THE PATNA INITIATIVE
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GHANA'S INTERNATIONAL SHIPPING EMISSIONS INVENTORY REPORT: 2018 – 2023 VOYAGE-BASED ANALYSIS



Dolapo Oluteye, Numbu Issahaque Sumabe,
Augustine Chongaterah, Fitzroy Meyer-Petgrave

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Table of Contents

TABLE OF FIGURES IV
AUTHORS V
PUBLICATION DETAILS V
ACKNOWLEDGEMENTS V
DISCLAIMER V
CONTACT DETAILS VI
ABOUT THE PROFESSIONAL AFRICAN TECHNICAL NETWORK ADVISORY (PATNA) INITIATIVE VI
ABOUT THE GHANA MARITIME AUTHORITY (GMA) VI
ABOUT UCL ENERGY INSTITUTE VI
EXECUTIVE SUMMARY VII
LIST OF ABBREVIATIONS VIII
1 INTRODUCTION 1
2 DATA ACQUISITION AND ANALYSIS 1
3 NATIONAL MARITIME CONTEXT 2
4 INTERNATIONALLY ARRIVING AND DEPARTING INVENTORIES BY VESSEL TYPE IN GHANA 7
5 INTERNATIONALLY ARRIVING AND DEPARTING INVENTORIES BY PORT IN GHANA 11
6 INTERNATIONALLY ARRIVING AND DEPARTING INVENTORIES BY PARTNER COUNTRY 14
7 DOMESTIC INVENTORIES BY PORT PAIR 17
8 CONCLUSION 18
REFERENCES 19

Table of Figures

Figure 1: Vessel traffic for Tema and Takoradi Ports from 2013 to 2023 3
Figure 2: Import Traffic for Tema and Takoradi Ports from 2013 to 2023 4
Figure 3: Export Traffic for Tema and Takoradi Ports from 2013 to 2023 5
Figure 4: Transhipment Traffic for Tema and Takoradi Ports from 2013 to 2023 6
Figure 5: GhPortcalls- 2018 International Voyages by Vessel Type 7
Figure 6: LeapAIS - International Arrivals- Energy Demand by Vessel Type 8
Figure 7: LeapAIS – International Arrivals - CO_2 Generation by Vessel Type 9
Figure 8: LeapAIS – International Departures- CO_2 Generation by Vessel Type 10
Figure 9: LeapAIS – International Departures- CO_2 Generation by Vessel Type 10
Figure 10: GhPortcalls- 2023 International Voyages by Vessel Type 11
Figure 11: 2018 LeapAIS – Internationally Arriving - Energy Demand by Port 12
Figure 12: 2018 LeapAIS – International Arrivals - CO_2 Generation by Port 12
Figure 13: 2018 LeapAIS – International Departures - Energy Demand by Port 13
Figure 14: 2018 LeapAIS – International Departures - CO_2 Generation by Port 13
Figure 15: LeapAIS – International Arrivals - Energy Demand by Partner Country 15
Figure 16: LeapAIS – International Arrivals - CO_2 Generation by Partner Country 15
Figure 17: LeapAIS – Departures Arrivals - Energy Demand by Partner Country 16
Figure 18: LeapAIS – International Departures - CO_2 Generation by Partner Country 16
Figure 19: LeapAIS – Domestic - Energy Demand by Port Pair 17
Figure 20: LeapAIS – Domestic - CO_2 Generation by Port Pair 18

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About The Professional African Technical Network Advisory (PATNA) Initiative

The PATNA Initiative is a non-profit network of African marine and blue-economy specialists. Formed to amplify Africa's voice in global maritime decarbonization, PATNA leverages evidence-based research to inform policies that balance economic growth with environmental protection. Our initiative brings together academics, technical experts, government professionals, and private-sector cohorts to ensure that African perspectives are represented in international maritime policy and climate action. For more information, please visit www.thepatna.org.

About the Ghana Maritime Authority (GMA)

GMA is the statutory agency responsible for regulating and monitoring activities in the maritime industry in Ghana, including the protection of the marine environment from pollution. The GMA collaborates with Ghana Ports and Harbours Authority (GPHA), the statutory agency established to build, plan, develop, manage, maintain, operate, and control all ports in Ghana; and the Ghana Shippers Authority (GSA), the statutory agency responsible for regulating commercial shipping activities in Ghana.

About UCL Energy Institute

The UCL Energy Institute hosts a world leading research group which aims to accelerate the transition to an equitable and sustainable energy and trade system within the context of the ocean. The Shipping and Oceans Research Group's multi-disciplinary work on the shipping and ocean system leverages advanced data analytics, cutting-edge modelling, and rigorous research methods, providing crucial insights for decision-makers in both policy and industry. The group focuses on three core areas: analysing big data to understand the drivers of shipping emissions, developing models and frameworks to explore the path toward zero-emission shipping, and conducting social science research to examine the policy and commercial structures that enable the decarbonization of the shipping sector. For more information visit www.shippingandoceans.com.

Executive Summary

The Fourth International Maritime Organization (IMO) Greenhouse Gas (GHG) Study, published in 2020, estimated that the maritime industry contributed 2.89% to global anthropogenic GHG emissions in 2018 (Faber et al, 2020). By 2050, these emissions could increase to between 90% and 130% of 2008 levels. In response, the 2023 IMO GHG Strategy aims to strengthen the IMO's role in global emission reduction efforts by addressing GHG emissions from international shipping, identifying actions for the sector, considering impacts on States, promoting incentives for research and development, and monitoring emissions (IMO, 2023).

For a truly global discussion, empirical evidence from Africa is necessary for informing policy decisions. In response, the Leading Effective Afro-centric Participation (LEAP) project initiative was developed to provide a technical toolkit with four key workstreams necessary for supporting the African member states. One of the four is the systematic assessment of greenhouse gas (GHG) emissions from shipping activities of six African IMO member states, namely Ghana, Kenya, Liberia, Malawi, Namibia and Nigeria.

Thus, this report presents a systematic assessment of greenhouse gas (GHG) emissions from Ghana's international shipping activities, covering the period 2018–2023. Undertaken as part of the LEAP Project, this GHG inventory report is a collaborative effort by the PATNA Initiative, the Ghana Maritime Authority (GMA), Ghana Ports and Harbours Authority (GPHA), and Ghana Shippers Authority (GSA), in partnership with and the UCL Shipping and Oceans Research Group, financially supported by Oceans 5.

The study aimed to quantify energy demand and GHG emissions from international voyages at Ghana's main maritime gateways: Tema and Takoradi ports. It utilized a combination of local vessel call data (2018, 2023) and Automatic Identification System (AIS) data (2018) to analyse emissions by vessel type, port, and partner country, also providing insights into domestic movements. Key technical parameters from AIS data enabled robust estimations of energy demand (terajoules) and CO_2 emissions (tonnes), with local data used for validation.

Key findings indicate that bulk carriers and container ships are the biggest contributors to energy demand and CO_2 emissions, a consistent trend between 2018 and 2023. Tema Port consistently shows the highest emissions due to its capacity and transshipment role. Emissions are significantly linked to voyages with neighbouring West African ports (e.g., Togo, Nigeria, Ivory Coast) due to transshipment, as well as long-haul voyages to Malaysia. Domestically, the Tema–Takoradi route accounts for the largest share of energy demand and CO_2 emissions. Overall, the stability in vessel types and trade profiles suggests Ghana's shipping-related GHG footprint remained largely unchanged during this period.

List of Abbreviations

Abbreviation	Full Meaning
AIS	Automatic Identification System
CO_2	Carbon Dioxide
FPSO	Floating Production Storage and Offloading (unit)
GHG	Greenhouse Gas
GMA	Ghana Maritime Authority
GPHA	Ghana Ports and Harbours Authority
GSA	Ghana Shippers Authority
IMO	International Maritime Organization
LEAP	Leading Effective Afrocentric Participation (Project)
MPS	Meridian Port Services
PATNA	Professional African Technical Network Advisory (Initiative)
Ro-Ro	Roll-on/Roll-off (vessels)
TJ	Terajoule
TORs	Terms of Reference
UCL	University College London

1 Introduction

This analysis is based on the Terms of Reference (TORs) of Task 1 LEAP Project for Ghana. The activities under this task were undertaken by three Ghanaian state agencies, namely, Ghana Maritime Authority (GMA), Ghana Ports and Harbours Authority (GPHA), Ghana Shippers Authority (GSA); in collaboration with the LEAP Project team.

GMA is the statutory agency responsible for regulating and monitoring activities in the maritime industry in Ghana, including the protection of the marine environment from pollution. GPHA is the statutory agency established to build, plan, develop, manage, maintain, operate, and control all ports in Ghana. Furthermore, GSA is the statutory agency responsible for regulating commercial shipping activities in Ghana.

The overall objective of this task is to estimate the energy demand and Greenhouse gas (GHG) emissions from international voyages in Ghana's maritime sector. This specifically focuses on internationally arriving and internationally departing voyages by vessel type, port, and partner country. Estimations of inventories of national maritime emissions are therefore not considered in this analysis.

The document is structured into five major sections. The next section deals with data acquisition and analysis. This is followed by a brief description of the national maritime context of Ghana, highlighting the major ports and seaborne trade (imports and exports). The last three sections deal with internationally arriving and departing inventories by vessel type, port and partner countries respectively.

2 Data acquisition and analysis

This analysis is based on data collected over the years by GPHA, GMA, and satellite Automatic Identification Systems (AIS) data for 2018 from the LEAP Project team. Data from the Ghanaian agencies consist of raw vessel calls recorded manually by the GPHA and the GMA for the years 2018 and 2023. The data from the LEAP Project team consist of pre-processed AIS data for the year 2018. Apart from the manually recorded data, secondary data on port statistics was also obtained from GPHA and utilized in this analysis.

The 2018 AIS data from the LEAP team was first analyzed into graphs to make meaning. The estimates used AIS vessel data attributes such as IMO numbers, build year, deadweight, gross tonnage, and voyage distance to compute averages of voyage frequencies, distances, and tonnages. These are fed into the estimation model to generate energy demand in tera joule (TJ) and CO_2

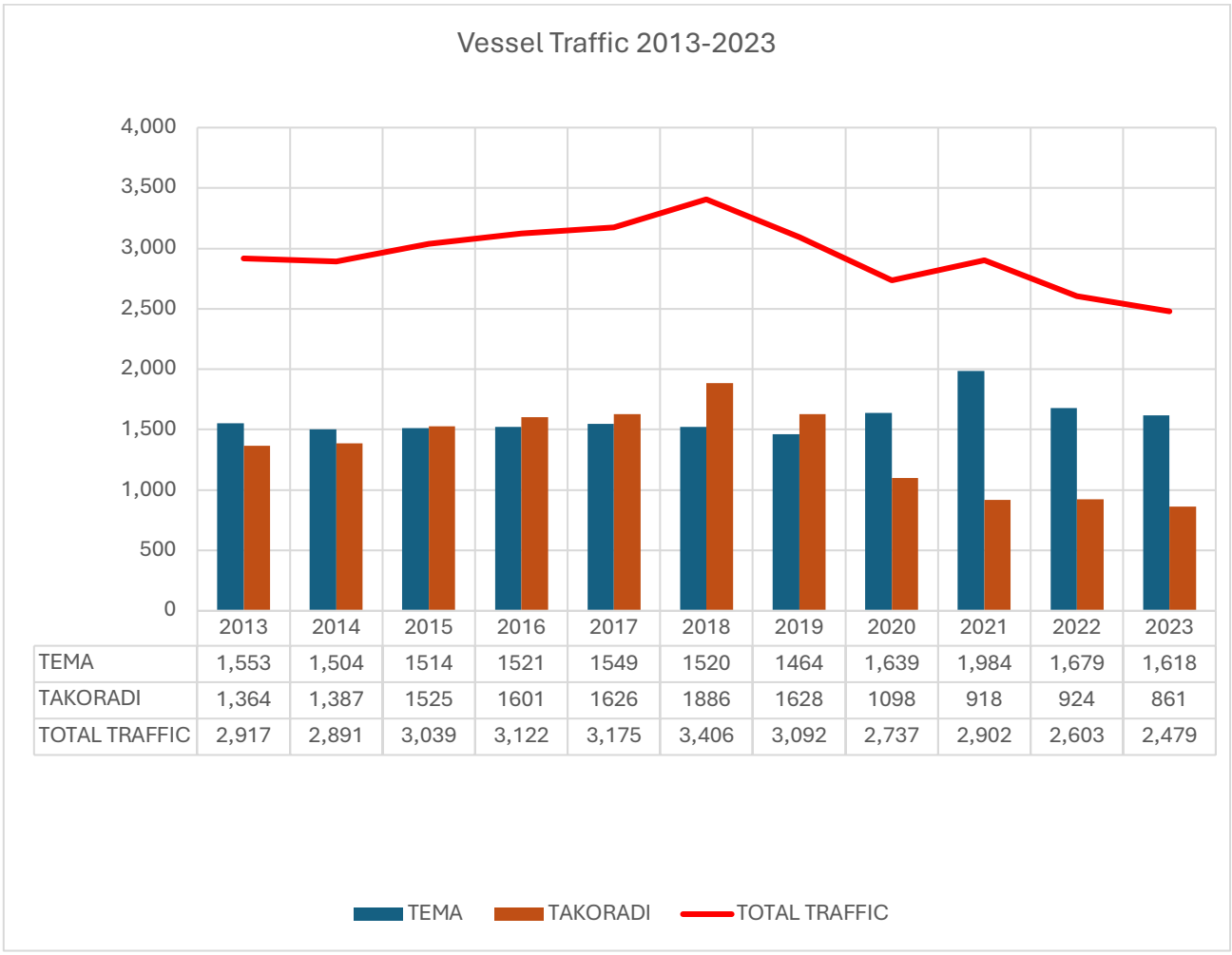
emissions in tonnes. The results are presented using inventories such as internationally arriving, departing, vessel type, and port pairs. The data collected by the Ghanaian agencies for 2018 and 2023 were sorted and aggregated before analysis and presentation. Comparison was then made between the 2018 AIS data and 2018 Ghana collected data to ensure consistency. The analyzed data from 2018 was also compared to the 2023 data to identify trends in the emissions inventory for the country. For clarity, summaries derived from local data as used in this document are labelled "GhPortcalls," whilst those from the AIS data are labelled "LeapAIS."

The locally recorded data for 2018 and 2023 had few limitations. Firstly, the deadweight, vessel types, and year of construction were not recorded. Even though the LEAP team provided support to populate these missing data fields, about 5% of vessels were still excluded from the summaries generated. This could partly be due to mismatch in the IMO numbers of vessels and/or duplications in data recorded. The missing data was however insignificant to affect the integrity of the 2018 and 2023 databases. Secondly, vessel departure dates from Takoradi Port for the 2018 locally recorded data was missing, thereby preventing specific port comparisons for 2018 and 2023 to be made. However, aggregates of vessel types calling on the ports were made for 2018 and 2023 to allow for meaningful comparisons.

3 National Maritime Context

Located on the West African coast in the Gulf of Guinea, Ghana enjoys relative peace, stability and good governance which makes it a major hub for international trade in the sub-region. The country's maritime activities revolve around port operations, fisheries, dry-dock and repair, ship bunkering, regulatory, tourism and other offshore operations and support services. Seaborne trade is vital to the national economy in facilitating imports and exports of goods.

There are two major seaports in Ghana: the Tema and Takoradi Ports. These are the primary ports of call for vessels from all continents and provide both direct and transhipment services. They account for about 85% of the international trade conducted in Ghana (GPHA 2024a). Vessel calls to the ports in Ghana have generally increased steadily over the years. Figure 1 shows that the number of international vessels calling at the Tema and Takoradi Ports steadily increased from 2013, peaking in 2018, before gradually decreasing from 2019 to 2023. The reduction in traffic from 2019 onwards may be due to the completion of the Tema Port expansion project which allowed for much bigger vessels to be admitted to the port.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TEMA	1,553	1,504	1514	1521	1549	1520	1464	1,639	1,984	1,679	1,618
TAKORADI	1,364	1,387	1525	1601	1626	1886	1628	1098	918	924	861
TOTAL TRAFFIC	2,917	2,891	3,039	3,122	3,175	3,406	3,092	2,737	2,902	2,603	2,479

Figure 1: Vessel traffic for Tema and Takoradi Ports from 2013 to 2023

Source: GPHA (2024b)

Notwithstanding the trends in vessel traffic, other imports and cargo throughput in the ports have witnessed steady growth as shown in Figure 2. Ghana imports a wide range of consumer goods such as electronics, clothing and apparel, furniture, and home appliances; industrial goods such as machinery and equipment, automotive parts, and construction materials. Other imports are food and beverages such as packaged foods, frozen meats and seafood, and other items requiring cold storage. Raw materials for the manufacturing industry such as plastics and polymers, textiles, and chemicals are also imported. Ghana also imports refined petroleum products to supplement its energy needs.

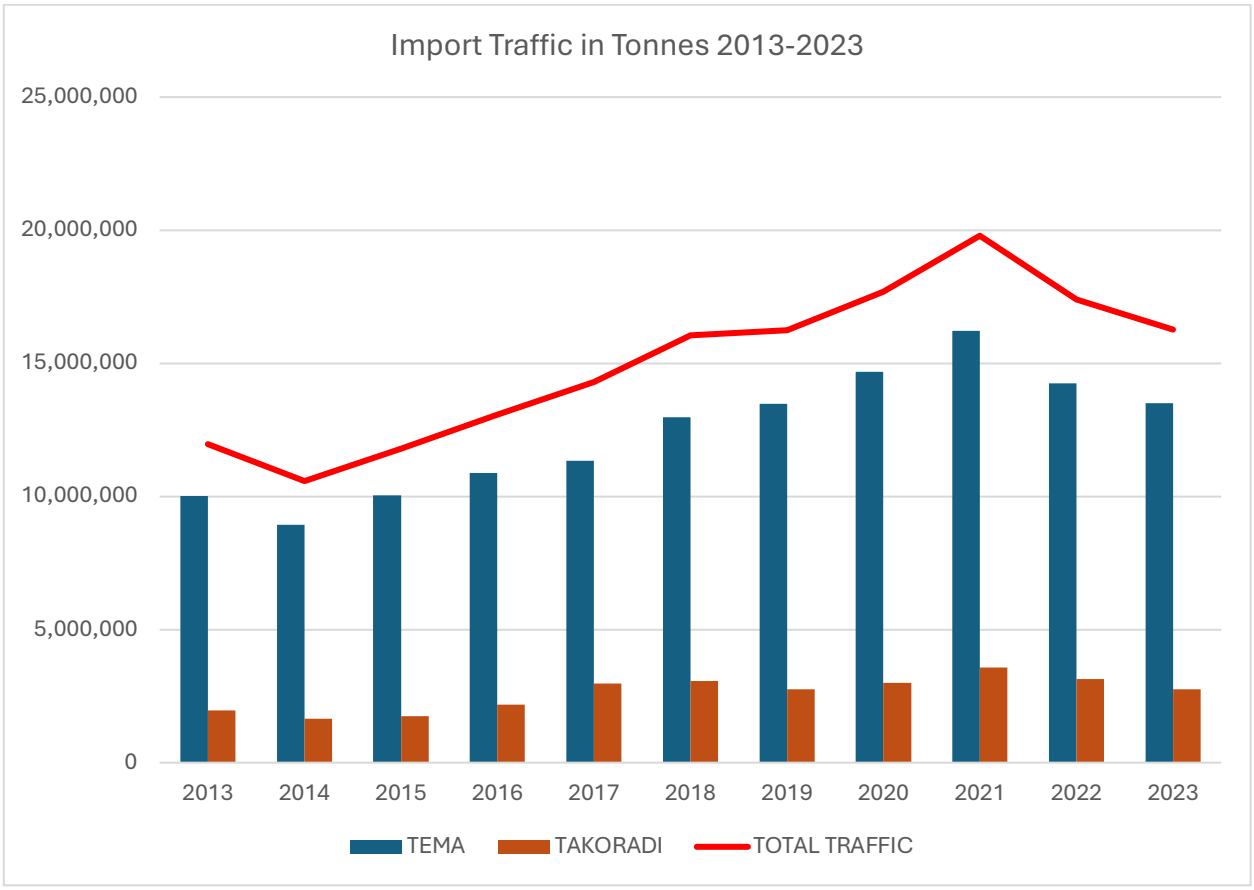


Figure 2: Import Traffic for Tema and Takoradi Ports from 2013 to 2023

Source: GPHA (2024b)

Ghana is rich in mineral resources and is a major exporter of various products. The country exports significant amounts of cocoa to the global market. Ghana and Cote d'Ivoire combined exported over 60% of the world's cocoa beans (International Cocoa Organisation, 2022). To a large extent, these are often exported as raw materials for factories worldwide. Ghana has significant reserves of crude oil in offshore oil fields. Although the country is a producer of petroleum products, the crude is generally exported and sold in the international market, while refined fuels are imported for domestic consumption. Total Export Traffic declined from 2013 to 2015, increased gradually until 2019, and remained consistent from 2020 to 2023. The data displayed in Figure 3 indicate that Ghana exported more in 2019 than in any other year between 2013 and 2023.

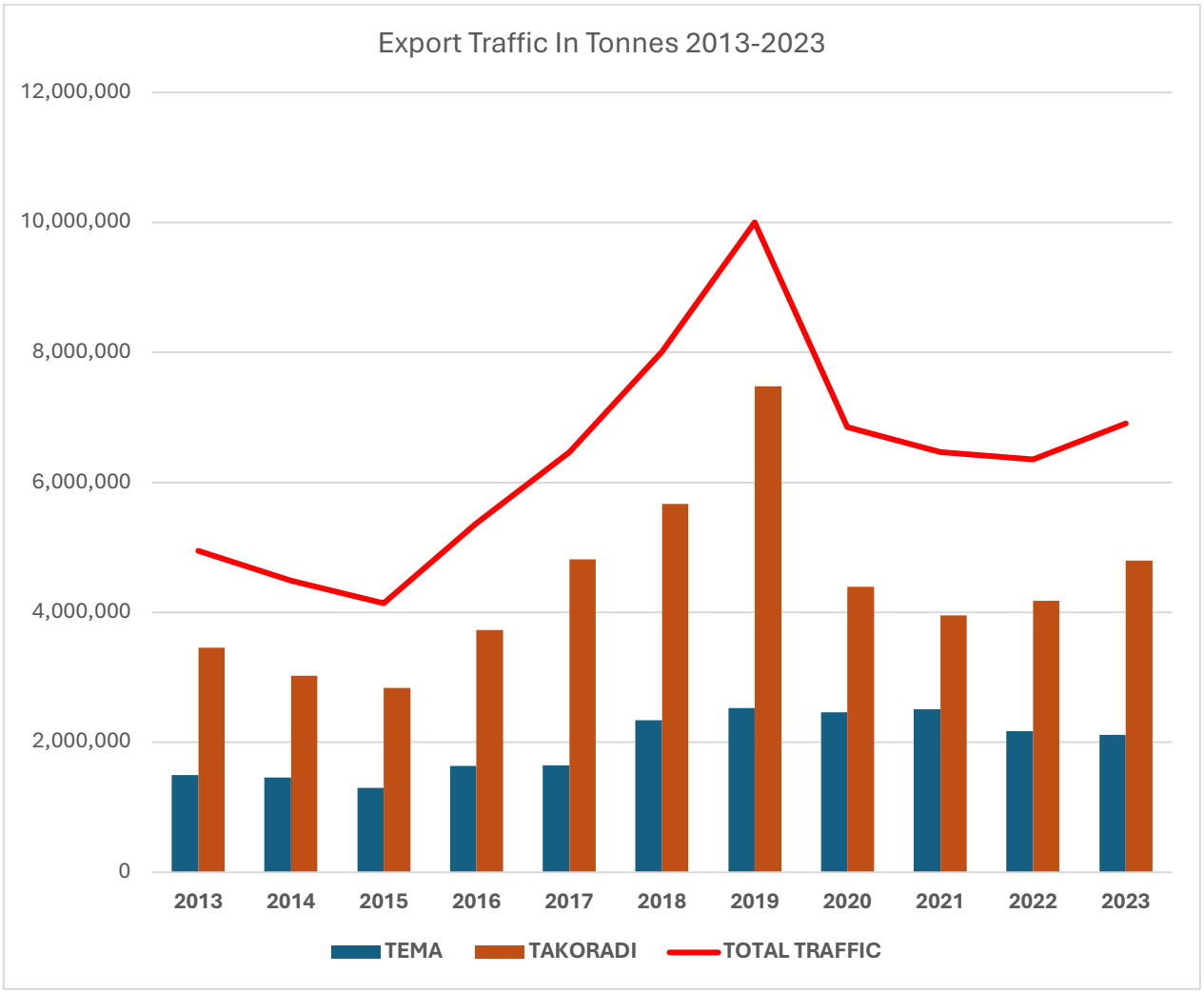


Figure 3: Export Traffic for Tema and Takoradi Ports from 2013 to 2023

Source: GPHA (2024b)

The ports of Tema and Takoradi are also major hubs for transshipment to other landlocked and coastal countries in the sub-region. Several landlocked countries in West Africa, including Burkina Faso, Mali, and Niger, import goods through the ports of Ghana over the years. As indicated in Figure 4, transhipment has increased since 2020 especially for Tema Port. These goods are generally similar to the categories of imports to Ghana described above, including consumer goods, vehicles and spare parts, raw materials, industrial feedstock, and pharmaceuticals.

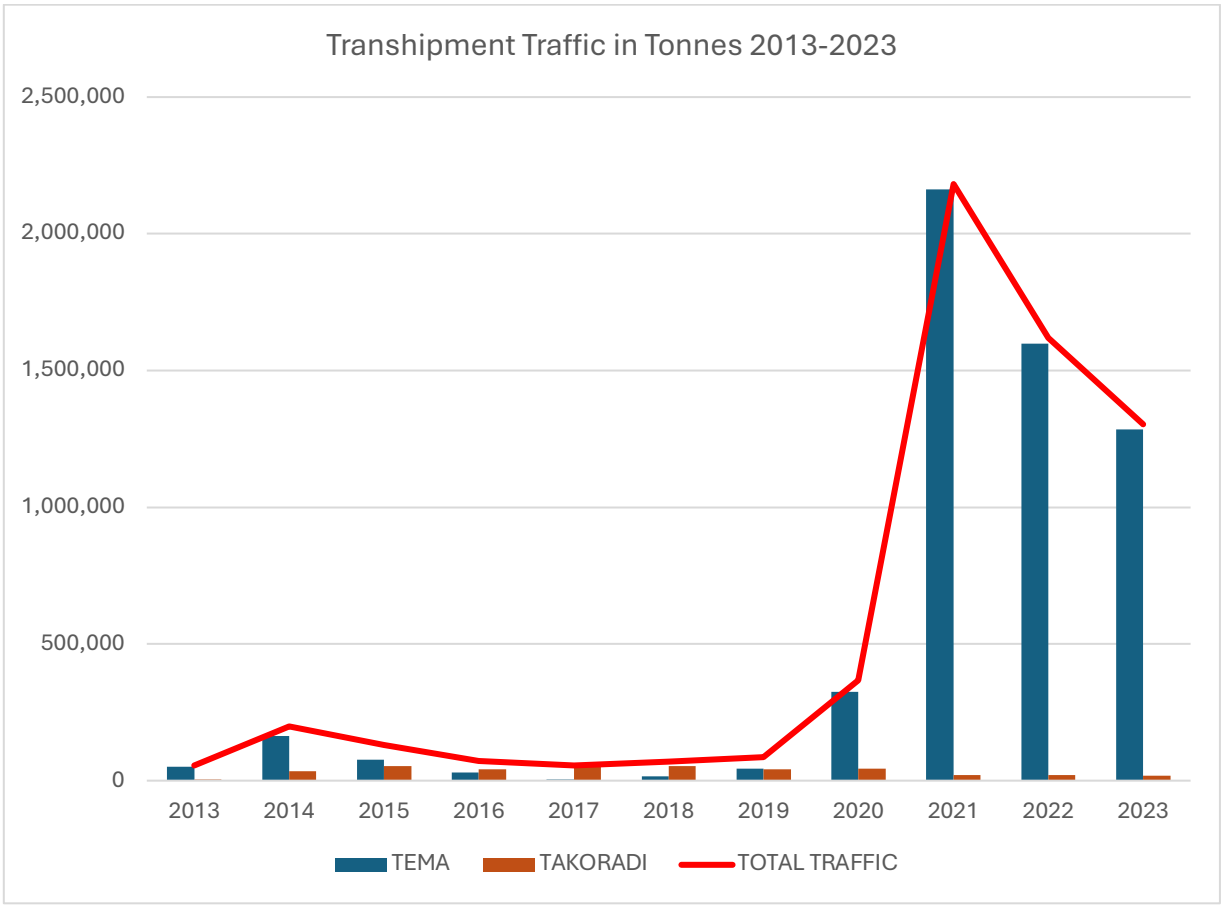


Figure 4: Transhipment Traffic for Tema and Takoradi Ports from 2013 to 2023

Source: GPHA (2024b)

The Tema port is well developed and improved compared to the Takoradi Port. Infrastructure improvements at this Port include the construction of the Meridian Port Services (MPS) terminal. The expansion works which resulted in deeper berths, advanced cranes, and more efficient cargo handling processes, has made the port a more attractive option for global shipping lines. As mentioned above, there has been a noticeable increase in the number of vessels calling at the port, including transhipment operations. With the construction of MPS Terminal 3, Tema Port is considered as one of the most advanced ports in West Africa, capable of accommodating larger vessels, such as ultra-large container ships.

On the other hand, the Takoradi Port is considered the major export hub for the country as compared to the Tema Port. The proximity of the port to offshore oil and gas, mining and agricultural production sites gives it a huge advantage in terms of export activities.

4 Internationally Arriving and Departing Inventories by Vessel Type in Ghana

Internationally arriving voyages are when vessels call at a port in Ghana from a port of origin outside Ghana whilst Internationally departing voyages are when vessels depart from a port in Ghana to a destination port outside Ghana. Whether arriving or departing, the energy demand and GHG emissions differ based on the vessel type.

In the Ghana recorded 2018 data (Figure 5), Bulk carriers, container ships, general cargo vessels, and refrigerated bulk vessels are among the leading vessels for international arrivals and departures due to the nature of imports and transshipment. Bulk carriers transport grains; container ships and general cargo vessels bring in consumer goods, industrial products, and food and beverages; while refrigerated bulk vessels bring in frozen meat, fish, and poultry. The data also shows that chemical tankers, oil tankers, and liquefied gas tankers are among the leading vessels on international voyages arriving and departing from Ghana. As noted earlier, the country is both an exporter of crude oil and an importer of refined petroleum products. Therefore, it is not surprising that the data shows chemical tankers, oil tankers, and liquefied gas tankers as some of the major vessels calling at Ghanaian ports.

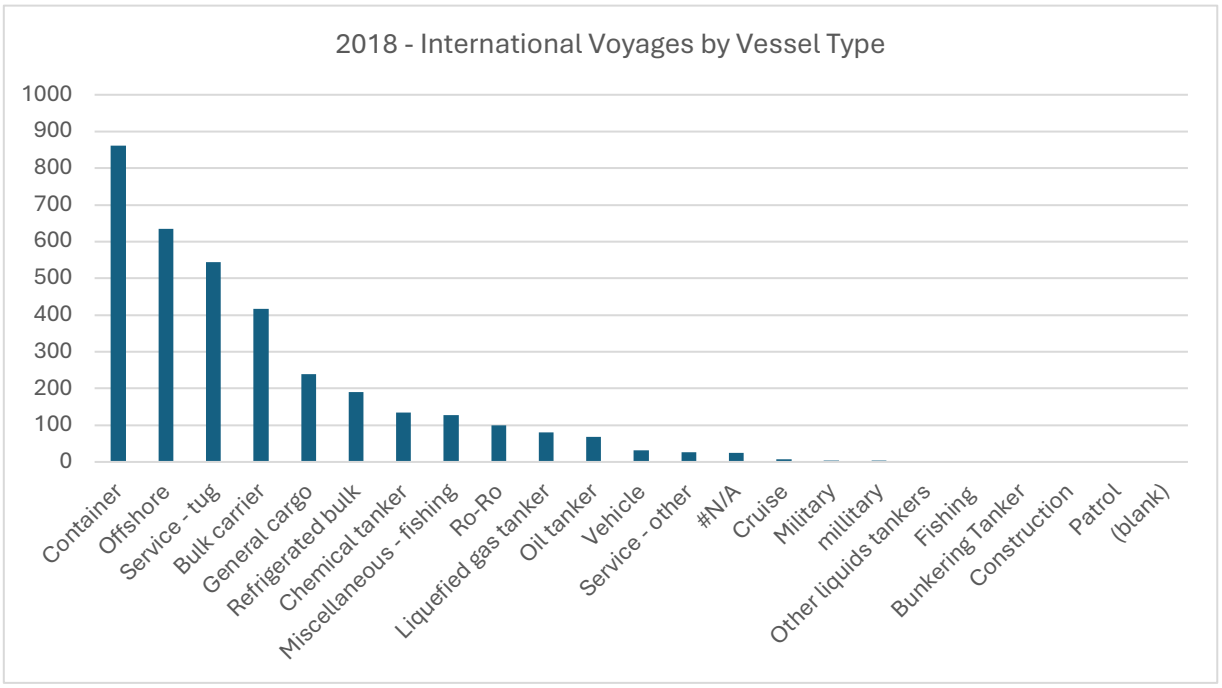


Figure 5: GhPortcalls- 2018 International Voyages by Vessel Type

LeapAIS 2018 data for international voyages in Ghana suggests that bulk carriers, chemical tankers, container ships, refrigerated bulk vessels, and oil tankers were the top five leading international arriving vessels at Ghanaian ports with high energy demands, as presented in Figure 6. Also, as shown in Figure 7, these vessel types also constitute the leading categories for higher CO_2 generation.

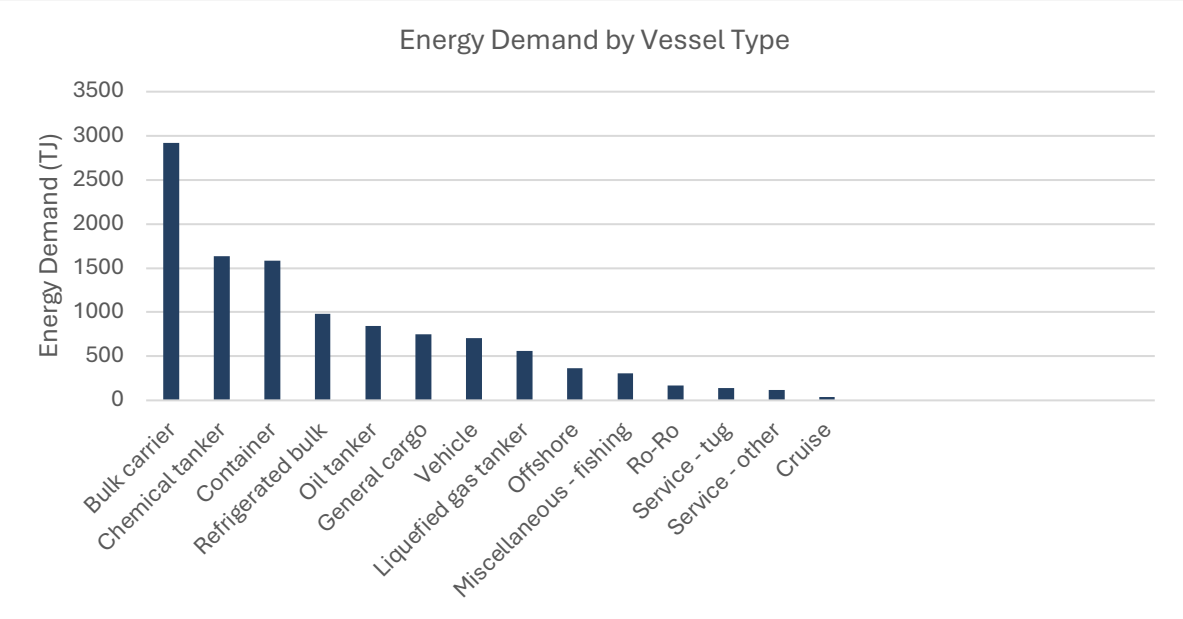


Figure 6: LeapAIS - International Arrivals- Energy Demand by Vessel Type

Comparing the GhPortcalls data for 2018 as presented in Figure 5 with the energy demand and CO_2 generation from the LeapAIS data in Figures 6 and 7, it shows a largely consistent trend, with a few variations in the types of vessels. Although offshore vessels and service tugs are among the leading vessels in the 2018 GhPortcalls data, most of these vessels are considered domestic voyages and would not be included in an inventory that considers only international voyages.

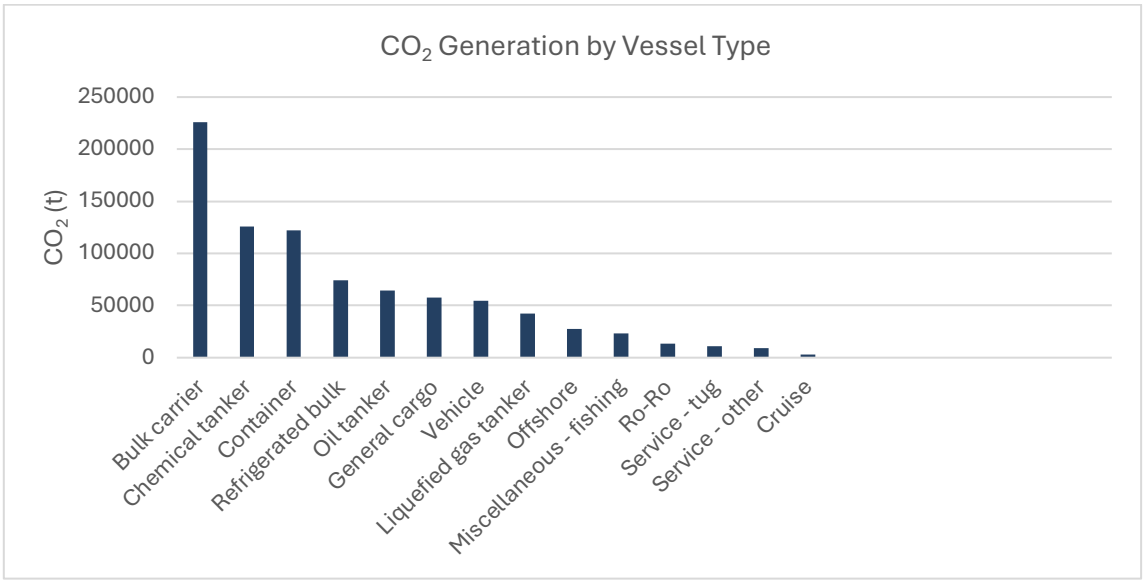


Figure 7: LeapAIS – International Arrivals - CO_2 Generation by Vessel Type

In addition, the estimation of energy demand and CO_2 generation uses gross tonnages, deadweight, engine make, and other parameters that consider the vessel type to estimate energy demands. Consequently, even if international offshore vessels and service tugs outnumber other vessels, their collective demand for energy may still be lower than that of bulk carriers or chemical tankers.

On the other hand, the international departing inventories by vessel type do not deviate from the trends as shown in the international arriving inventories indicated above. Container, bulk carrier and chemical tanker constituted the highest energy demands and CO_2 generation as shown in Figure 8 and Figure 9, respectively. The inventories for both arriving and departing are also consistent with trends in imports, exports, and transshipment data for the period of 2018 in Ghana.

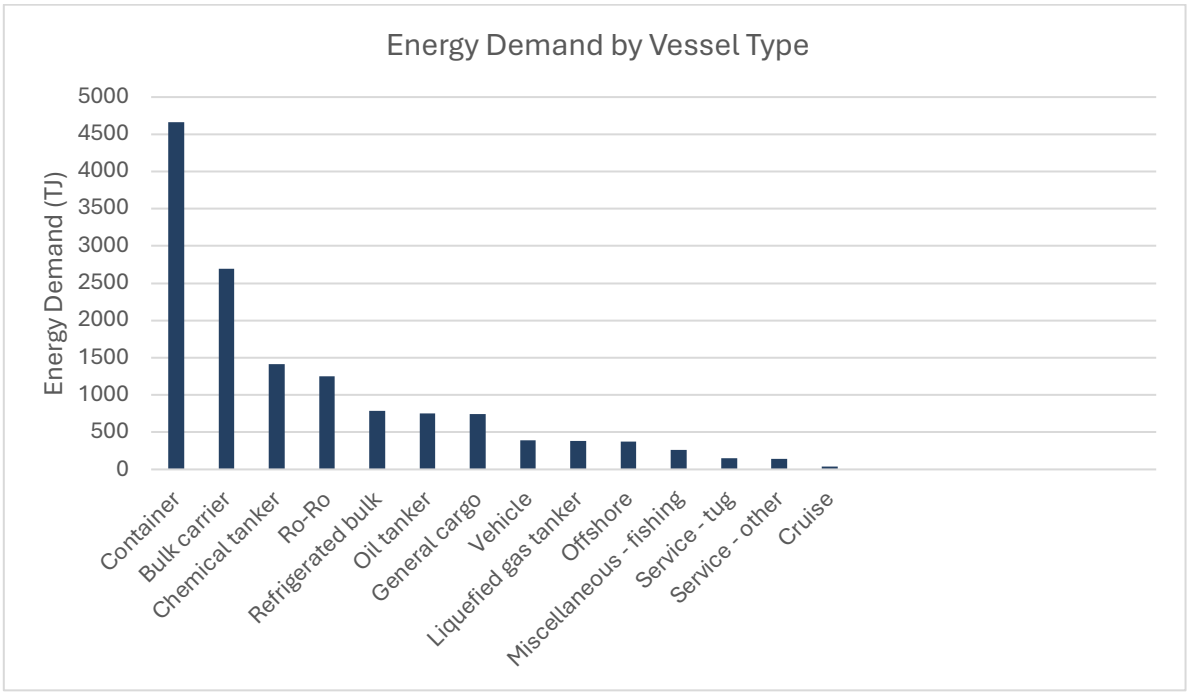


Figure 8: LeapAIS – International Departures- CO_2 Generation by Vessel Type

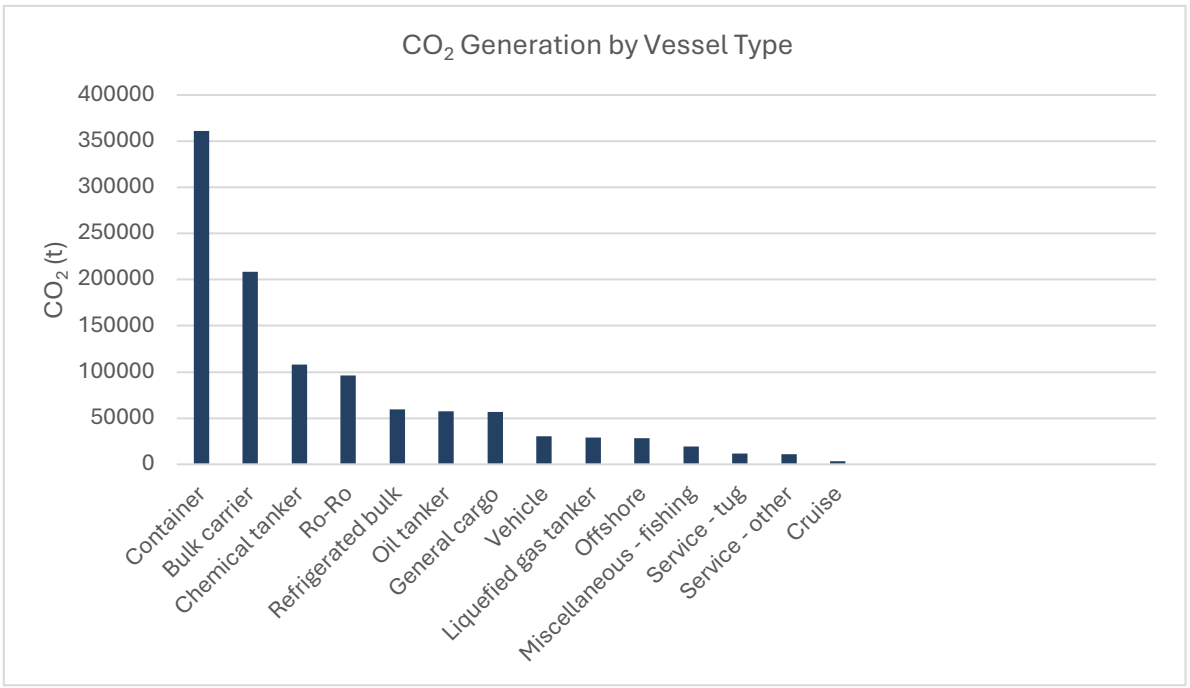


Figure 9: LeapAIS – International Departures- CO_2 Generation by Vessel Type

The trends as shown for 2018 can be used to estimate the energy demand and CO_2 generation for 2023. In the international voyages (both arriving and departing) for 2023 as shown in Figure 10, container, bulk carrier, offshore, general cargo, and refrigerated bulk constituted the leading vessel types. This trend is very much similar to the locally generated 2018 port call data. Therefore, it can be said that the energy demand and CO_2 generation will show similar trends for 2023 as the LeapAIS estimations for 2018.

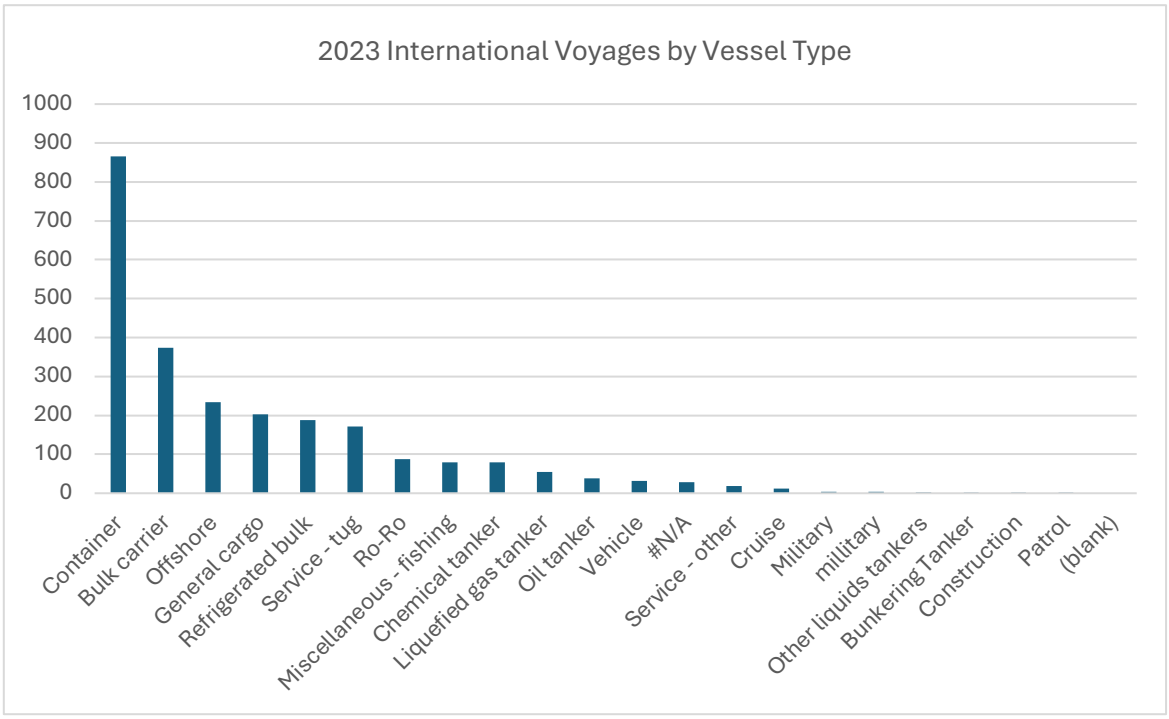


Figure 10: GhPortcalls- 2023 International Voyages by Vessel Type

5 Internationally Arriving and Departing Inventories by Port in Ghana

As mentioned above, the expansion works at Tema Port has seen a significant growth of the port to accommodate larger vessels. The port has also experienced an increase in cargo traffic and transshipment volumes since 2019. In addition, the Takoradi Port handles larger volumes of export commodities from Ghana and is also the port with a larger number of service tugs and offshore vessels. Consequently, Tema Port receives more international voyages and larger vessels as compared to Takoradi Port. It is therefore not surprising that Tema Port is leading in both energy demand and CO_2 generation for both arriving and departing voyages. Therefore, the energy

demand and CO_2 emissions by port, as estimated from the 2018 LeapAIS data and displayed in Figures 11-14, largely reflect shipping trends in Ghana.

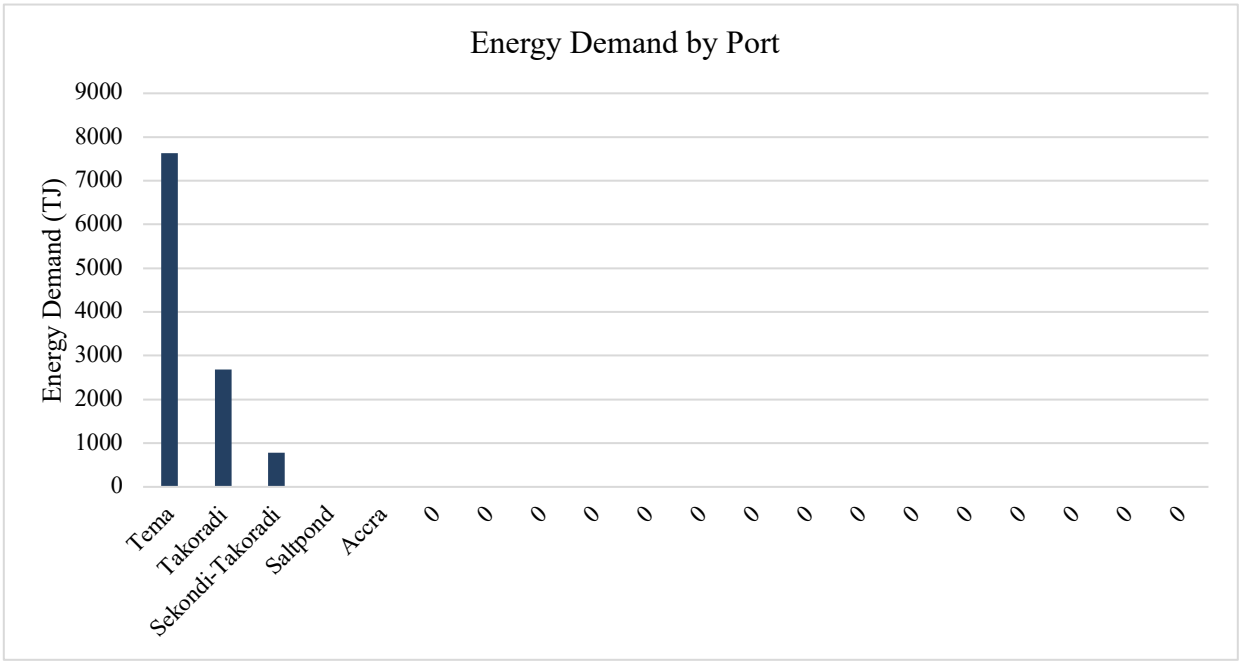


Figure 11: 2018 LeapAIS – Internationally Arriving - Energy Demand by Port

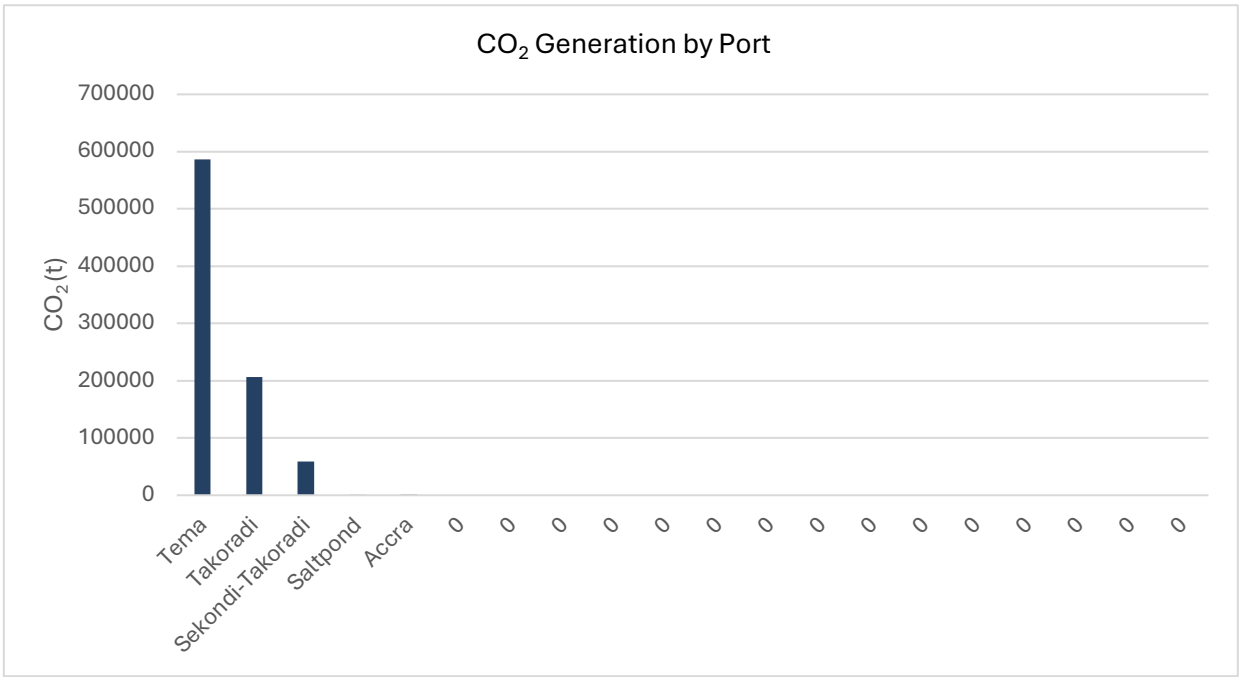


Figure 12: 2018 LeapAIS – International Arrivals - CO_2 Generation by Port

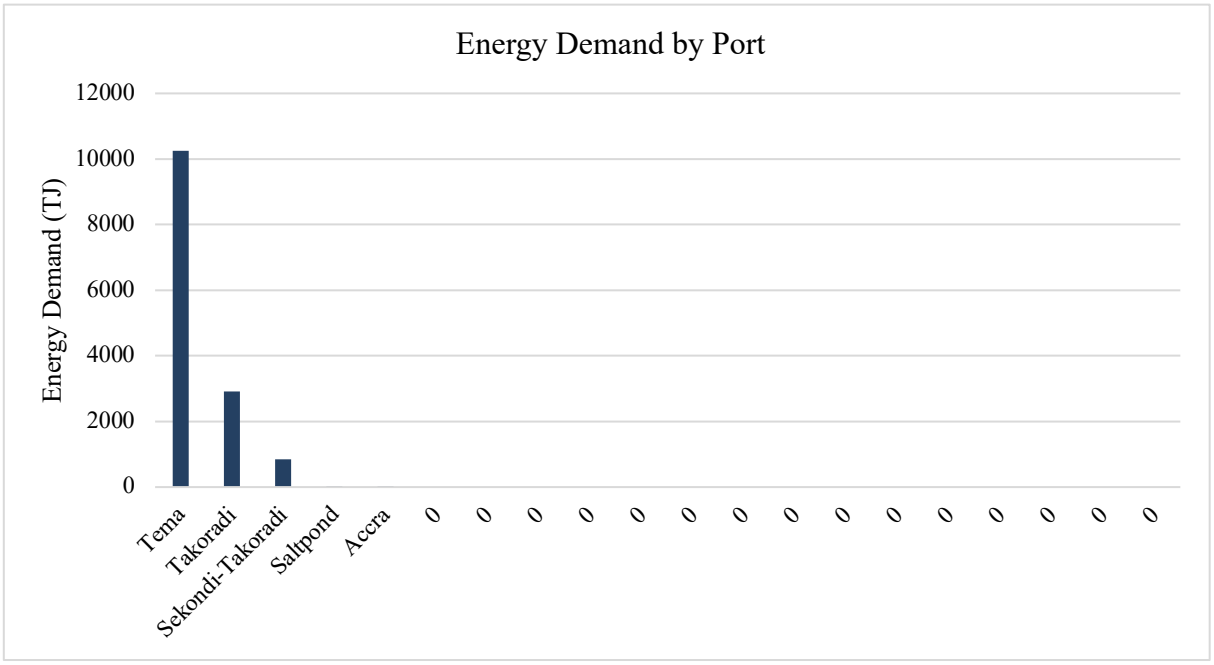


Figure 13: 2018 LeapAIS – International Departures - Energy Demand by Port

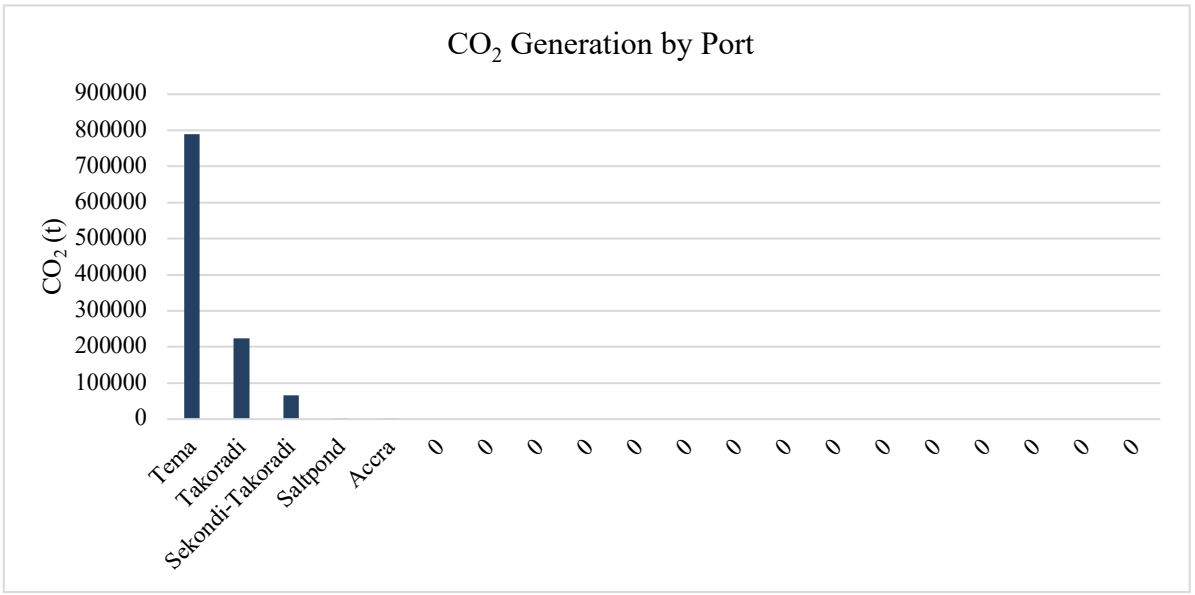


Figure 14: 2018 LeapAIS – International Departures - CO_2 Generation by Port

Going by trends in the inventories by vessel type for 2018 and 2023, similar comparisons can be made of inventories by port as well. Tema Port still recorded higher volumes of international voyages in 2023 due to the port's expanded range of activities. It can therefore be said that Tema Port would still remain the leading port in energy demand and CO_2 generation for 2023 just as the LeapAIS estimations for 2018.

6 Internationally Arriving and Departing Inventories by Partner Country

The estimates of energy demand and CO_2 generation by partner countries also reflect local trends in shipping in Ghana. From Figures 15-18, the graphs show energy and CO_2 generation from international voyages with partner countries. In Figures 15 and 16, internationally arriving shows higher energy demand and CO_2 generation within the West African sub-region, especially neighboring Togo, and Nigeria. This does not however show that there is direct stronger trade partnership within the sub-region. This state of affairs can be as a result of transit and transshipment activities of vessels who may originate outside West Africa.

For example, if Ro-Ro vessels are considered, they often load vehicles and offload at various ports across West Africa, country by country. As such, a vessel from Asia using the Indian Ocean is likely to offload at ports in South Africa, Nigeria, and Togo before arriving in Ghana. Similarly, international voyages from Europe, North, and South America may offload at Ivory Coast before coming to a port in Ghana.

Consequently, when estimating energy demand and CO_2 emissions by port pair, it is expected that port pairs involving Ghana's neighbouring ports—such as those in Togo, Nigeria, Ivory Coast, and South Africa—should have the highest energy demand and CO_2 generation. This pattern, based on the 2018 LeapAIS data as illustrated in Figures 15, 16, 17, and 18, seems to conform with expected trends.

Figures 17 and 18 indicates that the port pair with Malaysia, where many international departing vessels from Ghana have Malaysia as their first next port of call, generates the highest energy demand and CO_2 emissions by partner country. This may be due to the fact that many vessels leaving Ghana and heading to Asia often call at Malaysia before proceeding to their next destinations. Nonetheless, it is worth noting that Ghana exports cocoa beans, crude petroleum, and pure vegetable oils to Malaysia, while importing refined petroleum and palm oil from Malaysia.

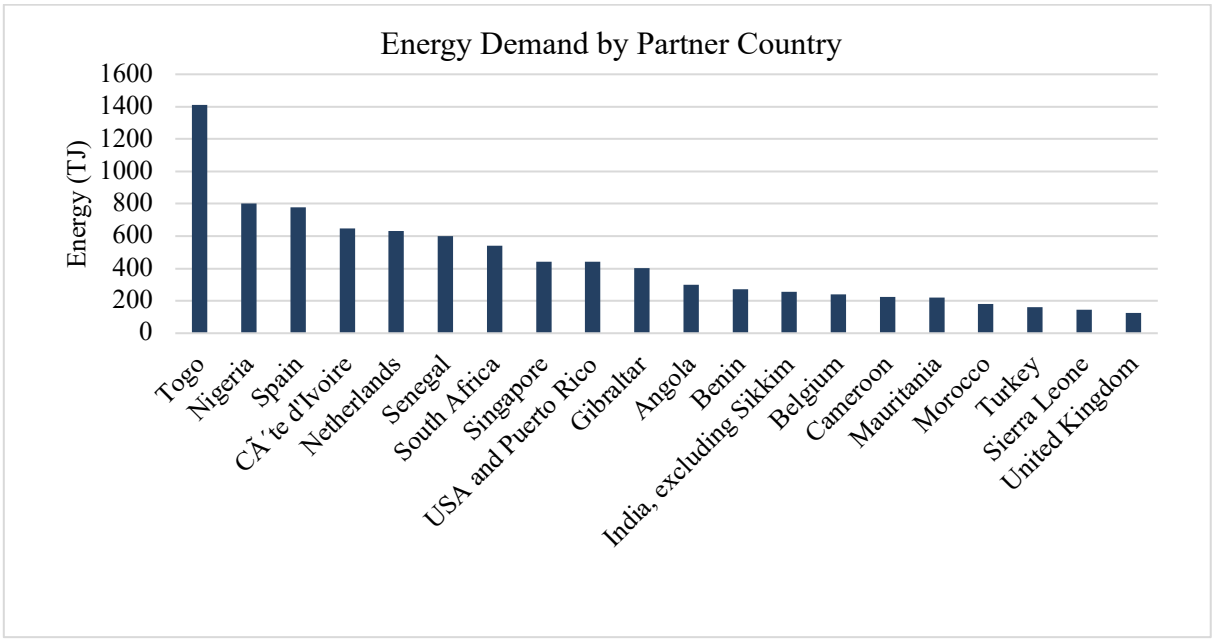


Figure 15: LeapAIS – International Arrivals - Energy Demand by Partner Country

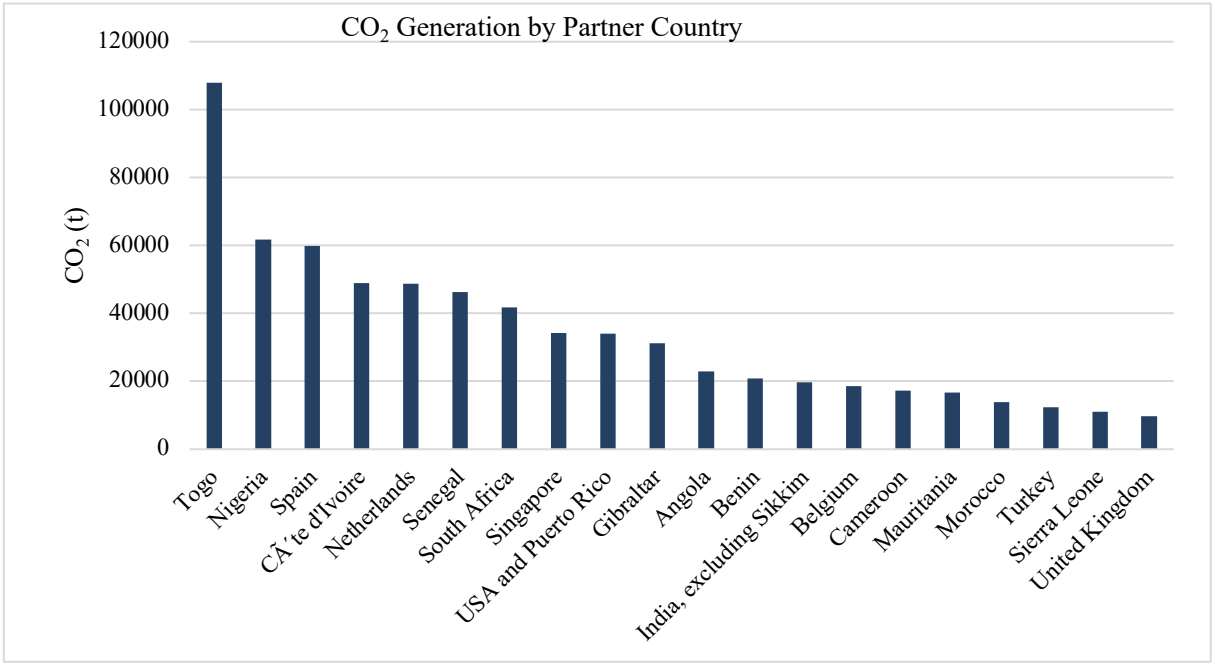


Figure 16: LeapAIS – International Arrivals - CO_2 Generation by Partner Country

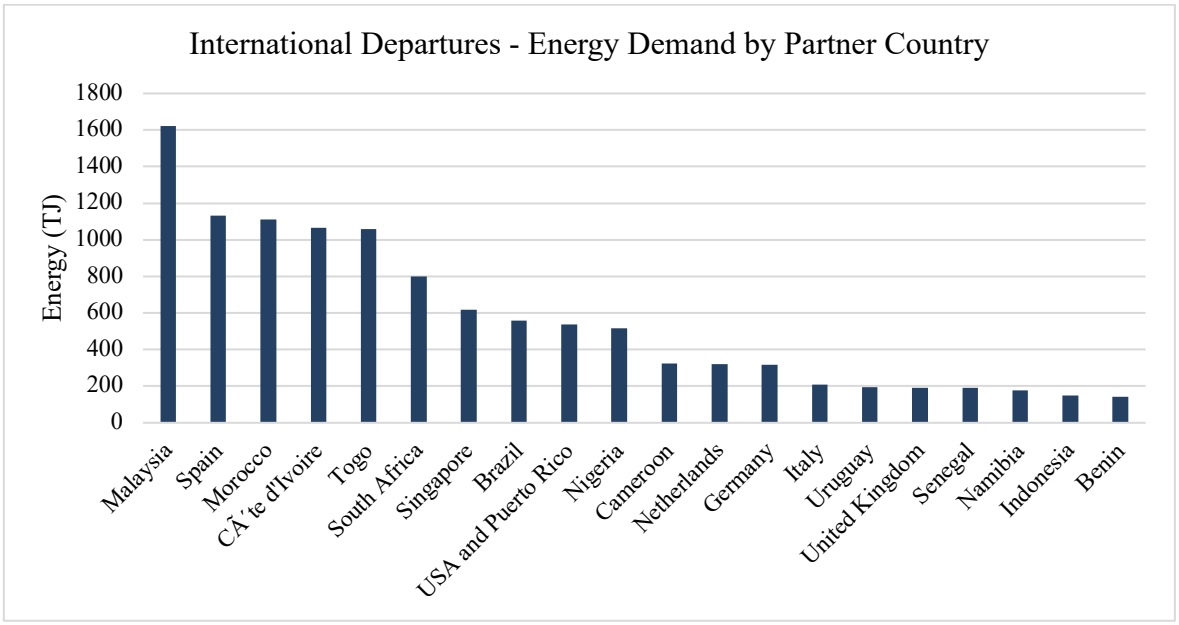


Figure 17: LeapAIS – Departures Arrivals - Energy Demand by Partner Country

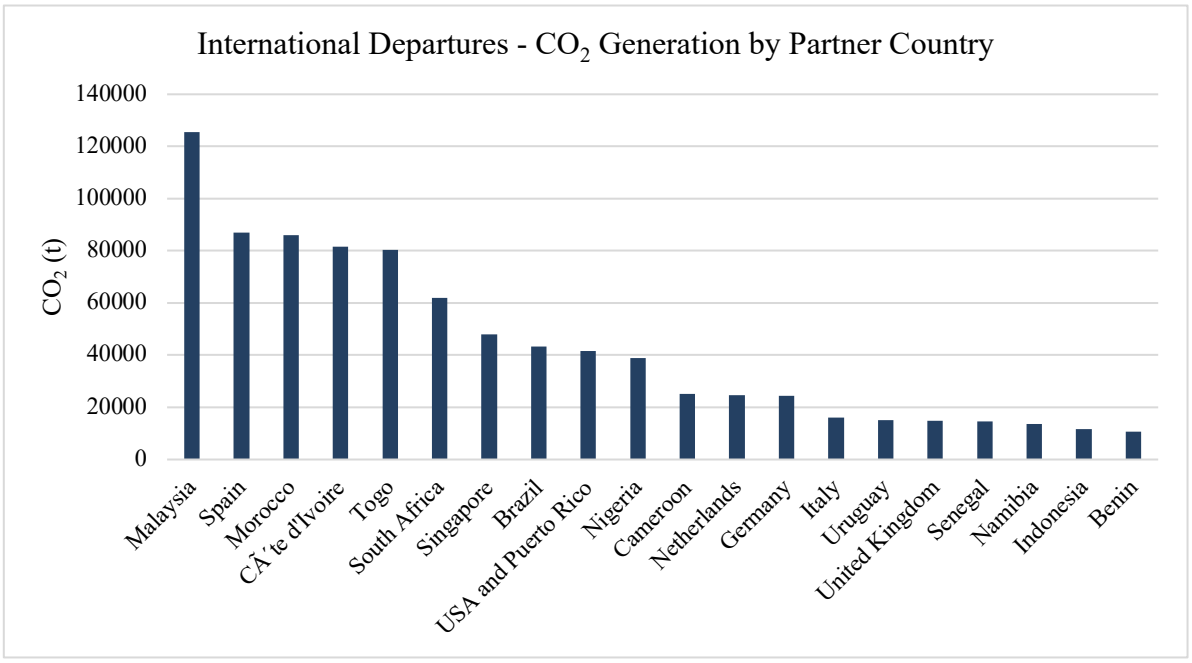


Figure 18: LeapAIS – International Departures - CO_2 Generation by Partner Country

7 Domestic Inventories by Port Pair

As already stated above, there are two major ports in Ghana: the Tema and Takoradi ports. The primary local voyages are therefore mainly between these two ports, generating the highest energy demand and CO_2 emissions (see Figures 19 and 20). The Sekondi Port is mostly used as a military wharf and occasionally for local fishing. The Saltpond port, which is now being decommissioned, was primarily used for the export of crude oil.

There are other local ports, such as Axim, Accra (James Town), and Keta, which are being upgraded for local fishing. In addition, the local FPSOs (Floating Production Storage and Offloading units) located offshore could also be considered in future analysis. Not only do international oil tankers take crude from these platforms, but offshore vessels and Service Tugs also visit these FPSOs for supply services.

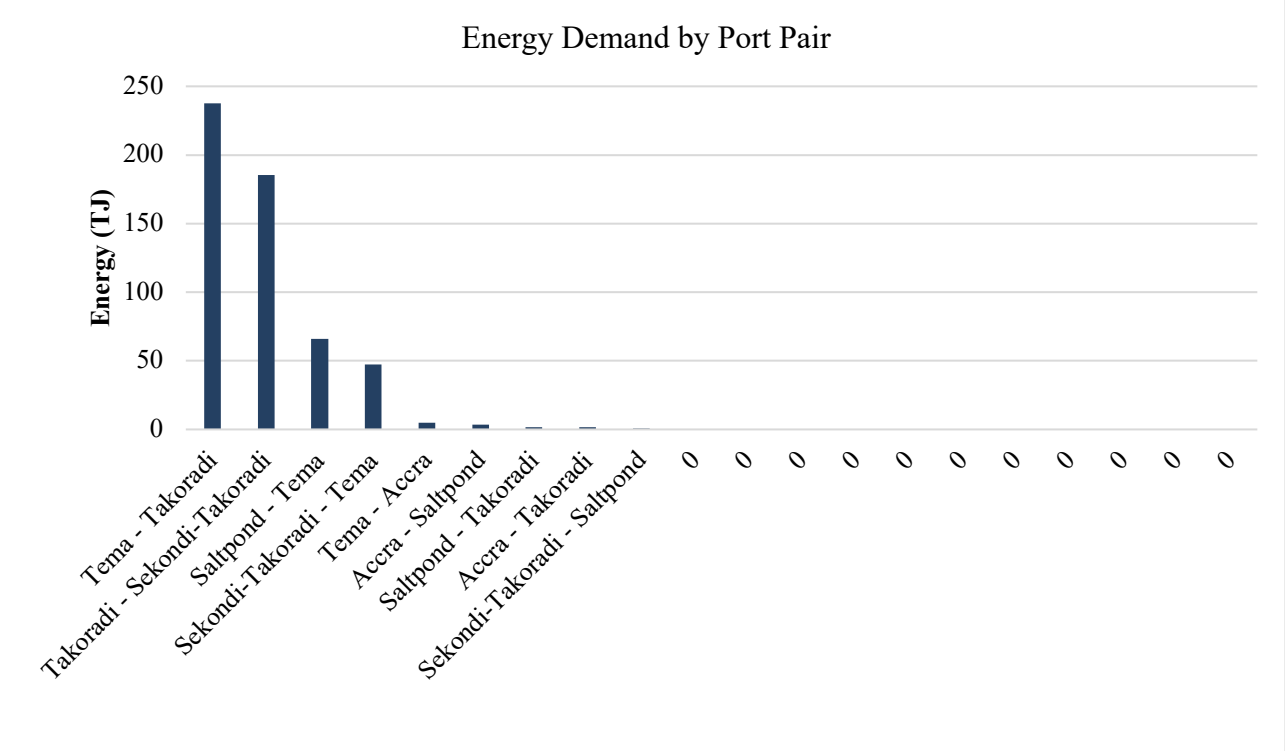


Figure 19: LeapAIS – Domestic - Energy Demand by Port Pair

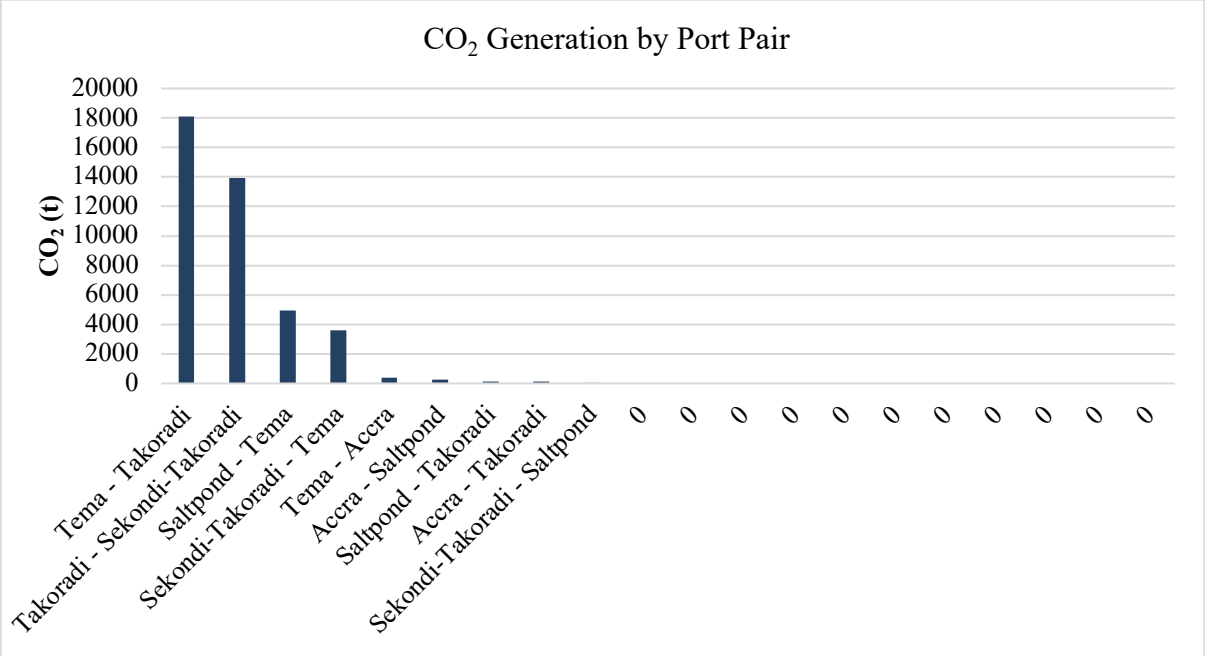


Figure 20: LeapAIS – Domestic - CO_2 Generation by Port Pair

8 Conclusion

This report provided an estimation of Energy Demand and CO_2 emissions of vessels that called on the Tema and Takoradi ports of Ghana in 2018. This analysis was made with AIS data of vessels arriving and departing from ports in Ghana and validated with port statistics data and manually recorded data of vessels calling on these ports in 2018. Based on the 2018 estimates and locally compiled 2023 vessel call data; projections of energy demand and CO_2 generation was also made for 2023.

The analysis suggested that bulk carriers and container vessels are key contributors to CO_2 generation and energy demand. The analysis also revealed the Tema Port as having the highest energy demand and CO_2 generation. Trends in the maritime context in Ghana corroborate the energy demand and CO_2 emission estimates from the AIS data. Specifically, aggregations of vessel types from local port call data for 2018 confirmed that the leading vessels calling on the two ports in Ghana are also the same vessel types requiring higher energy demands and CO_2 emissions. Finally, it was observed from port call data that vessel traffic in 2018 and 2023 is very similar, with vessel types remaining largely unchanged. This means that the energy demand and CO_2 generation as estimated for the internationally arriving and departing for 2018 are likely to remain at similar levels for 2023.

If the ongoing discussions on the mid-term (technical and economic) measures at the International Maritime Organization (IMO) are anything to go by, these findings have some potential implications. The implementation of a technical measure and a GHG pricing mechanism under the current fuels structure may increase the cost of transport logistics for containers, bulk carriers, and refrigerator cargo for example, which may then increase the cost of essential goods carried by these vessels. Furthermore, noting that the Tema Port is relatively the major import hub for the country and yet the leading port in energy demand and CO_2 emissions, this may also reflect in higher cost of goods imported through the port. At the same time, goods exported through Takoradi port which is relatively a larger export hub for the country, may attract higher transport costs. Accelerating the use of zero GHG fuels and other sustainable maritime fuels may therefore eventually result in lower GHG emissions. Also, implementation of energy efficiency measures such as just-in-time sailing and the provision of clean shore power at the Tema Port, can lead to a substantial reduction in CO_2 emissions. Other policy measures that will reduce import and export costs would be a good way to addressing the potential negative impacts of any mid-term measure that would be adopted.

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