CORPORATE GREENHOUSE GAS INVENTORY REPORT

2012 - 2022

Electro-Volta House, 28th Feb. Road,
P. O. Box MB 77, Accra, Ghana
Digital Address: GA 145-7445
Email: corpcomm@vra.com
Tel: +233-302 664 941-9
+233-302 318 540
+233 -302 744 400

VOLTA RIVER AUTHORITY

JULY 2023

CORPORATE ENVIRONMENTAL POLICY STATEMENT

The Volta River Authority (herein referred to as "the Authority") is a public power utility and supplies electricity to industries and mining companies as well as distribution companies in Ghana. The Authority commits to ensuring continuous improvement of environmental performance that minimizes potential impacts of all its operations on the environment in accordance with the principles of sustainable development and complying with national and international environmental protection regulations.

In respect of the above, VRA will:

1. Make environmental considerations a priority in all business planning and decision-making and comply with relevant national and international environmental protection regulations.
2. Take reasonable steps to mitigate the impact of its actions with regard to the development, operation and management of its assets.

VRA will thus pursue the following specific objectives:

a. Develop and implement Environmental Management Systems for all its business units to:

   i. Assess environmental impact of processes, operations and products.
   ii. Focus on pollution prevention and waste reduction.
   iii. Ensure compliance with national/international environmental protection regulations.
   iv. Set annual environmental targets to ensure continuous improvements.
   v. Monitor and report on environmental performance as required to the appropriate stakeholders.

b. Ensure minimum environmental impact of VRA's projects and take adequate steps to mitigate any such anticipated adverse impacts as far as is practicable.
c. Promote environmental awareness and individual sense of responsibility among its employees through print material for distribution, safety meetings, and the corporate website which will continue to be updated, and provide adequate empowerment and training for personnel to perform environmental jobs satisfactorily.
d. Support research efforts on materials, products, processes and pollution reduction techniques that are directly related to its operations.
e. Contribute to the development of public policy and programmes that enhance environmental awareness and protection.
f. Promote open communication on environmental issues.
g. Undertake projects and programmes in collaboration with relevant agencies to preserve the Volta Lake resource, and reasonably restore/mitigate ecological imbalance caused by the creation of the lake.
h. Undertake projects and programmes to mitigate the impact on the livelihood of individuals and communities displaced or affected by VRA's developmental projects.

VRA shall design evaluation procedures for all processes that fall under this policy to ensure that these processes comply. Deficiencies, in the policy or in the evaluation procedure, shall be addressed as required. Each employee of VRA is charged to exercise his or her responsibility on behalf of VRA to assure that the intentions of this Policy Statement are diligently carried out.

Approved: .....SIGNED..... Date: ..18 - 06 - 2019.....

Emmanuel Antwi-Darkwa
CHIEF EXECUTIVE

VOLTA RIVER AUTHORITY

Has this inventory been verified by an accredited third party?
☐ No ☒ Yes (if yes, fill in the verifier contact information below and attach the verification statement)
Date of verification: 01/20/2020
Verifier: Ghana Environmental Protection Agency
Email: infor@epa.gov.gh
Phone: +233 (0) 30-2662- 690
Address: P. O. Box MB 326, Ministries Post Office, Accra

REPORT DETAILS

Title:	**2012-2022 CORPORATE GREENHOUSE GAS INVENTORY REPORT**
Project Description:	The Volta River Authority (VRA) in 2016 initiated a "Corporate Carbon Footprint Management Programme" (CFMP) as part of its Corporate Strategic Objectives to allow for the measuring and publishing of its Greenhouse gases (GHG) assessment and strengthen its green credentials in the marketplace. The CFMP sets out the commitment of VRA to measure, monitor, manage, and communicate climate change impacts resulting from its activities – specifically greenhouse gas emissions. To give expression to this commitment, the VRA now presents its 2022 Greenhouse Gas Inventory Report. The report compares GHG emissions from 2012 to 2022 and includes several internal sustainability targets as well as emissions reduction initiatives achieved. As indicated, the results of our annual GHG inventory allow for the tracking of progress made against our emission targets, measuring the impact of implemented reduction initiatives, and identifying further reduction opportunities for future action.
Prepared for:	Volta River Authority Electro Volta House, 28Th February Road P. O. Box MB 77, Accra Digital Address: GA-145-7445 Tel No: +233-302-664941-9 WhatsApp: +233-501-620439 Email: desd@vra.com Web: www.vra.com
Authors:	Environment & Sustainable Development Department, VRA
Lead Authors	1. Mr. Benjamin A. Sackey – E&SDD, VRA 2. Mr. Ulysses Ocran-Hammond – E&SDD, VRA 3. Mr. Godfred Ofosu-Asare – E&SDD, VRA
Specialist Authors:	1. Dr. Daniel Tutu Benefor – Environmental Protection Agency 2. Dr. Samuel Ayesu – Forest Services Division 3. Mr. Kennedy Amankwa – Energy Commission 4. Mrs. Enam Eyiah – reNew Climate Limited 5. Mr. Nana Yaw Anane-Binfoh – Technical Services, VRA 6. Mr. Carl Asoalla – Procurement, VRA 7. Mrs. Enyonam Adinyira – TTPS, VRA 8. Mr. Hans Ofedie – TTPC, VRA 9. Ing. Isaac Kwadwo Owusu – Eng. Services, VRA 10. Mr. Isaac Doe – Technical Services, VRA
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ACRONYMS & ABBREVIATIONS

AERs	-	Annual Environmental Reports
AHL	-	Akosombo Hotels Limited
APML	-	Akosombo Paper Mill Limited
AR2	-	Second Assessment Report
AR5	-	Fifth Assessment Report
CAT	-	Carbon Accounting Team
CDM	-	Clean Development Mechanism
CEB	-	Communaute Electrique du Benin
CEMS	-	Continuous Emission Monitoring System
CFMP	-	Corporate Carbon Footprint Management Program
CH_4	-	Methane
CIE	-	Compagnie Ivorienne d'Electricite
CO_2	-	Carbon Dioxide
CWSP	-	Corporate Solid Waste Segregation Program
DFO	-	Distillate Fuel Oil
E&SDD	-	Environment & Sustainable Development Department
ECG	-	Electricity Company of Ghana
EPA	-	Environmental Protection Agency
ESI	-	Environment & Social Impact
GHG	-	Greenhouse Gases
GRIDCo	-	Ghana Grid Company
GWPs	-	Global Warming Potentials
HF_6	-	Sulfur Hexafluoride
HFCs	-	Hydroflorocarbon
HVAC	-	Heating Ventilation Air Condition
IPCC	-	Inter-Governmental Panel on Climate Change
KTPS	-	Kpone Thermal Power Station
LCO	-	Light Crude Oil
LNG	-	Liquified Natural Gas
MT	-	Metric Tonnes
MWH	-	Megawatts Hour
N_2O	-	Nitrous Oxide
NDA	-	Non-Disclosure Agreement
NDC	-	Nationally Determined Contributions
NED	-	Northern Electricity Department
NEDCo	-	Northern Electricity Distribution Company
NF_3	-	Nitrogen Trifluoride

PFCs	-	Perfluorocarbons
PDD	-	Project Design Document
R&M	-	Regulatory & Metering
SF_6	-	Sulphur Hexafluoride
SONABEL	-	Societe Nationale d'electricite du Burkina Faso
$tC0_2e$	-	Tonnes Carbon dioxide equivalent
T1	-	Takoradi 1 Thermal Power Station
T3	-	Takoradi 3 Thermal Power Station
TICO	-	Takoradi International Company
TT1PS	-	Tema Thermal 1 Power Station
TT2PS	-	Tema Thermal 2 Power Station
TTPC	-	Tema Thermal Power Complex
UNFCC	-	United Nations Framework Convention on Climate Change
VLTC	-	Volta Lake Transport Company Limited
VRA	-	Volta River Authority
WAPCo	-	West African Gas Pipeline Company
WAPP	-	West Africa Power Pool

EXECUTIVE SUMMARY

The Volta River Authority (VRA) in 2016 initiated a "Corporate Carbon Footprint Management Programme" (CFMP) as part of its Corporate Strategic Objectives to allow for the measuring and publishing of its Greenhouse gases (GHG) assessment and strengthen its green credentials in the marketplace. The CFMP sets out the commitment of VRA to measure, monitor, manage, and communicate climate change impacts resulting from its activities – specifically greenhouse gas emissions. Consequently, the VRA publishes this report annually to transparently disclose to its stakeholders its GHG emissions per this commitment. Furthermore, the report supports measuring, monitoring, and managing the environmental performance of VRA.

The report covers GHG emissions from 2012-2022 and includes several internal sustainability targets as well as emissions reduction initiatives achieved. Year 2015 has been set as baseline year against which emissions are compared. As indicated, the results of our annual GHG inventory allow for the tracking of progress made against our emission targets, gauging the impact of implemented reduction initiatives and identifying further reduction opportunities for future action.

The consolidation of GHG emissions is considered from an operational control standpoint. In this regard, VRA has included in its emissions inventory all sources and sinks over which it has 100% operational control. The Stationary Combustion (for generation of energy on-site) and the Mobile Combustion (for corporate-owned and controlled transportation sources) tools as deduced from the GHG Protocol, are utilized in this report. The report also uses Global Warming Potential values and default Emission Factors sourced from the Inter-Governmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories respectively. The use of these guidelines is to enhance the quality of the GHG emission estimates, transparency, completeness, consistency, comparability, and accuracy - in line with the National Greenhouse Gas Inventory of Ghana. The GHG inventory estimates are expressed in mass units, and carbon dioxide equivalents (CO_2e).

Total GHG emissions for the years 2012-2022 is 15,071,129.45 tCO_2e. A comparison of GHG emissions from all sources from 2012 to 2022 is presented in Figure 0.1. Results of the inventory indicate a decrease in specific GHG emissions by 27% and 20% from 0.2 in 2015 (which is our baseline year) to 0.15 and 0.16 in 2021 and 2022 respectively as shown Figure 0-2 below. The increase use of natural gas in combine cycle mode for power generation during the years 2021 and 2022 accounts for this result.

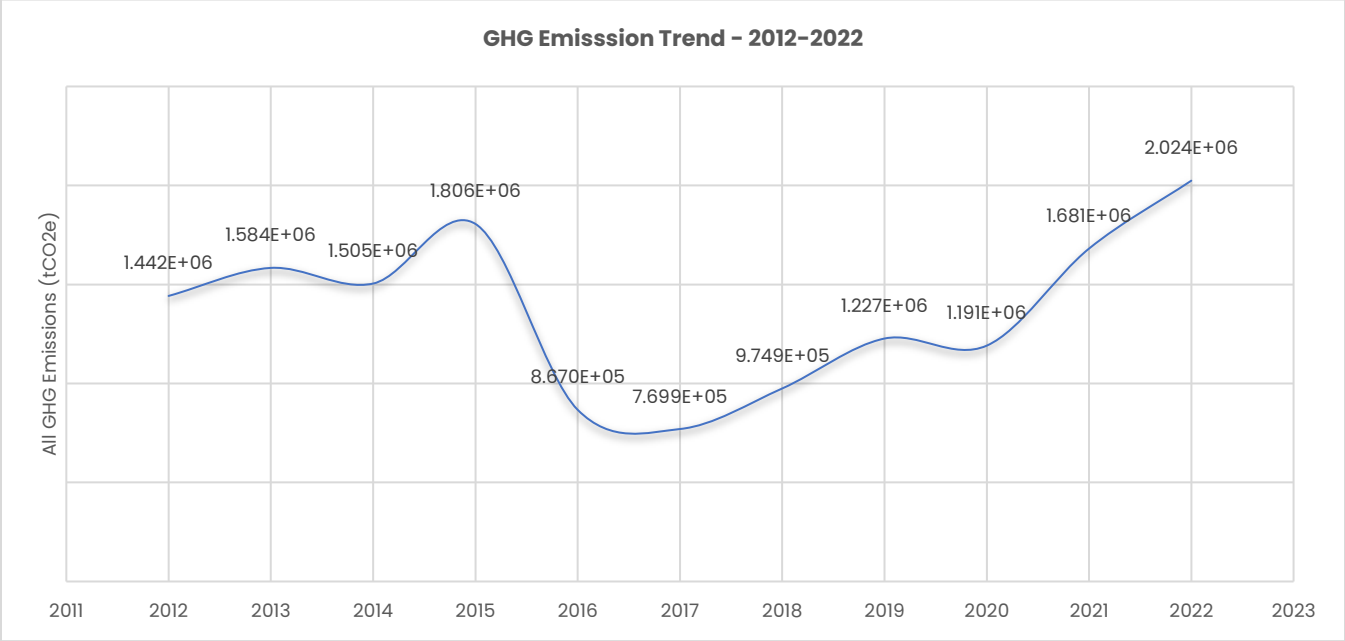

Figure 0-1: GHG Emission comparison from all sources per year (2012-2022)

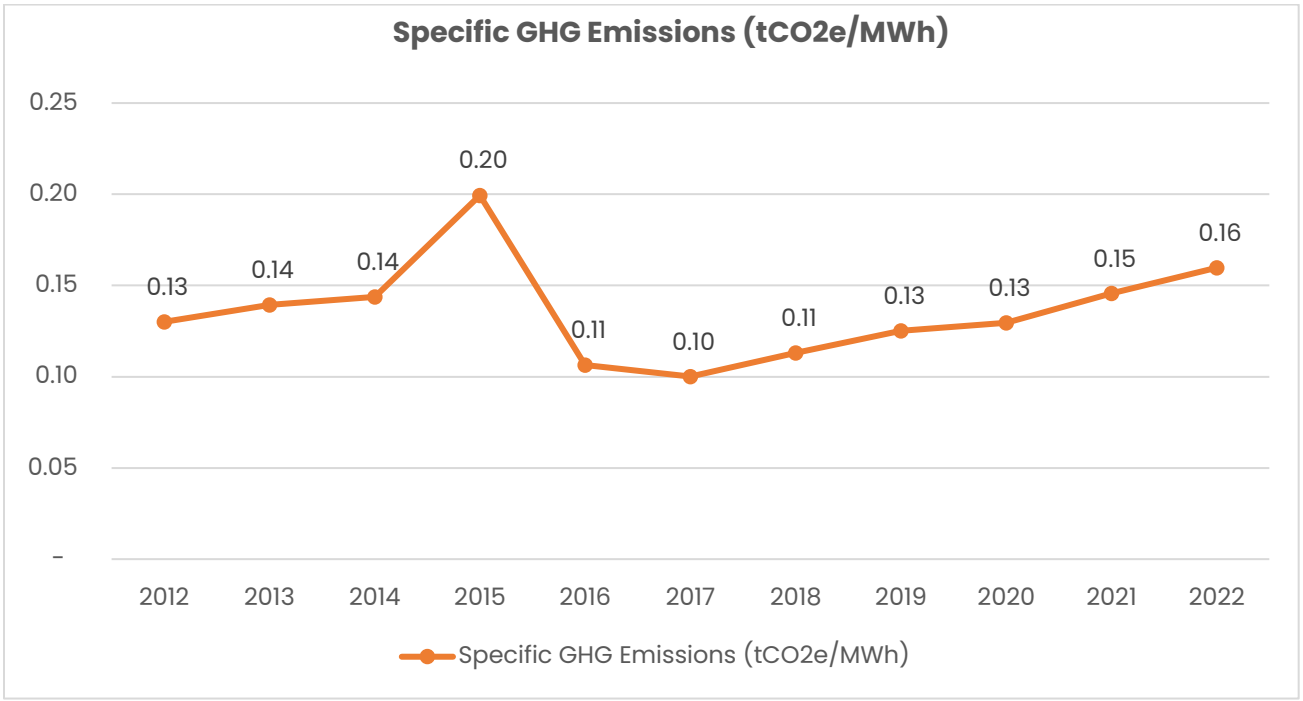

Figure 0-2: Specific GHG Emission for 2012-2022

Also, GHG emissions from stationary combustion sources form the bulk of emissions from VRA; contributing about 99.88% of total GHG emissions whilst mobile combustion contributed 0.12%. This is summarized in the table below.

Summary of GHG emissions by source category

Operational Emissions Category	Emissions Source Category	Corporate emissions source	Total GHG Emissions (tCO_2e)	Percentage of total corporate emissions
Direct Emission Sources	Stationary Combustion	T1	8,644,536.55	57.36%
		T3	135,120.36	0.90%
		TT1PS	3,684,407.43	24.45%
		TT2PS	741,131.00	4.92%
		MRPS	321,269.71	2.13%
		KTPS	1,508,122.72	10.01%
	Mobile Combustion	Vehicles	35,806.71	0.24%
		Water Transport	734.97	0.00%
Total Emissions from Direct Sources			15,071,129.45	100

To offset GHG emissions. VRA has initiated a variety of conservation programs, involving renewable energy projects (Wind/Solar), Retooling Single Cycle Plants to Combine Cycle, Reforestation programs, Solid Waste Management Programs, Utilization of Fuel-Efficient Stoves, Paper Usage Reduction, Reduction in Travel/Transportation, and all these will result in significant reductions in GHG emissions. A summary of these conservation programs is provided in the report.

The following actions are to be pursued to improve future data capture and reporting as well as reduce GHG emissions:

1. Continue with the implementation of resource use efficiencies programs under the Corporate Sustainability Plan, targeting a reduction in paper and vehicular fuel usage, the adoption of video conferencing for meetings, and the digitization of our Internal business processes and operations.
2. Continue staff awareness and training to effectively embrace carbon-caring values throughout the operation of VRA.
3. Continue with the "Eco-Friendly Department" awards.
4. Initiate strategies to collate data on Hydrofluorocarbon emissions from specifically office Air Condition systems by 2026. Responsible staff will be trained on data collection methods and input into the spreadsheets.

5. Undertake area and ground survey to assess carbon sequestration of the VRA Reforestation program to offset VRA's carbon emissions within its carbon accounting program by 2026.
6. Explore GHG savings from a reduced rate of deforestation or forest degradation within the catchment area of the Volta Lake as a result of VRA's social interventions.
7. Establish the "**Akosombo Plastic Waste Processing & Recycling Centre**" for the segregation and processing of plastic bottles within Akosombo and its environs by 2027.
8. Build the capacity of VLTC, AHL, KFL, and NEDCO to publish their own GHG Report by 2027.
9. Inclusion of electric vehicles in the Authority's fleet of vehicles to reduce GHG emissions.

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1 INTRODUCTION

The Volta River Authority (VRA) in 2016 initiated a "Corporate Carbon Footprint Management Programme" (CFMP) as part of its Corporate Strategic Objectives to allow for the measuring and publishing of its Greenhouse gases (GHG) assessment and strengthen its green credentials in the marketplace. The CFMP sets out the commitment of VRA to measure, monitor, manage, and communicate climate change impacts resulting from its activities – specifically greenhouse gas emissions. Consequently, the VRA publishes this report annually to transparently disclose to its stakeholders its GHG emissions in accordance with this commitment. Furthermore, the report supports in measuring, monitoring, and managing the environmental performance of the VRA.

The report covers GHG emissions from 2012-2022 and includes several internal sustainability targets as well as emissions reduction initiatives achieved. Year 2015 has been set as baseline year against which emissions are compared. As indicated, the results of our annual GHG inventory allow for the tracking of progress made against our emission targets, gauging the impact of implemented reduction initiatives and identifying further reduction opportunities for future action. VRA benefits from creating an inventory of its GHG emissions, as follows:

- It brings transparency, consistency, and credibility to environmental management.
- It identifies opportunities to reduce GHGs.
- It provides an impetus for innovation and continual business improvement to achieve proper environmental management.
- It recognizes the company's efforts to combat climate change.

This GHG inventory was compiled and written following the guidelines of the World Business Council for Sustainable Development (WBCSD) and World Resources Institute's (WRI) "Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard" (2004). This standard, considered international best practice for organizational GHG accounting, is articulated around the following principles:

- **Relevance**: VRA's GHG inventory appropriately reflects the emissions of the organization and was compiled in the spirit of serving decision-makers, both internal and external.
- **Completeness:** All material emission sources and activities within the chosen boundary are accounted for and reported, and any exclusions are disclosed and justified.

- **Consistency:** Consistent methodologies are used for meaningful comparisons of emissions over time. Changes to data, inventory boundaries, methods, or any relevant factors are transparently documented.
- **Transparency:** All relevant issues are addressed coherently based on a clear audit trail. Any relevant assumptions are disclosed and appropriate references to the accounting and calculation methodologies and data sources used are made.
- **Accuracy:** Quantification of GHG emissions is systematically neither over nor under actual emissions and uncertainties have been reduced as far as practicable. The achieved level of accuracy should enable decision-making with reasonable assurance as to the integrity of the reported information.

By the WBCSD/WRI GHG protocol, VRA has selected the Operational Control approach, to define its organizational and operational boundaries. Under this approach, VRA has included in its emissions inventory all sources and sinks over which it has a hundred percent (100%) operational control. The Stationary Combustion (for generation of energy on-site) and the Mobile Combustion (for corporate-owned transportation sources) tools as deduced from the GHG Protocol, are utilized in this report. The report also uses Global Warming Potential values and default Emission Factors sourced from the Inter-Governmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories respectively. The use of these guidelines is to enhance the quality of the GHG emission estimates, transparency, completeness, consistency, comparability, and accuracy - in line with the National Greenhouse Gas Inventory of Ghana.

2 REPORTING ENTITY

The Volta River Authority (VRA) was established on April 26, 1961, under the Volta River Development Act, Act 46 of the Republic of Ghana, with the mandate to generate, transmit and distribute electricity. However, following the promulgation of a major amendment to the VRA Act in the context of the Ghana Government Power Sector Reforms in 2005, VRA's mandate has been largely restricted to the generation of electricity. The amendment has the key function of creating the enabling environment to attract Independent Power Producers (IPPs) to Ghana's energy market. Following the amendment, the transmission function was hived off into an entity, designated Ghana Grid Company (GRIDCo) while VRA's distribution agency, the Northern Electricity Department (NED), has been transformed into the Northern Electricity Distribution Company (NEDCo), a wholly owned subsidiary of VRA.

Over the years, the VRA has strategically diversified its power generation portfolio to take advantage of available sustainable sources of energy, mainly hydro, natural gas, liquefied petroleum products, and renewables. Consequently, the VRA as of December 2022 operated a total installed electricity generation capacity of 2,532 MW, comprising 1180MW (47%) from the two hydroelectric plants, 22MW (0.9%) from three solar power plants, and 1330MW (53%) from six thermal power plants as detailed in Table 2.1.

Table 2-1: Power Generation Capacity of VRA (December 2022)

POWER PLANT	INSTALLED CAPACITY (MW)	TYPE OF PLANT	YEAR INSTALLED
Akosombo Generation Station	1,020	Hydro	1965
Kpong Generation Station	160	Hydro	1982
Takoradi 1 Thermal Power Station (T1)	330	Thermal	1997
Takoradi International Company (TICO)	340	Thermal	2001
Tema Thermal 1 Power Plant (TT1PP)	110	Thermal	2009
Tema Thermal 2 Power Plant (TT2PP)	80	Thermal	2010
Kpone Thermal Power Station (KTPS)	220	Thermal	2016
Ameri Power Plant	250	Thermal	2016
Navrongo Solar Plant	2.5	Solar	2013
Lawra Solar Plant	6.5	Solar	2020
Kaleo Solar Plant	13	Solar	2021
TOTAL	**2,532**		

Source: *https://www.vra.com/resources/facts.php*

Various departments and outfits are responsible for the variety of activities performed by the company. In fulfillment of its responsibility to provide facilities for its staff as well as assistance for the socio-economic development of the Volta Basin, the VRA also has seven (7No.) non-power subsidiary companies. The Corporate organizational Structure at the close of 2022 is provided in Appendix 1. Additional company information can be located at www.vra.com.

NEDCo became operational in May 2012 and is currently the sole distributor of electricity in the Upper West, Upper East, Northeast, Northern, Savannah, Bono, Bono East, Ahafo, and parts of Ashanti and Oti Regions of Ghana. Aside NEDCo, VRA's regulated customers in Ghana include the Electricity Company of Ghana (ECG) and Enclave Power located within the Tema Export Processing Zone. Bulk sales are also made to de-regulated customers (mining/industrial companies) as well as import/export of power with Communauté Electrique du Benin of Togo and Benin, Compagnie Ivoirienne d'électricité – La Cote d'Ivoire and SONABEL (Burkina Faso).

3 DESCRIPTION OF EMISSION SOURCES

3.1 INVENTORIES BOUNDARIES

3.1.1 Organizational Boundary

Organizational boundaries represent the distinction of GHG emissions that will be included or not included in an inventory. These boundaries define the portion of emissions for which an organization is responsible. The GHG Protocol Corporate Standard outlines two approaches to consolidating GHG data:

- **Equity share**: Accounts for an organization's GHG emissions based on its percentage ownership.
- **Operational Control**: Accounts for an organization's GHG emissions based on its financial or operational control.

VRA has selected the "**Operational Control** approach, to define our organizational and operational boundaries. This is to ensure that we focus on emission sources from operations over which it has both interest and control and can implement management actions consistent with its corporate environmental policy objectives. Under this approach, we have included emissions inventory from all sources and sinks over which we have 100% operational control during the reporting period, and these are listed in Table 3.1.

Table 3-1: Power Plants under VRA's Operational Control

#	Commissioning Year	Power Plant	Plant Type	Installed Capacity MW)	Location
1	1965	Akosombo Generation Station	Hydro	1080	Akosombo
2	1982	Kpong Generation Station	Hydro	160	Akuse
3	1997	Takoradi 1 Thermal Power Station	Thermal	330	Aboadze
4	2007	Mines Reserve Power Plant	Thermal	80	Tema
5	2009	Tema Thermal 1 Power Plant	Thermal	110	Tema
6	2010	Tema Thermal 2 Power Plant	Thermal	87	Tema
7	2013	Takoradi 3 Thermal Power Plant	Thermal	132	Aboadze
8	2013	Navrongo Solar Plant	Solar	2.5	Navrongo
9	2016	Kpone Thermal Power Station	Thermal	220	Kpone
10	2020	Lawra Solar Plant	Solar	6.5	Lawra
11	2021	Kaleo Solar Plant	Solar	13	Kaleo

Note: Mines Reserve Power Plant was decommissioned in 2016

3.2 Operational Boundaries

An operational boundary defines the scope of direct and indirect emissions for operations that fall within a company's established organizational boundary. It determines the business activities of the company that generates emissions, which of these activities should be included in the calculation, and how these activities would be classified. Establishing operational boundaries helps to verify that all applicable GHG emission sources are appropriately accounted for, and that "double counting" is avoided.

Subsequently, our operational boundaries are the locations of the related infrastructure and offices of the nine (9) power generating facilities as listed in Table 3.1 and these are Akosombo, Akuse, Aboadze, Navrongo, Tema, and Kpone. It also includes Accra, the country's capital, the where company's group head office is located.

As indicated, VRA currently operates seven (7No.) subsidiary companies that are wholly owned by the company. Three of these, the VRA Health Services Limited, VRA International School Limited, and Property Management Company were still under the direct management of VRA and have been included in this GHG inventory.

3.3 GHG Emissions Scope

3.3.1 Scope 1 – Direct Sources

A facility's direct GHG emission sources (Scope 1) are considered as those direct emissions resulting from sources that are within the 'fence line' of the facility (i.e., are under the operational control of the operator of the facility). Direct emissions may include emissions from stationary combustion, mobile combustion, process emissions, and fugitive sources resulting from the combustion of fossil fuels. Our direct emissions are included in the following categories:

3.3.1.1 Stationary Combustion

Direct combustion of fossil fuels from the thermal power projects, located in Aboadze, Tema and Kpone. Significant emissions of these plants are from the direct combustion of fossil fuels that it uses, which are distillate fuel oil (DFO), light crude oil (LCO), and Natural Gas.

3.3.1.2 Mobile Combustion

This involves the combustion of fuels, mostly diesel, and petrol, in VRA owned/controlled mobile sources, such as trucks, buses, cars and motorbikes. It also includes marine fleets being operated on the Volta Lake System for various activities.

3.3.1.3 Fugitive Emissions

This includes emissions from the following:

a) Refrigeration and air conditioning equipment at the various offices.

b) Mobile air conditioning sources from vehicles and marine fleets.

c) Emissions from fixed and portable fire suppression equipment at VRA power plant facilities.

d) Direct emissions from purchased industrial gases for use by VRA workshops and laboratories.

3.3.2 Scope 2 - Indirect Sources

Scope 2, also referred to as Energy Indirect GHG emissions are emissions that are a consequence of the activities of the reporting company but occur at sources owned or controlled by another company. VRA's indirect sources of emissions include those from purchased electricity and electrical line transmission/conversion losses and include:

i. Purchased electricity at Office buildings outside its power generating enclaves, which are the Electro Volta House (Head office), Heritage Towers, and Ridge Towers, all in Accra.

ii. The natural gas distribution lines associated with thermal power generation facilities at Aboadze, Tema, and Kpone.

3.3.3 Scope 3 – Other Indirect Sources

Scope 3 or Other Indirect GHG emissions are defined as *emissions that are a consequence of the operations of an organization but are not directly owned or controlled by the organization*. Indirect Optional sources of information that VRA could provide include emissions associated with power purchased to meet customer demand and support grid operations. Other indirect sources are employee business travel and full lifecycle/supply chain emissions. Our Scope 3 is included in the following categories:

i. Employee business air travel both internal and external.

ii. VRA-owned Akosombo waste landfill site

iii. Power purchased to meet electricity demand from utility companies in neighbouring countries as shown in Table 3-2, totalled 1.84% during the period.

Table 3-2: VRA Generation & Import Data (2012-2022)[1]

Year	Total Generation (GWh)	Total Import (GWh)	Percentage Import
2012	11,082.88	127.67	1.15%
2013	11,359.94	26.95	0.24%
2014	10,464.34	50.72	0.48%
2015	9,055.51	223.24	2.47%
2016	8,152.43	573.77	7.04%
2017	7,691.12	246.80	3.21%
2018	8,621.83	140.97	1.64%
2019	9,803.53	127.41	1.30%
2020	9,193.32	58.22	0.63%
2021	11,545.61	43.62	0.38%
2022	12,674.66	37.42	0.30%

3.4 EXCLUSIONS

The following sources of GHG emission have been excluded in the current quantification:

3.4.1 Scope 1 – Direct Sources

1. Fugitive emissions such as Hydrofluorocarbon (HFCs) from building Heating Ventilation Air Condition (HVAC) systems and mobile air conditioning sources (vehicles/mobile fleets) as described under Section Scope 1 - Direct Sources 3.2.1. *For air conditions and refrigeration, VRA intends adopting the guidelines for "**Calculating HFC and PFC Emissions from the Manufacturing, Servicing, and/or Disposal of Refrigeration and Air-Conditioning Equipment (Worksheet Version**), which was developed by ICF Inc, USA, with and for the GHG Protocol Initiative.*
2. Emissions associated with employee transport in their vehicle and business-related air travel have also been excluded. *The exclusion of these sources is because such data are not readily available and therefore difficult to incorporate.*

3.4.2 Scope 2 – Indirect Sources

1. Concerning purchased electricity, all VRA offices and facilities except those in Accra, utilize electricity from the company's power plants. In Accra, it is not clear where exactly it comes from as the electricity supply is not segregated in the country. It is however assumed that the electricity supply will be from power generating facilities in

[1] Source data provided by the Engineering Services Dept.

Tema as these are the nearest power plants, of which VRA's generating plants form about 30% of the power from Tema. Aside from the Electro Volta House which VRA shares with only ECG, the Heritage Towers and Ridge Towers are shared with various other companies. Thus, purchased electricity at these facilities is considered insignificant to the total GHG emissions and is excluded from the accounting.

2. Fugitive emissions from the natural gas distribution lines associated with thermal power generation in Aboadze, Tema and Kpone facilities have not been considered at this stage of the VRA's GHG calculation and reporting. It is planned that this will be incorporated in future reports after consultations with the EPA on the matter.

3.4.3 Scope 3 – Other Indirect Sources

Emission sources under Scope 3 are not mandatory under WRI reporting protocols. Therefore, at this initial stage of reporting, VRA is also not considering optional sources under Scope 3. VRA will however provide information on actions initiated to allow for a holistic view of the organization's activities in the area of carbon footprint management.

3.4.4 VRA Subsidiary Companies

The underlisted subsidiary companies are also excluded.

1. Northern Electricity Distribution Company (NEDCo), was incorporated in 1997 and became operational in May 2012
2. Akosombo Hotels (AHL), incorporated in 1991, runs the Volta Hotel in Akosombo, a 3-star hotel, restaurant and modern conference/seminar facilities and pleasure activities including cruising on the lake by MV Dodi Princess to promote tourism.
3. Volta Lake Transport Company Limited (VLTC), incorporated in 1970, operates river transportation for passengers, bulk haulage of petroleum products and significant quantities of cement, and cross-lake ferry services along the Volta Lake. It is responsible for inland water transport on Volta Lake. The company's current operational stations are Yeji, Dambai, Kete Krachi, Adawso and Akosombo. It operates inland water transportation with a ferry fleet of nineteen (19) made up of passenger vessels/water buses, cargo ferries and barges. The company carries an average of 647,000 passengers and 57,000 cars per year, on all its ferries.
4. Kpong Farms Limited (KFL), incorporated in May 1982, is a wholly owned agricultural commercial venture, to carry out mechanized commercial farming, agro-processing, and provision of machinery services. KFL was established to harness the water resources of the Volta Lake at Kpong for the use of viable agricultural ventures and for the Farm to serve as a demonstration project in a modern agricultural system. Over

the years, KFL has evolved into a commercial venture with a huge potential for expansion with the private sector.

It is planned that by the end of the year 2024 VRA in collaboration with the EPA will roll out a series of capacity-building programmes on Corporate GHG Reporting for Subsidiary companies.

3.4.5 Thermal Power Plants

In line with the opted inventory boundary, the underlisted thermal power plants in which VRA owns an interest but has no operational control are also excluded:

1. 345MW Takoradi International Company (TICO) owned as a joint venture with TAQA, from Abu Dhabi in the United Arab Emirates.
2. 250MW AMERI Plant is currently decommissioned and being relocated to Kumasi.

3.5 Scope of GHG Savings

3.5.1 Renewable Energy

In line with national actions in the renewable energy sector, VRA in February 2010 adopted a Renewable Energy Policy to develop and operate RE plants in an efficient, cost-effective, and environmentally sustainable manner. The REDP sets a 5-10 years Renewable generation capacity target, taking cognizance of the local and export demand and the system constraints, and is being rolled out in two (2) phases.

The Navrongo Solar Plant was commissioned in 2013, with an installed capacity of 2.5MW, and has since been in operation and CO_2 Equiv. has been assessed. The VRA, also in 2020 and 2021 commissioned the 6.5MW Lawra Solar Plant and the 13MW Kaleo Solar Plant. In 2018, the Ministry of Energy formally handed over the underlisted 5 mini solar power off-the-grid to VRA for operation and maintenance:

1. 50KW Perdiatorkope
2. 40.5KW Atigagorme
3. 39KW Wayokope
4. 54KW Aglakope
5. 54KW Kudorkope

The solar power infrastructure facility represents an investment in clean, renewable energy infrastructure, which given the challenges created by climate change, represents a positive

social benefit for society, as it would indirectly reduce/eliminate a considerable percentage of air pollutants emissions due to consistent use of thermal power generation to support the existing hydropower plants.

3.5.2 Waste Management Practices

VRA in 2017 adopted an "**Office Waste Segregation Policy**" aimed at reducing the total volume of office waste generated at its Offices and disposed of at landfills. The policy also seeks to address the control, management, and disposal of electrical and electronic waste on the operations of the Authority as required by the Hazardous and Electronic Waste Control and Management Act, 2016 (Act 917). Under this policy, VRA August 2017 commenced an "Office Wastepaper Exchange Programme" with Akosombo Paper Mill Limited (APML), involving the exchange involves the supply of 80 pieces of unwrapped toilet rolls for 1 ton of office wastepaper supplied to APML. Office Wastepaper exchanged are weighed at the factory premises and signed by both parties on an ***Office Paper Waste Log sheet***, which is then used as a source document for reporting purposes.

4 METHODOLOGY

4.1 EMISSION FACTORS

The emission factor refers to the rate at which a pollutant is released into the atmosphere (or captured) because of some processing activity or unit throughput. Emission factors convert activity data (e.g., amount of fuel used, kilometres driven, and kilowatt-hours of purchased electricity) into a value indicating carbon dioxide equivalent (CO_2 Equiv.) emissions generated by that activity. Default values are used by the GHG Protocol to assist businesses that are unable to develop accurate customized values. These default values are representative averages based on the most extensive data sets available and are largely identical to those used by the IPCC, the premier authority on greenhouse gas accounting practices at the global level.

The GHG Protocol recommends, however, that businesses should use customized values whenever possible, as industrial processes or the composition of fuels used by businesses may differ with time and by region. This report uses default emission factors from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

4.2 GLOBAL WARMING POTENTIAL & CARBON DIOXIDE EQUIVALENT

ISO 14064 recognizes that not all GHGs have the same properties. Due to the varying ability of greenhouse gases to trap heat in the atmosphere, some are more harmful to the climate than others. Each greenhouse gas has a 'global warming potential' (GWP), which refers to its heat-trapping potential relative to that of CO_2. GWPs compare the climate impact of different greenhouse gases with that of CO_2, and they are used to calculate emissions in terms of CO_2 equivalents. Therefore, to provide a comparable final figure, all emissions are reported as a relative figure to CO_2, i.e., as CO_2e values as required by the GHG Protocol. As scientific understanding advances, the GWP values of GHGs can change. The IPCC's Fifth Assessment Report, 2014 (AR5) values are the most recent has been adopted for the VRA reporting.

4.3 QUANTIFICATION METHOD

Quantifying GHG emissions includes the data collection process and the application of documented emission factors. The quantification is based on two calculation-based methodologies, depending on the type of emission source:

- Emission sources in which there is a chemical transformation process (combustion, fixed or mobile) and indirect emissions from electricity consumption:

Emissions of CO_2 (tCO_2e) = Activity data x Emission factor

- Emission sources where there is no chemical transformation process (fugitive emissions), or in case the results in GHG are different from CO_2 are converted to tonnes of CO_2e using the Global Warming Potential (GWP) values provided by the IPCC:

Emissions of CO_2 (tCO_2e) = Activity data x Global warming potential

The combustion of fuels produces emissions of the following greenhouse gases: Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). Carbon Dioxide accounts for most greenhouse gas emissions from most stationary combustion units. When weighted by their Global Warming Potentials (GWPs), CO_2 typically represents over 99% of the GHG emissions from the stationary combustion of fossil fuels. The GHG Protocol provides tools that present step-by-step guidance and electronic worksheets to help users calculate GHG emissions from specific sources or industries. These tools are consistent with those proposed by the IPCC for the compilation of emissions at the national level (i.e. latest versions of IPCC, 1996). Furthermore, they are designed to be user-friendly for non-technical company staff and to increase the accuracy of emissions data at a company level. Based on engagement with the Ghana Environmental Protection Agency, VRA utilized the following GHG quantification tools:

a) World Resources Institute (2015) Stationary Combustion Tool Version 4.1
b) Mobile Combustion GHG Emissions Calculation Tool Version 2.6.
c) Tool for GHG Accounting for Energy Projects, developed by KfW Development Bank
d) Waste Reduction Model (WARM), Version 12 (February 2012),

4.3.1 Stationary Combustions Emissions

As indicated the Corporate Accounting and Reporting Standard quantification methodology, "*World Resources Institute (2015) Stationary Combustion Tool Version 4.1*", was utilized in estimating the amount of CO_2, CH_4 and N_2O emissions from fuel consumed by VRA's thermal power plants. One needs to supply information on the type and amount of fuel combusted as well as the industry sector. Emissions are then automatically calculated using default emissions factors, chosen to reflect this information. Data on fuel usage, as indicated in Table 4-1, was utilized in quantifying GHG emissions from the stationary combustion plants.

Table 4-1: Fuel Usage in VRA Power Plants (2012-2022)

Power Plant	Amount of Fuel Utilized											
	Fuel Type	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
T1	Gas (MMBtu)	3908264	2190365	2049310	15615347	7073154	4961819	8447440	10837956	9036958	17896690	21769529	103786833
	LCO (litres)	257577300	358490410	183580690	50975800	109034080	27127110	10718790	0	0	0	0	997504180
	DFO (litres)	1003300	988830	641480	458250	609860	333030	593336	0	0	0	0	4628086
T3	Gas (MMBtu)	0		778185	338930	0	0	0	0	0	0	0	1117115
	LCO (litres)	0	27654720	0	0	0	0	0	0	0	0	0	27654720
	DFO (litres)	0	36570	0	0	0	0	0	0	0	0	0	36570
TT1PS	Gas (MMBtu)	1317219	1758458	3536265	3121148	0	2363056	3693511	4416606	5228308	4827948	5378091	35640611
	LCO (litres)	143102248	124932730	138546900	102756300	57476700	61661000	0	0	0	0	0	628475878
	DFO (litres)	1131020	664900	642800	473500	139000	86400	0	0	0	0	0	3137620
TT2PS	Gas (MMBtu)	1560257	1062298	2717206	2420967	308296	0	30960	1299967	776666.9	965801	1010311	12152730
	LCO (litres)	0	0	0	0	0	0	0	0	0	0	0	0
	DFO (litres)	4645000	3209600	0	0	0	0	0	0	0	0	0	7854600
MRPS	Gas (MMBtu)	0	0	2645692	2401936	0	0	0	0	0	0	0	5047628
	LCO (litres)	0	0	0	0	0	0	0	0	0	0	0	0
	DFO (litres)	8267300	0	0	0	0	0	0	0	0	0	0	8267300
KTPS	Gas (MMBtu)	0	0	0	0	0	35187	3282665	3351873.96	3891621.09	4384692	5060331	20006369
	LCO (litres)	0	0	0	0	0	0	0	0	0	0	0	0
	DFO (litres)	0	0	0	0	3599000	39397800	10622830	16561500	24890010	5238990	19871450	120181580

Source: E&SDD – Station's Annual Environmental Reports

T3 was not in operation in 2012, and from 2016 to 2020 and hence no fuel was utilized. Also, the plant was not operational for almost half of the year in 2014 as such no fuel was utilized during the period. MRPS was also not operational in 2013 and decommissioned in 2016. KTPS commenced operation in 2016. It should be noted that anytime natural gas is available, it is automatically the preferred fuel choice for power generation and the use of Light Crude Oil (LCO) is reduced. Except for MRPS in 2012, where Diesel Fuel Oil (DFO) was used as the only source of fuel for power generation, DFO is mainly used as a start-up fuel. MRPS operates only on DFO and Natural Gas and therefore there was no combustion from LCO. With the coming of natural gas on site in 2010, the MRPS was rendered redundant as the TT1PS and TT2PS were rather being utilized for power generation. Power generation on DFO resumed in 2012 due to challenges in gas flows as shown in Figure 6-3. The MRPS was retrofitted to utilize natural gas only in 2013 and therefore there has not been any utilization of DFO on site for power generation since then - until the plant was decommissioned in 2016.

4.3.2 Mobile Combustion Emissions

According to the GHG Protocol - Mobile Guide (03/21/05) v1.3, for all mobile sources, one may apply either a fuel-based or distance-based methodology to calculate CO_2 emissions. In the fuel-based approach, fuel consumption is multiplied by the CO_2 emission factor for each fuel type. This emission factor is developed based on the fuel's heat content, the fraction of carbon in the fuel that is oxidized (generally approximately 99% but assumed to be 100% in this tool), and the carbon content coefficient. Since this approach uses previously aggregated fuel consumption data, it is considered "fuel-based." Fuel based approach can be used also when vehicle activity data and fuel economy factors are available that enable the calculation of fuel consumption. In the distance-based method, emissions can be calculated by using distance-based emission factors to calculate emissions. The Mobile Combustion GHG Emissions Calculation Tool Version 2.6 calculates the CO_2, CH_4 and N_2O emissions from:

- Vehicles that are owned/controlled by the reporting entity, including freight lorries.
- Public transport by road, rail, air, and water.
- Mobile machinery, such as agricultural and construction equipment.

Activity data could be in terms of vehicle kilometres (or miles) travelled, freight ton-kilometers (or miles), passenger-kilometers (or miles), etc. Because the data on fuel are generally more reliable, the fuel-based method is the preferred approach for this tool. The distance-based method should only be used as a last resort as it can introduce considerably higher levels of uncertainty in the CO_2 estimates. In view of this, the "fuel-based" approach has been used in calculating the emissions levels from VRA owned/controlled mobile sources.

There is a detailed inventory of vehicles owned throughout the company and this is maintained by the Transport Section, under the then Technical Services Department. The Transport Section also tracks information regarding the fleet's fuel usage and distance in kilometres travelled. All departments are required to make available data on fuel usage and distance travelled for their mobile sources to the Technical Services Department, using what is called the "Vehicle Operational Chart". The key challenge was that some were not complying with the reporting requirements and data from such departments were obtained directly from the departments from the sourcebooks. During the assessment, some of the departments had sent data to the archives and these were difficult to retrieve, and therefore not assessed. To ensure that going forward vehicular data are properly captured, VRA in 2016 introduced online vehicular fuel requests via an Oracle data management system. In this regard, vehicular fuel usage by departments is tracked and managed by the Oracle data management system. Data regarding fuel usage from the vehicular sources were, thus, sourced from both the vehicular operational chart and the VRA Oracle Database for quantification purposes and provided in Table 4.2. Data not Available (DNA) is indicated in the table. The majority of VRA vehicles are from Asia and South Africa.

Table 4-2: Vehicular Fuel Usage (2012-2022)

Department	Fuel Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Board Secretariat	Diesel	NDA	NDA	NDA	NDA	NDA	120	NDA	2698	2826	483	2617
	Petrol	NDA	NDA	55	NDA	NDA	NDA	NDA	111	52	NDA	NDA
Commercial Services	Diesel	NDA	NDA	NDA	NDA	NDA	NDA	NDA	5007	3962	6282	4897
	Petrol	NDA	NDA	NDA	NDA	NDA	NDA	NDA	3671	4752	3199	216
Corporate Strategy	Diesel	405	NDA	2847	4018	9791	12534	8016	5768	1527	839	1727
	Petrol	38	941	752	1960	639	975	60	87	105	2349	3478
Deputy Chief Executives	Diesel	NDA	NDA	981	7390	119270	232608	3776	19968	12205	16067	11262
	Petrol	NDA	NDA	829	3494	9620	27234	960	5457	4447	6238	6000
Engineering Services	Diesel	49171	33667	63440	297857	142989	123222	23386	107854	149221	134910	140681
	Petrol	5630	16080	12366	52708	6154	5035	4070	2737	163	1287	1276
Environment & Sustainable Dev't	Diesel	44818	18226	43229	50231	36992	76199	23991	85678	33695	29594	47605
	Petrol	1840	20767	33369	34514	35691	6699	826	4593	6700	6277	6295
Finance & Investment	Diesel	40863	18019	11616	24542	23036	47923	14287	21535	16924	18231	16796
	Petrol	817	12365	1523	13620	706	1187	235	235	1127	3652	4434
Human Resources	Diesel	5414	5500	5837	2902	4974	9919	16801	26336	18407	15044	13620
	Petrol	NDA	4492	270	1926	432	625	335	1193	2669	372	895
Hydro Generation	Diesel	51743	11542	38306	25547	21396	69660	27739	3637	7935	38710	14622
	Petrol	2845	772	1807	1582	497	12789	609	478	686	6427	3235
Internal Audit	Diesel	1510	1991	988	730	1063	1530	45	2296	4503	4185	5220
	Petrol	334	1146	2293	4174	961	1079	55	312	785	NDA	1389
Legal Services	Diesel	3750	6116	NDA	170	1187	70	38	3536	2923	3111	2098
	Petrol	337	3733	NDA	170	NDA	45	45	504	1079	NDA	516
Management & Information System	Diesel	47762	10532	5111	6487	9164	11639	6829	27960	20111	17219	21600
	Petrol	3719	5516	1082	3532	410	701	75	819	794	999	1874
Office of CE	Diesel	NDA	NDA	NDA	NDA	NDA	NDA	NDA	10248	5601	10908	12646
	Petrol	NDA	NDA	NDA	NDA	NDA	NDA	NDA	899	968	2843	1765
	Diesel	6659	6192	1889	5709	438	2544	NDA	NDA	NDA	NDA	NDA

Department	Fuel Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Planning & Power Business[2]	Petrol	NDA	3429	894	2893	175	510	NDA	NDA	NDA	NDA	NDA
Procurement	Diesel	14427	12196	51328	51783	51149	96007	39272	36755	32411	30455	29946
	Petrol	600	11871	2559	10305	90	734	90	NDA	NDA	110	181
Real Estate and Security	Diesel	22256	20605	53651	40991	37147	70860	18694	11361	4319	74210	8227
	Petrol	1109	484	NDA	32499	460	1255	NDA	221	21	1664	9
Technical Services	Diesel	87138	17278	21194	56548	79125	71114	46792	76787	53648	36964	58003
	Petrol	6204	11594	1164	17788	892	755	1489	6151	1300	594	1896
Thermal Generation SBU	Diesel	NDA	8012	3597	26594	7985	64716	96695	15583	11267	44861	12911
	Petrol	NDA	6060	1372	16128	1340	2265	6504	746	521	163	NDA
VRA Academy & Schools	Diesel	9982	746	637	5642	1867	18322	27187	15194	9234	66701	19322
	Petrol	176	746	NDA	60	NDA	45	110	2681	3140	3551	4292
VRA Corporate Parent	Diesel	1070	1238	3124	25558	12177	20353	16953	10897	10136	15131	28821
	Petrol	338	NDA	1661	5089	2340	3190	2199	1321	575	1478	2483
VRA Health Services	Diesel	18384	NDA	60154	30051	22795	63415	31129	3542	11338	58705	8214
	Petrol	4729	NDA	495526	17638	4456	22054	6502	2483	1479	7496	744
VRA Property Holding Company Limited	Diesel	NDA	NDA	65	236	9872	32369	4466	1373	1637	10538	4119
	Petrol	NDA	NDA	NDA	NDA	NDA	150	250	267	NDA	245	NDA
Grand Total	Diesel	405352	171860	367994	662986	592417	1025124	406096	494013	413831	633149	464953
	Petrol	28716	99996	557522	220080	64863	87327	24414	34966	31362	48945	40981

Source: Oracle database and vehicle operational chart

Marine fleets are maintained by the Technical Services Department (TSD). Thus, regards to water transport, TSD is responsible for operating marine fleets as well as machinery such as sand/weed dredgers on the Volta Lake System. Data on fuel usage taken from tankers for water transport in litres are recorded and the amount utilized is provided in the

[2] The department was de-established and incorporated into Corporate Strategy Department from year 2018

vessel's logbook and reported monthly. Source data utilized was primary information from the logbooks and a total of 249,5 litres of diesel fuel was utilized by the marine vessels as shown in Table 4.3 from 2012-2022.

Table 4-3: Marine Fleet Fuel Consumption (2012-2022)

Period	Vessels	Diesel Fuel - Liters
2012	MV. Ohemaa LX1	5,149
	MV. Tilapia	2,975
	MV. Dodi Princess 1	21,165
	MV. Volta Princess	4,200
	TOTAL	**33,489**
2013	MV. Ohemaa LX1	12,366
	MV. Volta Queen	10,389
	MV. Onipanua	4,000
	TOTAL	**26,755**
2014	MV. Buffalo	817
	MV. Ohemaa LX1	6,232
	MV. Volta Queen	4,000
	TOTAL	**11,049**
2015	MV. Onipanua	1,845
	MV. Buffalo	280
	MV. Volta Queen	8,500
	MV. Volta Princess	2,500
	MV. Ohemaa LX1	1,600
	TOTAL	**14,725**
2016	MV. Ohemaa LX1	1,600
	MV. Volta Queen	11,400
	MV. Onipanua	7,900
	MV. Buffalo	474
	MV. Volta Princess	1,000
	TOTAL	**22,374**
2017	MV. Volta Queen	4,000
	Dipa Generator set	420
	MV. Ohemaa LX1	1,798
	MV. Volta Princess	2,500
	MV. Onipanua	3,000
	MV. Buffalo	209
	TOTAL	**11,927**
2018	MV. Volta Queen	32,400
	MV. Onipanua	9,756
	MV. Ohemaa LX1	1,334
	Dipa Generator set	200
	MV. Buffalo	80
	MV. Volta Princess	2,000

Period	Vessels	Diesel Fuel - Liters
	TOTAL	**45,770**
2019	MV. Volta Queen	32,873.00
	MV. Onipanua	6,772.00
	MV. Ohemaa LX1	1,344.00
	MV. Dodi Princess	9,499.00
	MV. Volta Princess	5,881.00
	TOTAL	**56,369**
2020	MV. Volta Queen	8,000.00
	MV. Onipanua	2,500.00
	MV CLARIAS	360.00
	MV. Dodi Princess	NDA
	MV. Volta Princess	16,200.00
	TOTAL	**27,060**
2021	MV. Volta Queen	0.00
	MV. Onipanua	0.00
	MV CLARIAS	8,000.00
	MV. Dodi Princess	0.00
	MV Buffalo	0.00
	MV. Volta Princess	0.00
	TOTAL	**8,000**
2022	MV. Volta Queen	10,000.00
	MV. Onipanua	3,000.00
	MV CLARIAS	0.00
	MV. Dodi Princess	0.00
	MV Buffalo	1,500.00
	MV. Volta Princess	2,600.00
	TOTAL	**17,100**
TOTAL FUEL CONSUMPTION		**249,518**

Source: TSD - Marine Services Unit Fleet Logbooks

4.3.3 GHG Savings from Renewable Power Plants

The "**Tool for GHG Accounting for Energy Projects**", developed by KfW Development Bank has been adopted and this allows for calculating carbon emissions as well as emissions savings. For renewable energy projects (solar/wind/hydro/geothermal/bioenergy), this is achieved by calculating the amount of electricity generated annually, on average, by the renewable energy project will be multiplied by and thus compared to the combined grid margin Operating Margin (OM) 75% / Build Margin (BM) 25 % for Solar and Wind, the rest assumes OM⅓ and BM⅔. It is assumed that this amount of renewable electricity displaces electricity that would be generated per the country-specific fuel mix.

The powerhouse equipment at the Hydro Generation Department is connected to a Data logger which logs and records the generation and other parameters from the PV Plants onto an external Secure Digital (SD) card. Data on Annual Energy Generated (MW hours) is utilized for the calculations of the GHG savings, supported by the plant's Project Specific Capacity Factor, Default Capacity Factor, and Default Emission Factor, in the case of solar energy.

The 2.5MW Navrongo Solar Power Station (NSPS) commenced operation in June 2013, and a total of 29881.4 MWh of electric energy has been generated within the period from 2013 to date. The 6.5MW Lawra Solar Plant (LSP) commenced operation in October 2020 whilst the 13MW Kaleo Solar Plant (KSP) commenced operation in November 2021. Total energy generated to date by the LSP and KSP is 15164.1 MWh and 19832.8 MWh respectively. Again, the 5 mini solar power off-grid, totaling 237.5KW was handed over to VRA in July 2018 for operations and maintenance, and a total of 595.05 MWh was generated during the period from July 2018 to December 2022. Table 4-4 gives the breakdown of the energy generated by each plant from 2012-2020. Years that are Not Applicable (N/A) because the PV plant was not operational is indicated. The PV power plant utilizes polycrystalline technology, with an expected operational lifetime of 20 years for the grid-connected NSPS and 25 years for the mini off-grid PVs.

Table 4-4: Energy Generated from Renewable Energy Sources (2012-2022)

Year	NSPS	LSP	KSP	Wayokope	Atigagorme	Kudorkope	Perdiatorkope	Aglakope
Installed Capacity (MW)								
	2.5	6.5	13	0.030	0.0405	0.054	0.05	0.054
Annual Energy Generated (MWh)								
2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2013	2197.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2014	3843.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2015	3312.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2016	3088.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2017	2725.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2018	2581.7	N/A	N/A	6.67170	8.807	18.36660	23.3083	23.30830
2019	3429.5	N/A	N/A	13.3343	25.2166	37.9083	41.3987	40.0772
2020	3160.1	1069.9	N/A	20.6912	14.6542	35.52203	26.49133	40.49686
2021	2987.6	5388.2	836.5	13.2215	10.1455	40.5837	33.4018	32.3593
2022	2554.6	8706	18996.3	22.0612	0.8057	27.88831	2.03007	36.3047

Source: Renewable Energy Unit – Power Generation Data

4.3.4 GHG Savings for Waste Reduction

VRA has adopted the Waste Reduction Model (WARM), created by the U.S. Environmental Protection Agency (EPA), to help solid waste planners and organizations estimate greenhouse gas (GHG) emission reductions and economic impacts from several different waste management practices. WARM calculates GHG emissions for baseline and alternative waste management practices, including source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in metric tons of carbon dioxide equivalent ($MTCO_2E$) and metric tons of carbon equivalent (MTCE) across a wide range of material types commonly found in municipal solid waste (MSW). The model has been used to calculate GHG savings from the amount of office wastepaper recycled by VRA (in Short Tons). It is assumed that the office wastepaper, if not recycled will have otherwise been landfilled for decomposing. Under the Office Wastepaper Recycling Programme, VRA had by the close of 2022, recycled a total of 7501.5 Kg (8.27 Short Tons), as shown in Table 4-5.

Table 4-5: Office Wastepaper Recycled

Period	Weight (kg)	Weight (Short Tons)
Aug – Dec. 2017	453	0.499
2018	1630	1.797
2019	1316	1.451
2020	1348	1.486
2021	2259.5	2.491
2022	495	0.546
Total	7501.5	8.27

Source: E&SDD - Office Wastepaper Log sheet

4.4 Greenhouse Gases Covered and Excluded in the Inventory

The seven main greenhouse gases covered by the GHG Protocol and reported as CO_2e are Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), and Nitrogen Trifluoride (NF_3). GHGs identified for the VRA's inventory are CO_2, CH_4 and N_2O.

Based on earlier discussion under Chapter 3, the following GHG gases are excluded in this GHG Report.

1. Sulfur Hexafluoride (HF_6) from power transmission and distribution equipment, and Hydrofluorocarbon (HFCs) from building Heating Ventilation Air Condition (HVAC) systems and mobile air conditioning sources (vehicles)

2. Perfluorocarbons and Nitrogen Trifluoride, because given the nature of its business, this class of chemicals is not used in any of VRA's operations in any sizeable amount.
3. Methane emissions from the Akosombo waste landfill site

4.5 Uncertainties In The GHG Inventory

4.5.1 Potential Sources of GHG Emissions Excluded

Uncertainties may exist in the inventory because of the failure to include or properly allocate emission sources within the boundaries of the inventory. Only those emissions believed to be of significant relevance to VRA's operations were included. Those excluded are

1) HFCs and PFCs emissions from refrigeration equipment leaks and Methane (CH_4) from natural gas distribution systems.
2) To avoid double counting, purchased electricity at VRA office facilities in Accra is excluded from the inventory.
3) Scope III emissions were also not included in this inventory. These emission sources were not quantified in the inventory because it was determined that the large effort necessary to estimate their emissions was not warranted by the scale of their potential emissions in relation to the overall inventory. VRA will commence discussions on how to systematically gather data and calculate emissions from these sources for inclusion in future reports.
4) Exchange of electricity resulting in the wheeling of power between Ghana and its neighbouring countries as shown in Table 3.2 have also been excluded from the inventory, as it is considered minimal and of little significance.

4.5.2 Uncertainty Associated with Data Sources and Methodology

Uncertainties may also exist in the inventory because of the failure to properly estimate emissions from each source. This issue could pertain to inaccurate emission estimation methods or erroneous input data (e.g., fuel throughput) that were used to estimate emissions. The GHG Protocol specifies that neither assumptions nor methodology should introduce systematic errors that would lead to either high or low estimates of emissions. The methodology generally used to estimate emissions is to apply generally accepted emission factors to translate the amount of activity (e.g., kWh, Volume of fuel) into GHG emissions. One of the most likely sources of systematic error can result from the improper use of emission factors, or the use of inaccurate emission factors. As indicated, this report utilized default emission factors from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as well as GWP from the Intergovernmental Panel for Climate Change (IPCC) Fourth Assessment

Report. The selection of these emission factors was recommended by the Ghana EPA and is based on assumptions regarding their suitability for the specific application.

Any errors resulting from improper use of emission factors could be evaluated in detail through emissions testing of equipment to develop equipment or source-specific emission factors. The VRA currently does not measure CO_2 emissions from its thermal generating plants. This detailed level of evaluation is outside the scope of this inventory. All emission factors used in this inventory are based on commonly accepted practices and best professional judgment to minimize sources of error to the maximum extent possible within the defined scope of the inventory.

Concerning actual fuel usage, inputs were obtained from data recorded by stationary plant facilities during generation. The primary data is recorded at the plant level and made available as part of the Annual Environmental Reports (AERs) that VRA submits to the EPA and the Energy Commission, the national regulatory agencies of the powers sector. The secondary data as provided in the AERs formed the source of this report. Thus, if the information is utilized without confirmation from the source data at the power plant there could be challenges with the data if the source entry is inaccurate. Primary data from the power plants was therefore obtained and crosschecked for use.

In their review comments, ICF International recommended the need to also include CO_2 in the direct measurement as a means of using the data to confirm the calculations. Going forward, facilities with CEMS that can undertake CO_2 measurements, like the KTPP will be used for such confirmatory exercises.

In general, the use of the fuel-based method in estimating emissions from vehicular sources produces less uncertainty than the use of the distance-based method and as indicated, VRA utilized the fuel-based method in this quantification. In this regard, VRA has allocated logbooks for all its vehicles for recording fuel usage. Drivers are subsequently required to input manually such primary data for compilation at the end of each month. The key challenge here is that individuals using the vehicles may fail to log in with the required data or provide the right data and this may affect the quantification. In addition, data may be omitted during compilation. To address this, the VRA in 2016 rolled out an oracle-based centralized fuel requisition system that captures data on fuel usage from all departments.

Data on the amount of office wastepaper recycled is obtained through weighing at the recycling facility by both parties, and the information is provided in monthly reports of the E&SDD using the ***Office Paper Waste Log sheet***. Key assumptions included that the paper is produced from 100% virgin material, lack of landfill gas conversion system in place, and default transport distances, as the paper is sourced from various work location areas.

4.6 Potential Sources of GHG Sequestration

Cognizant of the need to ensure the continuous flow of water resources in the Volta Lake basin for sustainable generation of hydroelectricity for the economic development of Ghana; the global need for reduction of greenhouse gas emissions; and the influence trees have on local climate as well as erosion control, VRA has embarked on various watershed management activities along the Volta Lake. VRA's watershed management activities focus on an integrated approach to the management of the Volta Lake Basin environment, by incorporating environmentally friendly livelihood options into the reforestation and wildfire management activities around the water bodies in the Basin. Current ongoing ones are the Volta Gorge Protection Programme and the Buffer Zone Tree Planting Programme. Activities being undertaken are seedling raising, tree planting, bush fire management, community and school environmental advocacy and education programmes and provision of alternative livelihood programmes, including non-farm activities.

The Volta Gorge is an area of about 5,149.24 hectares bordering the hills before the Akosombo dam. Areas being planted are degraded areas with grassy areas and fire-prone and as of December 2022, about 1,653 hectares of the Volta Gorge area had been planted. Tree species adopted are *Senna siamea* (cassia), *Acacia mangium, Khaya senegalensis (*Mahogany), *Cedrella odorata,* and *Leuceana leucocephala.*

The Buffer Zone Reforestation Programme, which started in 2007 is being implemented in collaboration with forty (40) communities within three (3) riparian Districts and these are the South Dayi, Kpando and Biakoye in the Volta Region. As at the close of December 2022, about 312.1 hectares of forest tree plantation had been established along the Volta Lake and its tributaries to serve as buffers to minimize siltation, water pollution and landslide along the catchment areas.

VRA has engaged an expert from the Forest Services Division under the Forestry Commission as a CAT Member to advise on strategies to calculate the carbon sequestration potential of forest tree species planted and being maintained. The 2008 IPCC Guidelines for National GHG Inventory is to be adopted for calculating the carbon stock, using tree dimensions (girth, wood density, basal area, height, etc.), depending on the tree species and types.

5 RESULTS OF GHG QUANTIFICATION

5.1 CONSOLIDATED GHG EMISSIONS

A comparison of GHG emissions from all sources from 2012 to 2022 is presented in Figure 5-1 and consolidated in Table 5-1 below. Total GHG emissions for the years 2012-2022 is 15,071,129.45 tCO_2e.

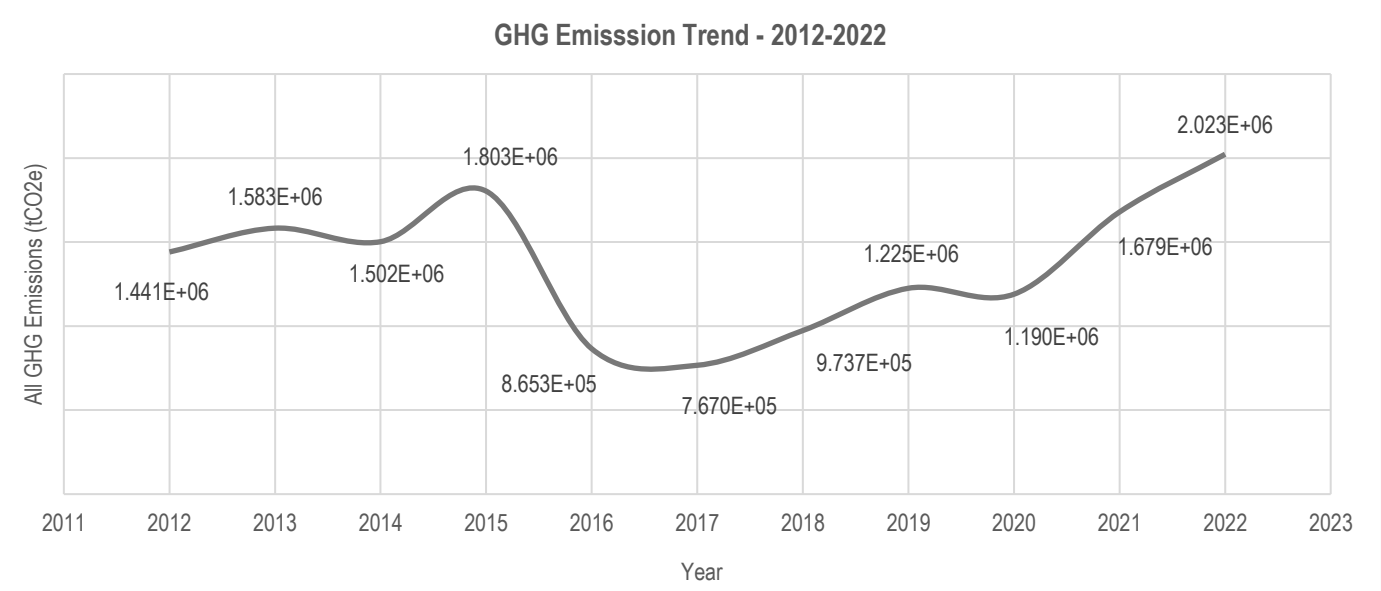

Figure 5-1: GHG Emission comparison from all sources per year (2012-2022)

Table 5-1: Summary of GHG emissions by source category (2012-2022)

Operational Emissions Category	Emissions Source Category	Corporate emissions source	Total GHG Emissions (tCO_2e)	Percentage of total corporate emissions
Direct Emission Sources	Stationary Combustion	T1	8,644,536.55	57.36%
		T3	135,120.36	0.90%
		TT1PS	3,684,407.43	24.45%
		TT2PS	741,131.00	4.92%
		MRPS	321,269.71	2.13%
		KTPS	1,508,122.72	10.01%
	Mobile Combustion	Vehicles	35,806.71	0.24%
		Water Transport	734.97	0.00%
Total Emissions from Direct Sources			15,071,129.45	100

Results of the inventory indicate a decrease in specific GHG emissions by 27% and 20% from 0.2 in 2015 (which is our baseline year) to 0.15 and 0.16 in 2021 and 2022 respectively as shown Figure 5-2 below. The increase use of natural gas in combine cycle mode for power generation during the years 2021 and 2022 accounts for this result.

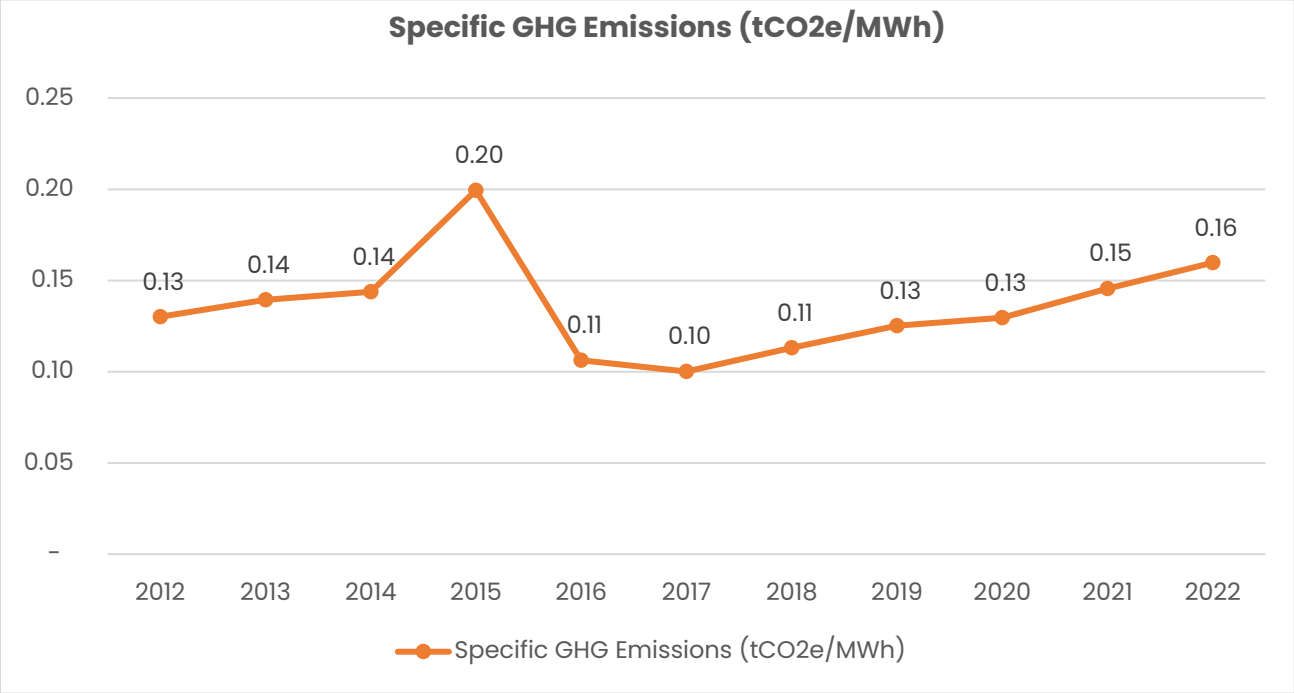

Figure 5-2: Specific GHG Emission for 2012-2022

GHG emissions from stationary combustion sources form the bulk of emissions from VRA; contributing about 99.88% of total GHG emissions whilst mobile combustion contributed 0.12%.

5.2 SCOPE 1 EMISSIONS

5.2.1 GHG Emissions from Stationary Combustion

Results of GHG emissions from stationary combustion in VRA's thermal plants are presented in Table 5-2.

Table 5-2: All GHG Emissions from Stationary Combustion for 2012-2022

Year	GHG Emissions (tonnes CO_2e)			
	CO_2	CH_4	N_2O	All GHGs
2012	1435802.02	49.47	9.18	1439773.58
2013	1577442.64	57.70	11.01	1582166.74
2014	1496579.78	45.21	7.81	1500036.20

Year	GHG Emissions (tonnes CO_2e)			
	CO_2	CH_4	N_2O	All GHGs
2015	1798390.53	40.92	5.66	1801101.20
2016	861578.57	25.16	4.25	863475.32
2017	762457.17	21.09	3.44	764010.30
2018	971381.13	18.61	2.09	972469.59
2019	1222608.84	22.80	2.46	1223911.64
2020	1187315.97	22.67	2.54	1188638.87
2021	1675820.29	30.19	3.08	1677491.61
2022	2019411.59	37.20	3.94	2021512.71
Grand Total	**15008788.53**	**371.04**	**55.45**	**15034587.77**

T1 and TTIPS represented the dominant contribution of GHG emissions; accounting for approximately 57.43% and 24.48% respectively of the overall GHG emissions of VRA. The trend in GHG emission is affected by the availability of the power plant and the fuel mix used for power generation during the period. Thus, the trend observed indicates that T1 and TT1PS were most utilized for power generation during the period. The low GHG emissions recorded in 2016 and 2017 is attributable to the unavailability of the T3 and MRPS plants in 2016 and 2017 respectively. The relatively low GHG emissions in 2018 and 2019 are also attributable to the predominant use of natural gas for power generation instead of light crude oil. GHG emissions rose from 2017 to 2019 due to an increase in energy generation (see Table 3-2) as a result of system demand for electricity during the period; the generation of electricity being directly proportional to fuel consumption and the amount of GHG released. T3 was not in operation in 2012, and from 2016 to 2019 and hence no emissions were recorded. The plant was also not operational for almost half of the year in 2014. MRPS was also not operational in 2013 and decommissioned in 2016. KTPS commenced operation in 2016. Emission trends of the combustion plants from the different fuel sources are shown in Figure 6-1. To help assess plant efficiency, the specific GHG emissions per energy generated for each power plant were also determined and this is provided in Table 6.1. We must note that the total power generated is based on all the fuel sources combined and not segregated, and therefore results may vary widely.

5.2.1.1 GHG Emissions by Power Plant

Table 5-3 presents the eleven-year GHG emissions data from the various thermal power plants in VRA.

Table 5-3: Summary of GHG Emissions by Power Plant in tCO_2e (2012-2022)

Year	GHG Emissions (tCO_2e)					
	T1	T3	TT1PS	TT2PS	MRPS	KTPS
2012	875,380.46	-	437,271.52	104,918.44	22,203.15	-
2013	1,024,736.81	68,932.49	416,937.56	71,559.89	-	-
2014	580,085.70	46,106.63	556,097.91	160,991.55	156,754.42	-
2015	1,053,305.12	20,081.24	441,962.99	143,439.70	142,312.14	-
2016	692,107.12	-	143,436.30	18,266.21	-	9,665.69
2017	362,397.90	-	293,718.54	-	-	107,893.86
2018	528,775.02	-	218,836.56	1,834.35	-	223,023.67
2019	642,137.30	-	261,679.20	77,021.65	-	243,073.49
2020	535,430.09	-	309,771.62	46,016.69	-	297,420.469
2021	1,060,359.74	-	286,050.76	57,222.67	-	273,858.43
2022	1,289,821.29	-	318,644.46	59,859.85	-	353,187.12
Sub-total	8,644,536.55	135,120.36	3,684,407.42	241,955.21	321,269.71	1,508,122.729
Grand Total						**15,034,587.77**

Table 5-4 and Figure 5-3 presents GHG emissions by fuel type by the various VRA-owned power plants.

Table 5-4: Summary of GHG Emissions by Fuel Type (2012-2022)

Year	GHG Emissions (tCO_2e)		
	Diesel Fuel Oil	Natural Gas	Light Crude Oil
2012	40410.09	402047.81	997315.67
2013	13159.46	296903.52	1272103.76
2014	3449.14	694791.97	801795.09
2015	2502.36	1415950.32	382648.51
2016	11303.56	437716.33	414455.42
2017	106935.51	436075.81	220998.99
2018	30122.80	915667.07	26679.72
2019	44478.55	1179433.10	-
2020	66846.09	1121792.79	-
2021	14070.14	1663421.47	-
2022	53367.94	1968144.77	-

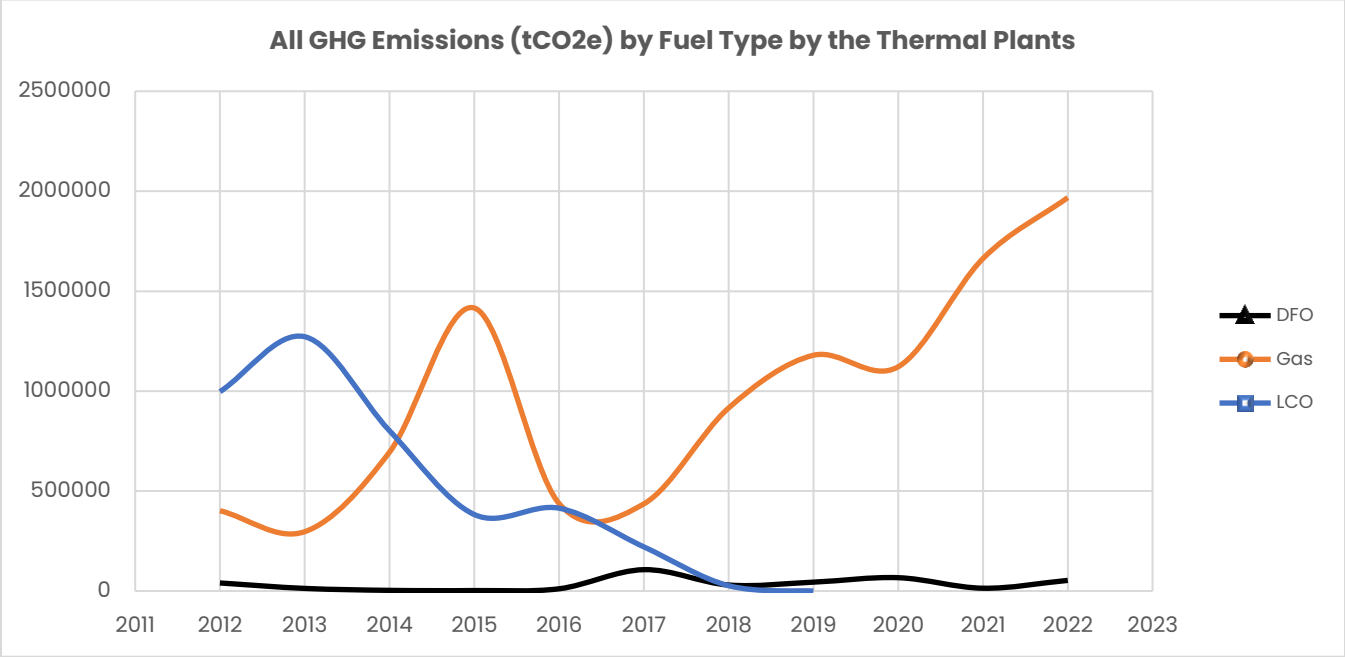

Figure 5-3: Total GHG Emission Trend by Fuel Type (2012-2022)

5.2.2 Performance Tracking for VRA Thermal Plants

The performance of VRA's thermal plants is tracked by monitoring their specific GHG emissions as indicated in Figure 5-4.

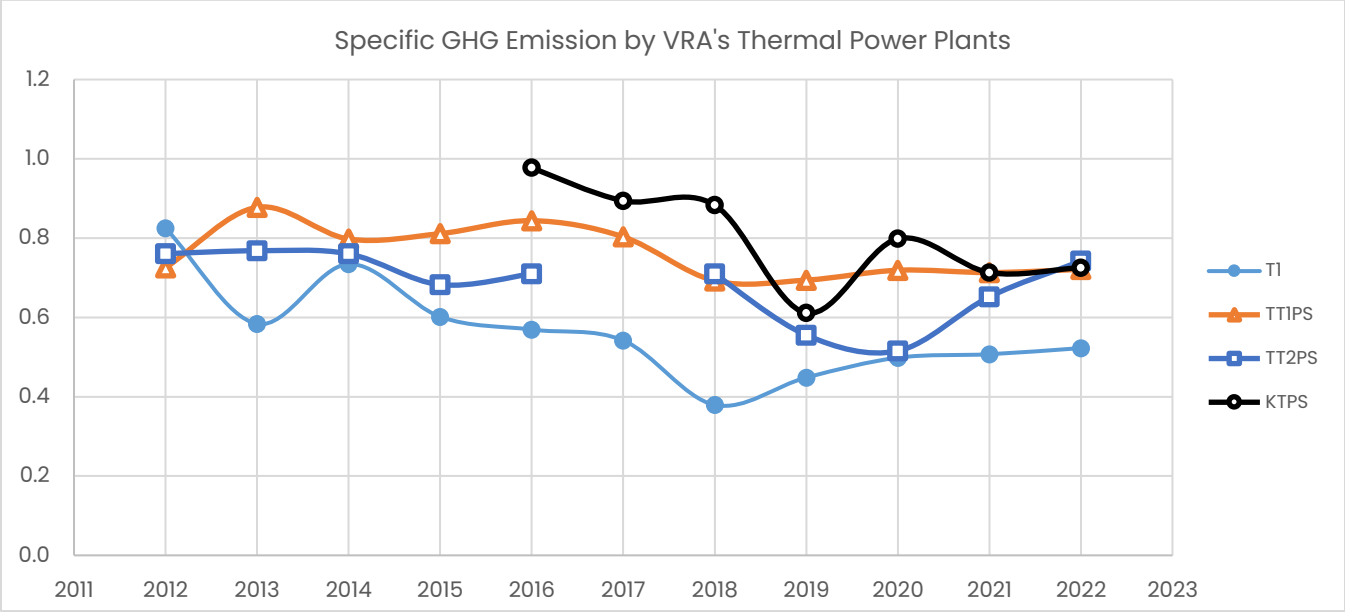

Figure 5-4: Specific GHG Emission by VRA's Thermal Power Plant (2012-2022)

The specific GHG emission of T1 was significantly lower than that of the other plants because T1 is a combined-cycle plant and, except in 2012 when it was run in simple-cycle mode, T1 has been operating in combined-cycle mode throughout the period under review. On the other hand, TT1PS, TT2PS and KTPS are simple-cycle plants and were operated as such throughout the period under review. Thus, the efficiency and performance of T1 were significantly better than the other plants. This underpins VRA's efforts in retooling existing simple-cycle plants into combined-cycle ones. The high specific GHG emission observed in 2012 was also due to the fact that although T1 was operating in simple-cycle mode the other plants were much newer and hence more efficient.

5.3 GHG Emissions from Mobile Combustion

5.3.1 Vehicle Combustion

The total GHG emissions for emissions arising from vehicle combustion of fuel on road is 14,760.21 tCO_2e. Results of GHG Emissions from mobile combustion are as presented in Table 5-5 and Figure 5-5 below.

Table 5-5: GHG Emissions from Vehicular Diesel and Petrol Consumption (2012-2022)

Year	GHG Emissions (tCO_2e)		
	Diesel	Petrol	All GHGs
	CO_2	CO_2	
2012	1084.86	65.23	1150.09
2013	459.95	227.15	687.10
2014	984.87	1266.44	2251.30
2015	1774.37	499.92	2274.29
2016	1585.50	147.34	1732.84
2017	2743.56	198.37	2941.93
2018	1086.85	55.46	1142.30
2019	1322.14	79.43	1401.57
2020	1107.55	71.24	1178.79
2021	1694.51	111.18	1805.69
2022	1244.37	93.09	1337.46
Grand Total	**15088.53**	**2814.85**	**17903.36**

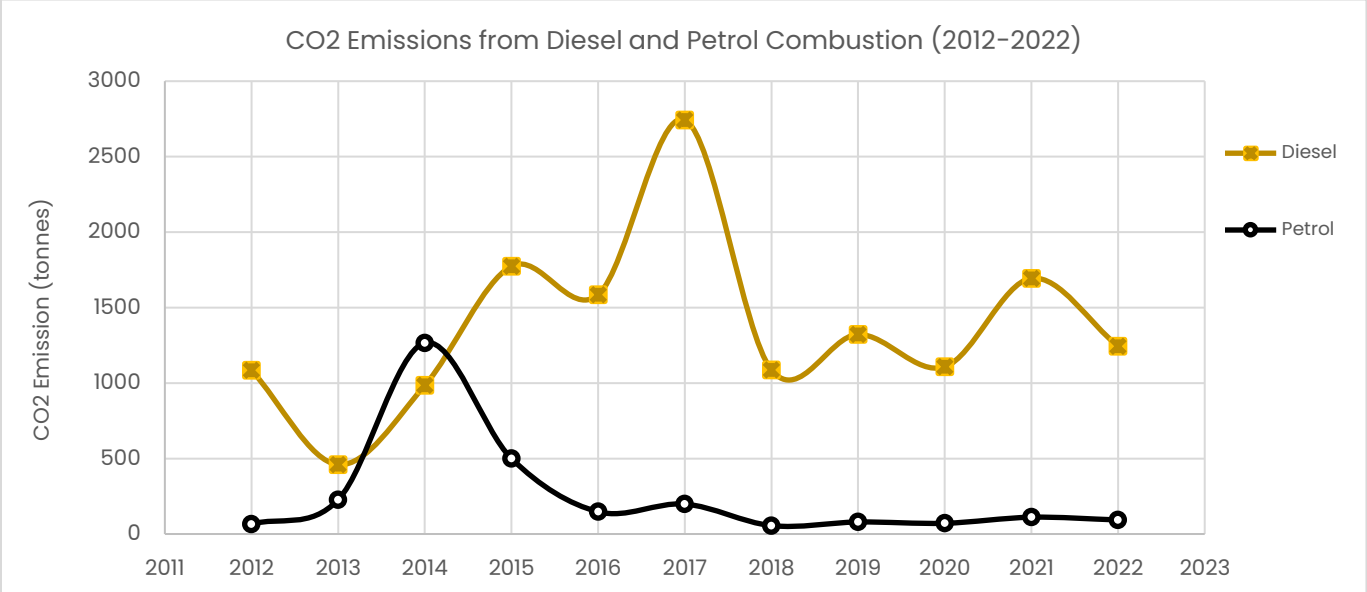

Figure 5-5: A Comparison of CO_2 from mobile combustion for 2012-2022

A breakdown of the emission contributed by each department is also provided in Table 5-6. It must be noted that the functions of the departments in VRA are diverse, and this determines fuel usage by each of them. Subsequently, there cannot be a comparison between the various departments with respect to GHG emissions. In view of this, the average GHG emission for the period under review has been calculated and presented in Table 5-6.

Table 5-6: Cumulative Mobile Combustion GHG Emissions (2012-2022)

Department	GHG Emissions (tCO_2e)	
	2012-2021	2022
Board Secretariat	16.89	7.00
Commercial Services	67.22	13.60
Corporate Strategy	140.39	12.52
Deputy Chief Executives	1235.74	43.77
Engineering Services	3254.09	379.41
Environment & Sustainable Development	1528.31	141.70
Finance & Investment	707.93	55.02
Human Resources	325.40	38.48
Hydro Generation	857.49	46.48
Internal Audit	75.72	17.12
Legal Services	6.86	-
Management & Information System	69.37	6.79
Office of the CE	475.83	62.06
Planning & Power Business	82.31	37.85

Department	GHG Emissions (tCO_2e)	
	2012-2021	2022
Procurement	80.66	-
Real Estate and Security	1172.65	80.56
Technical Services	1033.34	22.04
Thermal Generation SBU	1571.73	159.54
VRA Academy & Schools	827.25	34.55
VRA Corporate Parent	440.07	61.46
VRA Health Services	353.48	82.78
VRA Property Holding Company	2079.02	23.67
Grand Total	**16565.90**	**1337.46**

5.3.2 Marine Services (Water Transport)

The total GHG emissions for emissions arising from water transport is 734.97 tCO_2e from 249518 litres of diesel fuel utilized. GHG emission trend from water transport is as provided in Figure 5-6. The increase in GHG emissions from 2017 to 2019 is attributable to an increase in demand for maritime services by external stakeholders during the period.

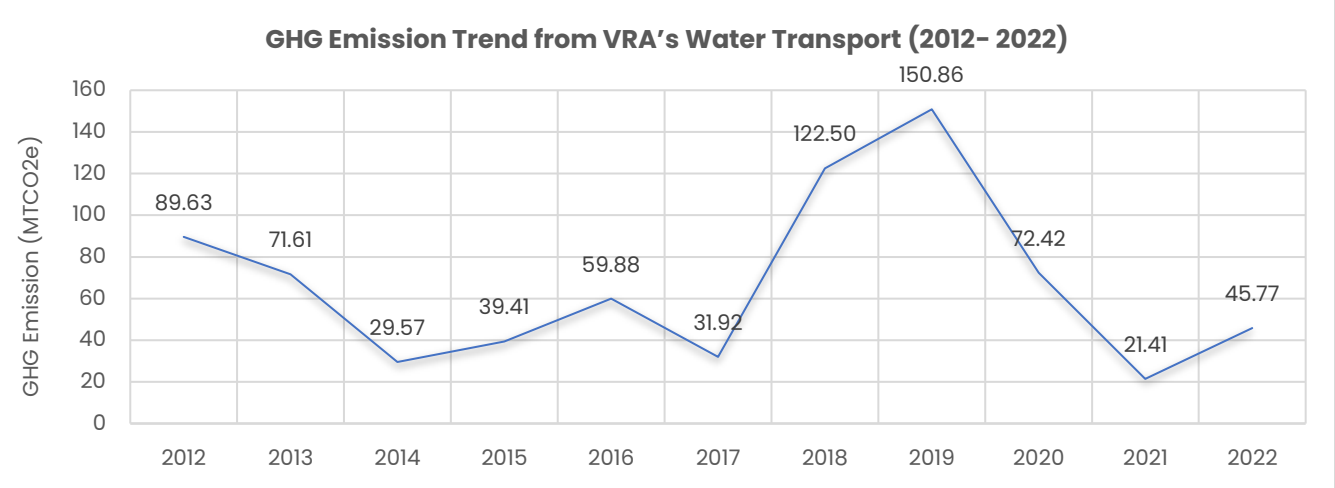

Figure 5-6: GHG Emission Trend from VRA's Water Transport (2012- 2022)

5.4 GHG Emissions Savings

5.4.1 Solar Power Plants

The Specific Capacity Factor, Default Capacity Factor and Default Emission Factor of the VRA's Solar Power Plants have been determined to be 16%, 15.5% and 0.509 tCo2/MWh

respectively. Consequently, and based on data on Annual Energy Generated (MWh) from 2013 – 2022 totaling 29,881.50 MWh, GHG Savings for the period is 32,813.95 tCO_2e as detailed in Table 5-7 below.

Table 5-7: GHG Emission Savings from Solar Power Plants

Year	Annual Energy Generation (MWhrs)					Annual GHG Emission Savings (tCO2e)
	NSPP	LSP	KSP	Mini-Grids	Total	
2013	2,197.80	***	***	***	2,197.80	1,120.00
2014	3,843.30	***	***	***	3,843.30	1,958.00
2015	3,312.30	***	***	***	3,312.30	1,688.00
2016	3,088.80	***	***	***	3,088.80	1,574.00
2017	2,725.80	***	***	***	2,725.80	1,389.00
2018	2,581.70	***	***	80.46	2,662.16	1,356.34
2019	3,429.50	***	***	157.94	3,587.44	1,827.76
2020	3,160.10	***	***	137.86	3,297.96	1,680.27
2021	2,987.60	5,388.20	836.50	129.71	9,342.01	4,759.65
2022	2,554.60	8,706.00	18,996.30	89.09	30,345.99	15,460.93
Total	**29,881.50**	**14,094.20**	**19,832.80**	**595.06**	**64,403.56**	**32,813.95**

***Not Operational

5.4.2 Waste Management Practices

Under the Office Wastepaper Recycling Programme, VRA had by the close of 2022, recycled a total 7501.5 Kg (8.27 Short Tons), as shown in Table 4-5.

Assuming this amount of office paper will have been landfilled, instead of recycled, the total emission savings was 23.68 $MTCO_2e$. Thus, the total GHG Savings from our Renewable energy programme and office wastepaper segregation programme is 32,837.63 tCO_2e as detailed in Table 5-8 below.

Table 5-8: Summary of GHG Emission Savings

Source	Annual GHG Emission Savings (tCO_2e)
Solar Power Station & Mini Grids	32,813.95
Office Wastepaper Recycled	23.68
Total	32,837.63

6 DATA MANAGEMENT

6.1 ADMINISTRATIVE MANAGEMENT

A twelve-member Carbon Accounting Team (CAT) led by the Director Environment & Sustainable Development Dept. has been formally appointed by the Chief Executive to be responsible for developing the Corporate Greenhouse Gas Emission Inventory Report on an annual basis under the ongoing CFMP. The team includes four (4) external individuals who have been engaged to provide technical backstopping in various areas to the CAT.

The Terms of Reference for the CAT are as follows:

a) To calculate net Greenhouse Gas (GHG) emissions of the Authority on an annual basis.

b) Prepare annual "***GHG Emission Inventory Report***" for the Authority in line with international standards for Executive consideration and approval for public disclosure.

c) Develop and make recommendations on strategies for reducing the Authority's Carbon footprint for Executive approval for implementation.

d) Evaluate the Authority's planned power projects and advise Management on which project can be presented as a candidate for carbon trading and financing.

The Secretariat for the CAT is within E&SDD and some key staff have been co-opted to assist with associated administrative responsibilities.

6.2 ACTIVITY DATA

The following source data have been utilized for capturing GHG calculations and inventory:

a. Environmental Progress Reports for the various power plants that VRA submits to the Ghana EPA on a quarterly/annual basis provide data for fuel usage as well as power generated and consumed at each plant.

b. Procurement Department is responsible for purchasing fuel and each department reports on their fuel usage to the General Services Department, using what is called a "***Vehicle Operational Chart"***, and these data are eventually stored as part of records by both departments.

c. Marine Logbooks are used for recording fuel utilized by marine fleets, and this provides source data for water transport combustion.

d. Office Paper Waste Log sheet provides source data for progress reporting of office wastepaper recycled by E&SDD.

6.3 DATA MANAGEMENT

The Director, E&SDD through Manager, Environment and Social Impact (ESI) is responsible for coordinating the collection of inventories for all data required and maintaining this information in the relevant formats, such as reports, electronic files and calculation spreadsheets.

The specific steps of the process are as follows:

a) **Data Receipt**

- Data on the amount of fuel consumed and energy produced from the power stations are recorded by the operational team and made available by the respective departments through their Quarterly Environmental Monitoring Progress reports and annual environmental reports to the Director, E&SDD.
- Fuel utilised by company vehicles is received from all departments via the Technical Services Department, using either the "***Vehicle Operational Charts***" or the Oracle E-Business Suite. That for marine fleets is provided by E&SDD through the marine Logbooks.
- Waste office paper from the various VRA outfits is transported to Akosombo, mainly through the mail van and stored at the Environment & Social Impact (ESI). The waste office paper, when in sufficient volumes, is then transported to the Akosombo Paper Mill. The volumes are then weighed and recorded on signed Waste Transfer Notes, which are then reported in monthly progress reports of E&SDD.
- All the data received are then inputted into spreadsheet files and saved to a directory under the 'Corporate Carbon Footprint' folder in the Corporate One Drive.
- DATA REVIEW AND MANIPULATION – spreadsheets are accessed and reviewed for the relevant information. In some cases, the data are sorted, totaled, and formatted to facilitate entry into the inventory spreadsheet. The data also is reviewed during this step to evaluate the overall magnitude to identify any obvious errors or omissions.
- DATA ENTRY – data is entered in the draft-working version of the GHG inventory. During this step, an additional review for data reasonableness and completeness is performed. Any obvious errors or omissions are addressed directly with the data manager by phone or email, as needed. All the data sources either are entered directly into the inventory or are used for further calculation of the necessary data points required to develop the overall inventory.
- QA/QC AND TECHNICAL REVIEW – where data entry is required, a double check and a reverse double check are always performed. A double-check review is simply another

review of the numbers entered in the working draft version of the inventory, while a reverse double check is an evaluation of the data entered against the working draft version of the inventory to ensure all data points are included. Once the review is completed, the draft version is circulated to the Carbon Accounting Team within the company; feedback is used to modify the inventory as needed.

6.3.1 Data Collection Process Quality Assurance

The owners of data identified in the previous section are responsible for maintaining data quality assurance. Every effort would be made to ensure that the data reported are accurate and complete. Manager ESI will evaluate the data, once collected, to ensure that it is reasonable and consistent with past years. Manager ESI will also conduct and document QA checks during the production of the inventory. All possible errors as well as the QA/QC actions used to maintain accuracy will be defined and documented as part of the process for collecting the GHG data. Any departures from these data quality measures (i.e. non-compliance events) would be communicated. Any inconsistencies and large, unexpected changes from the previous year's data would be sufficiently explained when the data is transmitted. The Manager, ESI will also compare the current year's data for each source category to the previous year's data to identify any large, unexpected variations. Data will be reviewed, and all calculations validated to ensure that calculations are correct.

6.3.2 Frequency

The VRA GHG Reports are to be updated on an annual basis. Annual inventories will be published and on VRA's Corporate website (www.vra.com). VRA will continue to use and update the inventory template in future years to remain as consistent as possible.

7 CARBON OFFSET AND REDUCTION STRATEGIES

7.1 VRA's Renewable Energy Development Programme

In line with national actions in the renewable energy sector, VRA in February 2010 adopted a Renewable Energy Generation Policy in order to develop and operate RE plants in an efficient, cost-effective and environmentally sustainable manner. To achieve the purpose set out in the VRA RE Generation Policy, the Renewable Energy Development Programme (REDP) was formulated. The VRA REDP sets a 5-10 years' Renewable generation capacity target, taking cognizance of the local and export demand and the system constraints and is being rolled out in phases. Details of planned renewable energy projects are as listed in Table 7-1.

Table 7-1: Planned Renewable Power Projects

	Project
15 MW	Solar (Kaleo, Lawra) – Phase 2 (Commissioned)
60MW	Bongo Solar Power Project (EIA Study concluded, Environmental Permit obtained)
0.448MW	Akuse Residential & Institutional Office Buildings Solar PV Rooftop Project
0.057MW	Head Office Solar Car Park
0.079MW	Head Office Rooftop Project
75MW	Wind Power Project -1 (Anloga, Srogbe, Anyanui) (EIA Study concluded, Environmental Permit obtained)
50MW	Solar Power Component - Pwalugu Multipurpose Dam
50MW	Sawla Solar Power Project
20MW	Sherigu Solar Power Project
20MW	Zebilla Solar Power Project
70MW	Loagri Solar Power Project
5MW	Akuse Floating Solar Power Project

Annual GHG emissions savings are estimated at 207,506 tCO_2e for the solar power projects (291 MW) and 98.077 tCO_2e for the wind power projects (75MW).

7.2 Tree Planting Programmes

As indicated in Section 4.6 VRA is engaged in two major tree planting programmes along the Volta Lake known as the Volta Gorge Reforestation Project and the Buffer Zone Project. Tree

species adopted are *Senna siamea* (cassia), *Acacia mangium, Khaya senegalensis* (Mahogany), *Cedrella odorata,* and *Leuceana leucocephala*. As at close of 2022, about 1,653 hectares of the Volta Gorge area had been planted, whilst 312.1 hectares of forest tree plantation established under Buffer Zone Project. Thus, the total area covered is 1965.1 ha.

VRA is yet to calculate the carbon sequestration potential of its tree planting programme. However, considering the type of species being planted, it is estimated that 28 tCO_2e is sequestrated annually per hectare Thus, the total 49,394.8 tCO_2e could be sequestrated annually[3].

VRA intends to utilize both aerial and ground surveys to capture data on the tree dimensions for use in calculating the amount of carbon sequestrated by this plantation. The reduction in the amount of carbon emissions can then be measured and used to offset VRA's carbon emissions within its carbon accounting programme.

7.3 Energy Efficiency & Fuel Switch

Simple cycle power plants (SCPP) use fuel and compressed air in gas turbines, which drive a generator producing electrical energy. The hot exhaust gases are released into the environment without further use of the containing energy in form of heat. The purpose of combined cycle power plant (CCPP) is to utilize the energy from the hot turbine exhausts for steam generation in a downstream heat recovery steam generator (HRSG). This steam is used for power generation in a steam turbine. Therefore, the total electrical power generation capacity of a CCPP is made up of the power output of gas turbines and the steam turbine without the need for additional fuel.

VRA currently plans, under the KTPS Phase 1 - Stage 2 development, to convert the Gas Turbine Generating Units into a 330MW Combined Cycle Unit. The Project Idea Note submitted to CDM operational entity for the West Africa Region as a CDM Programme Activity Design Document in May 2011 estimated the GHG annual savings at 400,000 Tonnes of CO_2 Equiv.

7.4 Cleaner Cooking Solutions through adoption of fuel-efficient stoves

Our Climate Smart Stove project aims to minimize the harvesting and utilization of trees as firewood in the Volta Lake basin. The Authority in 2016 successfully piloted these fuel-efficient and energy-saving improved domestic cook stoves in twenty-one (21) riparian communities. As at close of 2022, a total of five hundred and five (505) cook stoves had been constructed.

[3] *Source: VRA - Immediate Opportunities Ecosystem Services Trading Enam Eyiah, reNew, 2020*

The provision of these fuel-efficient domestic cookstoves, termed, "Climate Smart Stoves" is to complement our commitment to ensuring the communities minimize the consumption of firewood and re-enforce attitudinal change among the community members. These stoves are built from clay, which is locally available in the area, and accommodates two (2) cooking pots with an elevated chimney primarily designed to remove the smoke from the cooking area. The use of the CSS has shown to have immense economic and health benefits to users as it contributes to financial savings of the families and the reduction in exposure of wood smoke, heat, and fire burns from open fires, which mostly affect women and children that are engaged in this activity.

An assessment of the Climate Smart Stoves by the Council for Scientific & Industrial Research showed that an efficiency in terms of fuelwood savings of 51.45% and processing rate of 76.6%. According to the CSIR, this performance met international requirement of a minimum of 40% fuel saving. The CSIR results also show an estimated annual carbon savings of 664 kg CO_2 per stove as against the traditional "3-Legged Cook Stoves". VRA in 2019 provided funding for two MPhil students and one PhD student at the Institute of Environmental & Sanitation Studies (IESS) of the University of Ghana, to undertake an assessment of the health, environmental and economic impacts of the "climate smart stoves". The research will involve a detailed assessment of the carbon savings of the stoves.

7.5 Resource Use Efficiency

VRA in 2020 embarked on a four-year Sustainability Plan to help VRA achieve its financial and operational sustainability in the period 2021 to 2025, with the primary objective of maintaining VRA's position as a market leader in the Ghana power market. Under the Plan, the underlisted targets were set for all departments to achieve resource use efficiency:

- Reduction in paper usage
- Reduction in transport / travel costs
- The adoption of video conferencing for meetings, and
- The digitization of our Internal business processes and operations.

To achieve the above, a paperless system, using "**Laserfiche"** as well as "**Microsoft Teams**" have been adopted in all operations of VRA. The implementation of these is geared towards reducing administrative costs and will in addition, invariably also reduce GHG emissions and corporate carbon footprint.

7.6 Most Eco-Friendly Department Awards

VRA in 2019 instituted the "**Most Eco-Friendly Department"** awards and this has been incorporated into the annual Corporate Safety Awareness Day Celebration, held each year on the third Thursday of November. The awards involve using the average vehicular emissions data for the preceding three years as baseline for which department's annual performance is compared to that of the award year. As fuel usage requirements differ for each department due to the separate workloads, the use of annual percentage reduction of the baseline data has been adopted.

7.7 PET Segregation & Processing Programme

Under the Corporate Solid Waste Segregation Programme, VRA intends embarking on the segregation and disposal of Polyethylene Terephthalate (PET) bottles or plastic drinking bottles, targeting Akosombo and its environs. This will involve the setting up a "**Waste Plastic Recycling Center"** in Akosombo to serve all VRA facilities (including institutional houses), the Akosombo community and its environs. The procurement process to solicit for a partner company for a collaboration is ongoing and is expected to be completed by close of 2021. The partner company will be required to process waste PET Bottles, in the first instance, as well as any other plastic waste that may be required.

The recycling effort of VRA is to be incentivized through a waste exchange programme to be determined by the amount of plastic waste generated and recovered. The Partner Company will be required to provide VRA with the quantitative data on the amount of plastic recovered in tonnes relying solely on the United Nations Framework Convention on Climate Change assessment standards. This information is expected to feed into the Corporate Annual GHG Inventory Report as well as the Sustainability Report.

8 PLANNED IMPROVEMENTS – STATUS OF IMPLEMENTATION

The following actions are to be pursued to improve future data capture and reporting as well as reduce GHG emissions:

No.	Activity	Status
1.	Centralizing (through the business oracle system) requisite data for the activity data for fuel consumption for mobile emissions, vehicular/water transport.	Completed
2.	Institute the "Eco-Friendly Department" awards.	Completed
3.	Capacity building of staff using safety meetings to effectively embrace carbon caring values throughout the operation of VRA and report on outcome by 2021.	Ongoing
4.	Implementation of resource use efficiencies programs under the Corporate Sustainability Plan, targeting a reduction in paper and vehicular fuel usage, the adoption of video conferencing for meetings, and the digitization of our Internal business processes and operations.	Ongoing
5..	Establish the "Akosombo Plastic Waste Processing & Recycling Centre" for the segregation and processing of plastic bottles within Akosombo and its environs by 2027.	Ongoing
6.	Build the capacity of VLTC, AHL, KFL, and NEDCO to publish their own GHG Report by 2027.	Ongoing
7.	Undertake area and ground survey to assess carbon sequestration of the VRA Reforestation program to offset VRA's carbon emissions within its carbon accounting program by 2026.	Yet to commence
8.	Initiate strategies to collate data on fugitive emissions such as Methane from natural gas distribution systems within the Tema Area under Scope 2 and report on outcome by 2026.	Yet to commence
9.	Initiate strategies to collate data on Hydrofluorocarbon emissions from specifically office Air Condition systems by 2026.	Yet to commence
10.	Inclusion of electric vehicles in the Authority's fleet of vehicles to reduce GHG emissions.	Yet to Commence

9 REFERENCES

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APPENDIX

Appendix 1 - VRA Corporate Organizational Chart

APPENDIX 1

VRA CORPORATE ORGANIZATIONAL CHART