.47	13.64	136.20
April	1,217.23	157.14	19.28	115.25	62.14	13.94	135.14
May	1,245.08	152.94	19.33	119.05	65.91	13.43	124.51
June	1,151.40	140.50	19.22	107.92	63.44	13.23	121.12
July	1,121.96	139.52	19.61	119.85	61.97	12.61	124.33
August	1,108.09	132.51	17.42	116.76	66.76	12.93	123.40
September	1,104.30	132.19	18.37	117.79	66.22	12.17	147.51
October	1,198.34	152.13	19.70	120.39	65.91	12.33	157.11
November	1,194.15	149.79	19.26	114.56	64.82	11.53	163.82
December	1,299.01	146.06	19.62	124.13	70.62	12.20	175.45
Total	**14,194.91**	**1,752.93**	**232.47**	**1,409.86**	**771.76**	**153.39**	**1,733.98**

Table 17: Electricity consumption by market participants 2022

	Electricity Purchases (GWh) - 2022						
Month	**ECG**	**NEDCo**	**Enclave Power**	**Mines**	**VALCO**	**Bulk Customers**	**Export**
January	1,294.98	139.19	19.41	126.93	72.45	12.96	181.82
February	1,225.46	145.83	19.30	113.87	67.08	12.09	161.16
March	1,371.62	174.90	20.91	132.81	75.73	13.35	196.82
April	1,256.66	164.32	19.02	126.66	72.30	11.72	193.34
May	1,288.80	164.36	19.07	127.22	73.17	12.06	85.34
June	1,172.97	147.60	18.58	124.54	70.71	11.17	169.49
July	1,155.54	146.27	17.24	129.86	74.82	11.71	203.24
August	1,112.52	139.77	22.26	120.05	70.31	11.80	185.27
September	1,097.00	133.25	18.57	122.67	67.94	11.16	180.90
October	1,204.56	152.01	16.17	121.68	70.55	11.53	191.55
November	1,268.84	156.08	20.09	123.47	10.29	10.75	177.15
December	1,306.80	149.47	17.26	126.12	46.93	11.19	188.91
Total	**14,755.74**	**1,813.04**	**227.88**	**1,495.89**	**772.29**	**141.51**	**2,214.99**

Appendix 4 – Fuel Consumption and Prices

Table 18: Fuel Consumption for 2020

	Fuel Consumption (MMBtu)					
	Import (NG)	**Domestic (NG)**	**LCO**	**DFO**	**HFO**	**Total**
January	2,148,476.61	5,512,890.67	312,333.11	186,002.09	764,197.88	8,923,900.37
February	1,973,073.94	3,814,341.17	970,404.62	252,710.16	737,615.23	7,748,145.12
March	1,613,877.76	6,050,939.40	778,912.05	317,125.89	385,415.47	9,146,270.57
April	2,063,042.44	7,562,097.08	0.00	7,643.87	142,480.07	9,775,263.46
May	2,393,646.57	7,480,637.78	0.00	80,025.79	183,616.91	10,137,927.05
June	2,228,653.56	7,731,359.25	0.00	0.00	92,726.68	10,052,739.48
July	2,222,158.37	7,420,647.16	0.00	0.00	113,045.21	9,755,850.74
August	1,977,587.37	6,535,682.27	0.00	0.00	139,613.90	8,652,883.54
September	1,928,421.42	5,728,460.24	0.00	0.00	178,057.42	7,834,939.08
October	1,948,502.28	7,663,740.27	0.00	0.00	163,947.59	9,776,190.14
November	1,999,754.28	7,203,364.00	0.00	0.00	212,716.01	9,415,834.29
December	2,228,643.04	8,400,215.93	0.00	0.00	129,216.95	10,758,075.92
	24,725,837.63	**81,104,375.21**	**2,061,649.78**	**843,507.80**	**3,242,649.33**	**111,978,019.76**

Table 19: Fuel Consumption for 2021

	Fuel Consumption (MMBtu)					
	Import NG	**Domestic NG**	**LCO**	**DFO**	**HFO**	**Total**
January	1,940,029.19	9,137,364.09	0.00	0.00	160,331.12	**11,237,724.40**
February	1,461,278.58	8,215,569.57	0.00	0.00	226,648.32	**9,903,496.47**
March	1,816,615.53	8,620,136.05	442,666.21	37,714.33	176,238.87	**11,093,370.99**
April	1,905,397.91	9,199,264.87	19,295.92	0.00	259,440.49	**11,383,399.20**
May	1,832,808.10	8,486,631.93	14,536.66	12,514.79	267,706.75	**10,614,198.23**
June	1,515,132.02	7,567,973.29	65,827.64	747.51	210,068.23	**9,359,748.69**
July	1,558,579.26	7,768,223.24	65,269.34	404.52	153,940.53	**9,546,416.89**
August	1,490,042.79	7,730,389.15	61,617.30	467.66	208,220.87	**9,490,737.77**
September	768,223.28	6,675,067.44	770.50	1,876.58	69,518.17	**7,515,455.96**
October	1,546,836.12	6,215,680.14	230,801.13	485.42	321,735.67	**8,315,538.49**
November	1,490,586.31	5,879,423.54	766,003.30	41,815.26	468,769.39	**8,646,597.80**
December	1,393,434.05	8,225,091.24	237,524.17	4,721.53	396,807.09	**10,257,578.08**
Total	**18,718,963.14**	**93,720,814.56**	**1,904,312.18**	**100,747.59**	**2,919,425.50**	**117,364,262.96**

Table 20: Fuel Consumption for 2022

	Fuel Consumption (MMBtu)					
	Import NG	Domestic NG	LCO	DFO	HFO	Total
January	1,326,675.31	9,418,576.46	107,022.75	20.62	420,387.68	**11,272,682.82**
February	1,706,275.74	7,900,148.64	261,206.20	87,054.84	393,014.50	**10,347,699.92**
March	2,034,208.62	8,869,863.38	150,925.40	205,080.00	393,343.54	**11,653,420.94**
April	1,577,601.97	9,390,617.69	315,239.69	158,122.32	0.00	**11,441,581.68**
May	1,577,851.54	9,697,395.26	79,082.13	123,005.39	0.00	**11,477,334.32**
June	2,403,142.91	8,668,063.72	0.00	22,251.55	0.00	**11,093,458.18**
July	1,704,073.22	9,457,921.44	14,195.74	2,318.91	0.00	**11,178,509.31**
August	1,890,306.51	8,923,114.32	50,416.93	8,180.90	0.00	**10,872,018.67**
September	1,086,679.67	8,143,708.95	0.00	0.00	0.00	**9,230,388.62**
October	1,066,801.19	8,525,046.00	1,567.70	12,687.21	0.00	**9,606,102.10**
November	1,753,235.52	8,396,574.96	0.00	0.00	0.00	**10,149,810.48**
December	1,685,011.83	9,553,228.32	0.00	0.00	0.00	**11,238,240.15**
Total	**19,811,864.05**	**106,944,259.13**	**979,656.54**	**618,721.74**	**1,206,745.73**	**129,561,247.18**

Table 21: Fuel Prices for 2020

	Fuel Price (US$/MMBtu)			
	Natural Gas	LCO	HFO	DFO
January	6.08	12.98	13.46	18.91
February	6.08	11.47	11.15	17.69
March	6.08	7.00	7.29	15.45
April	6.08	4.42	6.67	11.46
May	6.08	6.50	7.03	9.09
June	6.08	8.56	8.26	9.15
July	6.08	9.12	8.77	12.66
August	6.08	9.40	9.02	12.86
September	6.08	8.68	8.69	12.38
October	6.08	8.54	8.77	11.54
November	6.08	9.02	9.23	12.13
December	6.08	10.40	10.09	13.08

Table 22: **Fuel Prices for 2021**

	Fuel Price (US$/MMBtu)			
	Natural Gas	LCO	HFO	DFO
January	6.08	11.30	10.82	14.35
February	6.08	12.72	12.30	14.90
March	6.08	13.31	12.68	16.55
April	6.08	13.19	12.29	15.93
May	6.08	13.90	12.39	16.94
June	6.08	14.89	12.96	16.61
July	6.08	14.89	12.96	18.46
August	6.08	14.89	12.95	18.21
September	6.08	15.02	14.05	17.73
October	6.08	16.73	15.22	20.12
November	6.08	16.26	14.69	22.31
December	6.08	14.96	13.77	21.01
Average	**6.08**	**14.34**	**13.09**	**17.76**

Table 23: **Fuel Prices for 2022**

	Fuel Price (US$/MMBtu			
Month	Natural Gas	LCO	HFO	DFO
January	6.08	14.96	13.77	25.29
February	6.08	19.3	16.3	23.05
March	6.08	23.11	15.22	32.16
April	6.08	20.71	18.26	37.39
May	6.08	22.37	18.39	38.39
June	6.08	24.14	18.2	38.48
July	6.08	18.22	15.83	43.33
August	6.08	19.93	15.88	40.17
September	5.97	17.92	14.8	41.42
October	5.97	18.58	15.02	35.52
November	5.97	18.22	14.25	45.91
December	5.97	16.24	13.1	30.56

Appendix 5: Cost of electricity traded

Table 24: **Cost of Electricity Traded in 2020 based on market type**

	Bilateral			Spot		
	kWh	USD	GHS	kWh	USD	GHS
January	1,066,452,477.16	125,572,225.81	694,452,080.42	557,965,500.00	12,596,488.22	69,662,358.80
February	974,252,527.79	120,797,983.41	642,898,947.49	637,857,100.00	14,402,866.62	76,653,496.44
March	1,118,548,711.89	126,598,578.59	678,467,102.37	607,748,800.00	13,909,754.68	74,545,157.28
April	1,132,508,920.36	122,108,723.48	673,783,725.28	457,930,700.00	10,778,811.30	59,476,402.87
May	1,200,762,635.74	128,710,057.79	722,539,651.41	508,452,700.00	11,910,229.58	66,860,455.79
June	1,192,947,928.49	129,684,646.56	732,134,672.15	389,872,900.00	9,219,521.06	52,048,806.14
July	1,177,944,683.56	126,387,017.58	717,246,324.74	383,814,500.00	9,096,486.30	51,622,559.75
August	1,083,601,486.28	118,029,263.54	670,878,333.99	435,414,900.00	10,254,581.22	58,287,039.65
September	1,000,318,595.14	108,166,064.77	616,546,569.22	471,298,900.00	11,068,444.10	63,090,131.37
October	1,149,430,193.00	121,227,600.57	692,003,512.33	494,728,600.00	11,549,983.56	65,930,771.16
November	1,131,989,022.13	120,699,126.07	689,771,365.68	558,762,000.00	13,020,041.52	74,406,933.28
December	1,322,232,476.82	140,532,083.34	803,843,516.73	519,859,700.00	12,151,462.98	69,506,368.25
Total	**13,550,989,658.37**	**1,488,513,371.52**	**8,334,565,801.79**	**6,023,706,300.00**	**39,958,671.14**	**782,090,480.79**

Table 25: **Cost of Electricity Traded in 2021 based on market type**

	Bilateral Contract Market			Spot Market		
	kWh	US$	GHS	kWh	US$	GHS
January	1,374,065,050.00	147,690,013.19	851,236,265.13	467,991,200.00	10,971,049.68	63,233,492.59
February	1,233,755,465.00	133,810,381.08	770,802,657.25	473,957,500.00	11,038,263.66	63,584,924.37
March	1,353,516,070.00	145,963,676.39	836,434,895.47	492,852,100.00	11,533,594.14	66,092,474.84
April	1,336,160,920.60	140,636,683.62	806,364,333.80	509,916,300.00	11,909,779.34	68,286,744.51
May	1,256,737,645.00	130,138,231.82	746,500,980.18	607,835,700.00	14,188,189.14	81,386,514.57
June	1,177,963,920.00	120,147,227.52	691,477,877.30	548,038,900.00	12,847,503.34	73,940,652.00
July	1,186,237,245.00	121,461,128.62	702,983,466.03	525,415,700.00	12,358,644.74	71,528,422.42
August	1,173,453,140.00	119,477,923.59	696,322,715.20	509,883,300.00	11,997,357.74	69,921,140.79
September	1,116,516,555.00	112,910,181.52	661,896,151.77	485,905,600.00	11,398,027.88	66,816,922.00
October	1,164,600,435.00	126,551,545.06	744,708,235.22	642,312,500.00	14,957,523.06	88,019,396.33
November	1,171,753,240.00	138,931,108.92	821,086,642.74	633,821,300.00	14,695,095.22	86,848,413.53
December	1,304,476,645.00	140,682,197.06	837,043,597.47	631,682,100.00	14,619,436.78	86,984,040.70
Total	**14,849,236,330.60**	**1,578,400,298.39**	**9,166,857,817.57**	**6,529,612,200.00**	**152,514,464.72**	**886,643,138.63**

Table 26: Cost of Electricity Traded in 2022 based on market type

	Bilateral Contract Market			Spot Market		
	kWh	US$	GHS	kWh	US$	GHS
January	1,365,510,010.00	141,792,584.59	852,655,528.20	571,761,400.00	13,204,571.00	79,404,367.25
February	1,256,359,455.00	135,937,086.77	857,871,767.16	573,531,300.00	13,288,324.02	83,859,955.23
March	1,432,991,025.00	162,120,648.93	1,142,950,574.95	648,780,800.00	15,070,427.72	106,246,515.43
April	1,343,170,935.00	149,105,036.10	1,061,031,436.86	601,618,300.00	13,982,264.50	99,497,794.18
May	1,324,056,510.00	145,340,946.02	1,036,222,808.76	643,419,900.00	14,837,233.50	105,783,539.96
June	1,257,006,925.00	126,768,412.02	912,022,663.45	553,395,800.00	12,939,060.12	93,088,774.13
July	1,284,546,945.00	131,909,426.65	975,404,255.33	550,367,500.00	12,869,141.34	95,160,865.64
August	1,264,477,155.00	132,476,217.99	1,068,818,126.70	482,253,800.00	11,358,249.36	91,638,355.84
September	1,227,910,355.00	126,253,529.31	1,104,970,888.53	476,385,800.00	11,211,784.76	98,125,540.22
October	1,331,417,295.00	137,463,124.10	1,535,875,485.57	510,286,700.00	11,874,992.86	132,679,295.22
November	1,306,160,405.00	132,596,814.33	1,734,233,734.63	541,785,500.00	12,585,536.46	164,606,231.36
December	1,367,284,070.00	139,428,363.84	1,399,721,344.55	563,977,600.00	13,024,361.68	130,751,566.91
Total	**15,760,891,085.00**	**1,661,192,190.64**	**13,681,778,614.69**	**6,717,564,400.00**	**156,245,947.32**	**1,280,842,801.36**

Table 27: Cost of Electricity Traded in 2020

	Average Total Cost (ATC)	Spot Market Cost (SMC)	PURC Gazetted Tariffs	Estimated Regulated Market Price (ERMP)
	US$/MWh	US$/MWh	US$/MWh	US$/MWh
January	85.44	143.21	84.75	97.88
February	84.43	134.00	88.07	97.47
March	81.68	157.21	87.46	90.50
April	83.56	106.65	84.94	89.73
May	82.41	106.07	83.49	89.28
June	87.74	109.11	83.02	95.81
July	88.19	112.04	82.59	98.77
August	84.45	116.09	82.46	98.08
September	81.03	113.33	82.23	94.37
October	81.35	115.75	77.30	89.00
November	79.28	105.96	77.21	88.27
December	83.10	123.13	77.14	93.86
Annual	**83.51**	**120.46**	**82.47**	**93.45**

Table 28: Cost of Electricity Traded in 2021

	Average Total Cost (ATC)	Spot Market Cost (SMC)	PURC Gazetted Tariffs	Estimated Regulated Market Price (ERMP)
	US$/MWh	US$/MWh	US$/MWh	US$/MWh
January	86.13	98.48	76.55	97.48
February	84.82	107.77	76.60	102.77
March	85.30	112.69	77.00	97.26
April	82.63	108.70	76.95	96.49
May	77.40	107.06	76.92	90.17
June	77.05	107.99	76.66	83.67
July	78.18	105.50	76.23	84.98
August	78.10	102.48	75.71	88.14
September	77.58	88.48	75.27	87.68
October	78.32	109.11	74.98	91.09
November	85.08	116.68	74.66	99.13
December	80.21	108.18	74.16	96.98
Annual	**80.96**	**106.29**	**77.28**	**94.58**

Table 29: Cost of Electricity Traded in 2022

	Average Total Cost (ATC)	Spot Market Cost (SMC)	PURC Gazetted Tariffs	Estimated Regulated Market Price (ERMP)
	US$/MWh	US$/MWh	US$/MWh	US$/MWh
January	80.05	141.66	73.37	89.25
February	81.61	158.00	69.92	87.76
March	85.18	178.09	62.58	92.68
April	83.93	183.93	62.00	88.71
May	81.48	129.22	61.89	84.65
June	77.24	108.16	61.33	77.67
July	78.96	95.66	59.67	83.79
August	82.41	83.86	54.69	86.84
September	80.72	82.88	72.21	87.18
October	81.17	81.27	56.56	85.16
November	78.63	80.06	48.32	76.67
December	79.00	76.29	62.95	81.37
Average	**80.92**	**117.90**	**62.12**	**85.20**

Appendix 6: Allocation Framework Model

General Allocation formula cap$T_G = T_l + \sum_{p=1}^{n} G_p + \sum_{d=1}^{m} C_d$

Conditions for allocation

(a) The variable T_l will be considered first in the allocation, such that;

$$T_G - T_l = \sum_{p=1}^{n} G_p + \sum_{d=1}^{m} C_d$$

Let $T_G - T_l = C$

(b) The reminder of the total electricity generation C, will then be allocated to GoG priorities.

$$C - \sum_{p=1}^{n} G_p = \sum_{d=1}^{m} C_d$$

Let $C - \sum_{i=1}^{n} G_p = D$

The allocation of Y_i will be done by EMOP in consultation with GoG in the order of priorities; Y_1 beforeY_2, Y_2 before $Y_3 \ldots Y_{n-1}$ before Y_n

The respective allocation (quantities of energy) to each GoG policy in the order determined above will be based on assumptions determined every year.

(c) The remainder of the total electricity generation D, will be allocated on pro-rata basis

Let the respective total electricity demand for other customers be Z_j:

Let the total electricity demand for other consumers be

$$\sum_{j=1}^{m} Z_j = W$$

Hence,

$$\sum_{j=1}^{m} \frac{Z_j}{W} = 1$$

Therefore, $C_d = D * \frac{Z_j}{W}$

The final allocation equation of,

$$T_G = T_l + \sum_{p=1}^{n} G_p + \sum_{d=1}^{m} C_d$$

Becomes;

$$T_G = T_l + \sum_{p=1}^{n} G_p + \sum_{j=1}^{m} D * \frac{Z_j}{W}$$