11-4-2018

# Adopting port energy efficiency and management plan: the Port of Banjul in consideration

Alhagie Sisawo

**WORLD MARITIME UNIVERSITY**
Malmö, Sweden

# ADOPTING PORT ENERGY EFFICIENCY AND MANAGEMENT PLAN: THE PORT OF BANJUL IN CONSIDERATION

By

**ALHAGIE SISAWO**

**The Gambia**

A dissertation submitted to the World Maritime University in partial
Fulfilment of the requirements for the award of the degree of

**MASTER OF SCIENCE**

**In**

**MARITIME AFFAIRS**

**(MARITIME ENERGY MANAGEMENT)**

2018

**DECLARATION**

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has been previously conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature):  ..............................................

(Date): 18th September, 2018

Supervised by: **Dr. Fabio Ballini (PhD)**

Lecturer
Maritime Energy Management Specialisation
World Maritime University

## ACKNOWLEDGEMENTS

Sincere appreciation goes to my family – wife, mum, kids (Fatoumata and Omar) and the rest of the family for their love, encouragement and patience during these 14 months. Warm appreciation goes to the Head of Maritime Energy Management Specialization – Prof. Aykut Ölçer for his dedication to duties and proper coaching and to my very helpful and active Supervisor – Dr. Fabio Ballini, without whose guidance, knowledge and support the journey would have been tough. The guidance of Dr. Momoko Kitada towards writing a good dissertation is hereby recognised and appreciated.

Special thanks go to the International Maritime Organization (IMO) for funding my study in the World Maritime University. Without their sponsorship, the journey might be impossible. The support of my employers – Gambia Ports Authority – Ferry Services is hereby recognised. Granting me 14-month study leave with all necessary support is indeed a generous gesture. To the Director of Technical Services – Ferries and his team, I say thank you for standing by me from the onset. The support from the staff of GPA – Estate and Civil Engineering Department towards this dissertation is appreciated.

I say thank you to all WMU faculty and staff (notably Library, IT and Student Services) for providing a conducive learning environment and to our various hosts who received us on our field trips across Europe (Copenhagen, Gothenburg, Genoa, Helsinki, London and Turku), which were very valuable learning experiences.

Finally, to the S18 MEM class, I say thank you all for sticking together in the struggle for success despite the harsh winter months, long class periods and challenging assignments, memories shall surely remain.

# ABSTRACT

Title of Dissertation **ADOPTING PORT ENERGY EFFICIENCY AND MANAGEMENT PLAN: THE PORT OF BANJUL IN CONSIDERATION**

Degree **Master of Science (MSc)**

World population expansion, economic growth and technological advancements are fuelling the demand for goods and services, thereby putting pressure on energy resources. The expansion in world sea-borne trade (accounting for about 80% of world trade in volume) is putting pressure on ports to develop, modernise and expand their infrastructure to cope with the trend. Investments in energy infrastructure have become a prerequisite, as ports lean towards automated terminals and modern cargo handling equipment to facilitate quick cargo movements and fast turn-around time of ships.

Energy security has been a challenge in so many Sub-Saharan African countries. Port operations are mostly affected by the erratic electricity supplies from national grids due to generation, transmission and distribution challenges, thus leading to low throughputs, less competitiveness and profitability. Most ports in Africa are dependent on standby generators for a continuous supply of electricity, which has adverse effects of driving up operating costs and contributing significantly to emissions from port areas. Growing international policy changes towards better environmental protection is forcing ports into adopting innovative energy solutions like Port Energy Management Plans (PEMP) and Smart Port Initiatives to cut down on energy consumption and emissions.

To this end, this dissertation intends to help the Port of Banjul in setting up a Port Energy Management Plan to better manage its energy resources in line with ISO 50001: 2011 guidelines. Through experiences from Genoa, Gothenburg and Hamburg, who are pacesetters in sustainable port energy solutions, it will enable the Port of Banjul to adopt innovative energy solutions, lower its energy consumption, save costs and live up to its obligations of environmental protection from pollution and emissions.



**Keywords: Port Energy Management Plan, Renewable Energy, Energy Efficiency, GHG Emissions**

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF BOXES

## LIST OF ABBREVIATIONS

| | |
|---|---|
| **CO** | Carbon Monoxide |
| **$CO_2$** | Carbon Dioxide |
| **CSR** | Corporate Social Responsibility |
| **ECA** | Emission Control Area |
| **ECOWAS** | Economic Community of West African States |
| **ECREEE** | Ecowas Centre for Renewable Energy and Energy Efficiency |
| **EMAS** | Eco-Management and Audit Scheme |
| **EMS** | Environmental Management System |
| **EnB** | Energy Baseline |
| **EnMS** | Energy Management System |
| **EnPI** | Energy Performance Indicators |
| **EPA** | Environmental Protection Agency |
| **E-RTG** | Electric Rubber-Tyred Gantry |
| **ESPO** | European Sea Ports Organisation |
| **EU** | European Union |
| **GDP** | Gross Domestic Product |
| **GHG** | Green House Gases |
| **GMA** | Gambia Maritime Administration |
| **GPA** | Gambia Ports Authority |
| **GW** | Gigawatt |
| **HPS** | High-Pressure Sodium |
| **IEA** | International Energy Agency |
| **IMO** | International Maritime Organization |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IRENA** | International Renewable Energy Agency |
| **ISO** | International Organization for Standardization |

| | |
|---|---|
| **kVA** | Kilo Volt Ampere |
| **kW** | Kilo Watt |
| **kWh** | Kilo Watt Hour |
| **LCOE** | Levelized Cost of Energy |
| **LED** | Light Emitting Diode |
| **M&R** | Maintenance and Repair |
| **MARPOL** | International Convention for the Protection of Pollution from Ships |
| **MEM** | Maritime Energy Management |
| **MWh** | Mega Watt Hour |
| **NAWEC** | National Water and Electricity Company |
| **NECA** | NOx Emission Control Area |
| **NGO** | Non-Governmental Organisation |
| **NOx** | Nitrogen Oxides |
| **OECD** | Organisation for Economic Cooperation and Development |
| **OPEC** | Oil Producing and Exporting Countries |
| **OPS** | Onshore Power Supply |
| **PDCA** | Plan, Do, Check and Act |
| **PEEP** | Port Energy and Environmental Plan |
| **PEMP** | Port Energy Management Plan |
| **PERS** | Port Environmental Review System |
| **PM** | Particulate Matter |
| **PURA** | Public Utilities Regulatory Authority |
| **PV** | Photovoltaic |
| **PWD** | Public Works Department |
| **RTG** | Rubber-Tyred Gantry |
| **SDG** | Sustainable Development Goals |
| **SEU** | Significant Energy Uses |
| **SMART** | Specific, Measurable, Achievable, Realistic and Time-bound |
| **SOx** | Sulphur Oxides |

| | |
|---|---|
| **TEU** | Twenty-ton Equivalent Unit |
| **UN** | United Nations |
| **UNCTAD** | United Nations Conference on Trade and Development |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **US** | United States |
| **VOC** | Volatile Organic Compound |
| **WAPP** | West African Power Pool |
| **WB** | World Bank |
| **WHO** | World Health Organization |

# Chapter 1

## 1.0 INTRODUCTION

### 1.1 BACKGROUND

The term energy efficiency can be defined as a process of improving on energy use productivity (the ratio of energy out/energy in), and energy management is the utilisation of financial, technical and socio-political means for effective utilisation of energy resources across the energy chain (Fawkes, 2013a). Maritime Energy Management dilates into the management of the overall energy chain within the maritime domain (ports and shipyards) for achieving cost reductions and overall system improvements (Ölçer et al, 2017). Increase in world population, economic growth, policy changes and technological advancement are translating into increased demand for goods and services and effectively increased demand for energy to support the provision of these goods and services (OPEC, 2017). Businesses, as well as the industry in recent times, have raised concerns with high energy consumption patterns, unstable supplies and volatile prices, coupled with environmental concerns (Fawkes, 2013b), thus the need for energy utilisation strategies (energy efficiency and management) from regulators and industry to curb the situation. The International Renewable Energy Agency (IRENA) in its report on the Renewable Readiness Assessment of The Gambia (IRENA, 2013) indicated that utilisation of renewable energy systems and energy efficiency measures could provide the achievement of consistent energy system improvement and efficiency. These measures could be pronounced during peak load periods while also providing reprieve during generating system downtimes in the electricity sector, thus enhancing the energy security of the country.

With increasing energy consumption by industries like the Ports, there is a greater need for better and efficient energy management system with clear policies and guidelines for implementation (ISO, 2011). Introduction of innovative energy efficient and renewable technologies alongside sustainable and responsible consumption behaviours are the most genuine way of reducing or cutting down on energy costs. Setting up innovative environmental and sustainable energy targets in the near and long terms should form part of a port's strategic plan (Boile et al, 2016). Seaports by the nature of their mandates, i.e. hub of transportation of raw materials, semi-finished and finished goods - are high energy consumers, thus also increasing their contribution to pollution and emissions. Adoption of energy efficiency measures and policies in ports has of late been driven by the need to curb the high energy costs, stringent environmental regulations as well as improving their environmental footprints. Rationalisation of port operations and the adoption of a Port Energy Management Plan (PEMP) (Visvikis & Panayides, 2017) could lead to substantial energy savings. Cargo handling equipment like rubber-tyred gantry cranes (RTGs), reach stackers, yard tractors and forklifts together with air conditioning and general lighting systems form a large chunk of energy consumers in ports (Pavlic et al, 2014). Energy efficiency and management measures in ports – aimed at improving the productivity of energy use is thus linked with modernising and optimising the utilisation of energy resources from both the supply and demand sides of the energy system.

With the expansions in world trade, alongside increases in cargo volumes and competition, optimisation in energy resource utilisation to cater for this trade increase through cost-saving ventures in the form of deployment and use of environmentally friendly, cost-effective and efficient cargo handling equipment is becoming a priority for many ports (UNCTAD, 2017). The Gambia faces energy security challenges (due to reliance on importation of fossil fuels for its electricity generation and natural gas for household and industrial uses), with frequent shortages especially in petroleum products and inability to satisfy the electricity demand of the nation. This situation trickles down to the Port of Banjul and affects its operations, thereby, making the port less competitive in the sub-region due to delays in cargo handling services, compelling most agents to divert their cargo to other neighbouring ports, e.g. Port of Dakar. The Gambia is one of the West African countries with the highest electricity tariff - 0.28 US$/kWh (IRENA, 2013) due to heavy reliance on imported fossil fuels for electricity generation, less utilisation of renewable energy generation, as well as poor transmission and distribution infrastructure. The Port of Banjul in its operations rely on diesel driven cargo handling equipment and uses diesel generators to supply electricity to the offices, warehouses, high mast lighting and other installations in the absence of supplies from the national grid. Curbing this situation through the development of a sustainable port infrastructure with sound environmental considerations, anchored on a "Green Port" concept, without hindering economic growth should be a prime focus for the Gambia Ports Authority, like many other ports in the world. The utilisation of renewable energy could provide cost cuttings on fuel and maintenance for the running of the backup generators. Renewable energy can deliver the triple effect of reducing direct operating costs, indirect costs (pollution and other externality costs) - as the port is located in a metropolitan residential area and making the port competitive.

## 1.2 PROBLEM STATEMENT

The importance of energy to the operations of ports is critical but often represents a significant cost – both to them and the environment. Ports are modernising their energy infrastructure for automation of cargo handling and port operations as a response to the continuous growth in world seaborne trade. There is unreliability of supply from The Gambia's national grid due to low generating capacity, ageing transmission and distribution system. The cost of in-house generation is prohibitive due to the high cost of imported fuel and maintenance challenges. Power outages cause substantial economic losses to both the port and other stakeholders involved in the port business.

Even though most of the cargo handling equipment is diesel engine driven, areas like the administrative and service buildings, reefer stations, container scanning yard, engineering workshop, shipyard, the ferry terminals and general lighting systems continue to be significant electricity consumers. There is no sub-metering to account for localised consumption as the entire port is billed through only two meters. Exorbitant amounts are paid to the utility company (0.233 US$/kWh) (GPA, 2018) for the electricity supplies and equally so much is spent on diesel fuel (US$127.2/hr) and spare parts for the operation of the in-house generators.

Notwithstanding the foregoing, much attention has not been given to the utilisation of renewable energy and energy efficiency and management measures as potentials to provide cleaner, affordable, sustainable and low-cost energy. Considerable cost savings could be made when these conventional diesel generators are complimented with cleaner alternative energies such as solar, wind or biomass, the potentials of which is evidently available (IRENA, 2013).

In an economic situation of price instability - especially that of crude oil (OPEC, 2017), institutions like the Port of Banjul cannot continue coping with high energy costs while at the same time ignoring energy efficiency and management measures to cut cost (Vassallo, 2014). This study analyses the precarious energy situation of the Port of Banjul, identify gaps and suggests mechanisms for corrective measures through a Port Energy Management Plan, anchored on ISO 50001:2011 standard, thereby improving energy supply and demand in Banjul Port.

## 1.3 AIMS AND OBJECTIVES

This study is aimed at assisting the management of the Port of Banjul to adopt new energy efficiency and management policies to manage its energy resources.

Specific objectives are: -

I. To analyse the pattern of electricity consumption in the Port of Banjul from both the national grid and in-house generation and also look at consumption distribution from various sectors within the port.

II. Analyse the electrical situation in the Port of Banjul from availability, reliability, resiliency, efficiency and sustainability points of view to identify gains and gaps that require further improvement.

III. Analyse the adoption of energy efficiency and management measures and options for sustainable gains and cost savings and taking lessons from other success story ports.

IV. Recommend setting up a Port Energy Management Plan (PEMP) with clearly defined targets, objectives and strategies centred on resilient, reliable, efficient and sustainable policies anchored on ISO 50001:2011 guidelines.

## 1.4 RESEARCH QUESTION

I. What is the current energy profile of The Gambia and the Port of Banjul?

II. Is there potential for the introduction of energy efficiency and management measures looking at the current situational challenges?

III. What is the vision and readiness of the Port of Banjul management about renewable energy as complementary to conventional fossil fuel generation and energy efficiency and management measures as technical, managerial and financial tools to cut down on energy costs?

IV. Are there potentials for cost savings and what will be the environmental impacts if robust and effective energy efficiency and management measures are adopted and implemented by the port management?

V. Can the Port of Banjul be an energy management promoter?

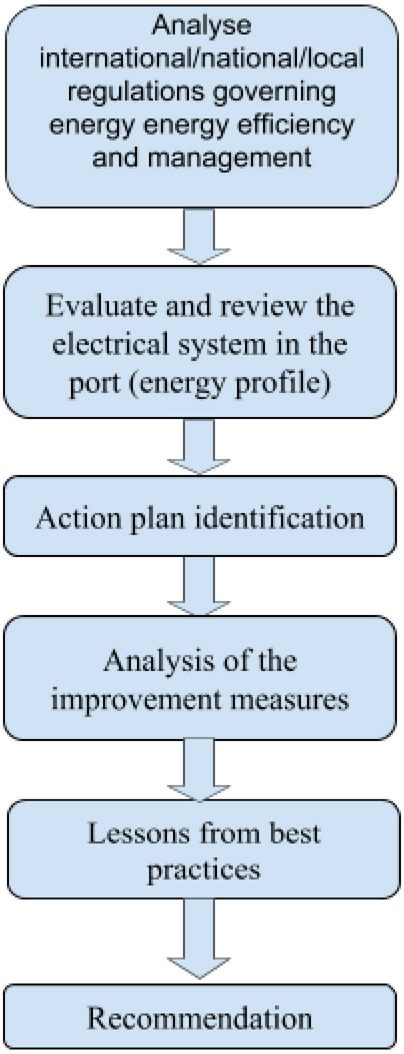
## 1.5 METHODOLOGY

This study intends to follow an analytical approach to deal with the highlighted problem statement above. The study aims to obtain relevant information from the Port of Banjul, the National Water and Electricity Company (NAWEC), Public Utilities Regulatory Authority (PURA), and from other ports intended to be used for best case studies - Genoa, Hamburg and Gothenburg through direct contacts, interviews and possibly questionnaire.

Other useful information that might be relevant to this study will be obtained from peer-reviewed journals, periodicals, conference papers, reports and books from credible institutions and academia like the World Bank (WB), International Renewable Energy Agency (IRENA), International Energy Agency (IEA), West African Power Pool (WAPP), European Sea Ports Organisation (ESPO), amongst others.

International Organization for Standardization (ISO 50001:2011) guidelines shall be the basis of the analysis. Legal frameworks governing energy efficiency and management from international and national perspectives shall be studied. Cost and consumption analysis shall include both from the national grid and from in-house generation. Consumption of key areas within the port, i.e. operations, support/maintenance functions and buildings, considering related sub-units in each category, will be analysed and grey areas identified. Ports with an already established Energy Management System shall be studied to paint a clear picture of the differences and similarities in the scenario and map out relevant recommendations about energy efficiency and management methods for the Port of Banjul. Cost-Benefit Analysis shall be done on some projects in the port considering solutions that best fit the situation of the port based on short, medium and long terms. Suggestions/recommendations shall be made for a way forward in setting up a Port Energy Management Plan for the Port of Banjul. The study intends to approach the task as per the flowchart in figure 1 below.

*Figure 1. Flow Chart of the Methodology*




***Source: Author***

## 1.6 SCOPE

This dissertation aims at looking at the electrical energy situation of the Port of Banjul, with the possible introduction of energy efficiency and management through the development of a Port Energy Management Plan (PEMP). The study will be centred on drawing up an Energy Management Action Plan for the Port of Banjul as per ISO 50001:2011, considering environmental, human, technological and regulatory guidelines. Only the electrical energy situation and associated issues within the confines of the port and its affiliates shall be considered. This does not include the influence of external factors from the city and the immediate outside surroundings of the port, but it is, however, inclusive of other stakeholders in operation and discharge of the port's mandate. The nature of power generation and supply by the national electricity company is an essential element that will be considered.

## 1.7 JUSTIFICATION

The current energy situation is not sustainable in the long run because of high electricity costs and low production from the national supplier and the cost of diesel fuel for in-house generation, coupled with the increasingly stringent environmental regulations. The demand for electricity is projected to grow far above the current levels due to planned port expansions accompanied by the future demand for energy services. The existing electrical infrastructure cannot handle this forecasted growth, thus the need for new electrical energy sources and management and utilisation practices to instil system efficiency and reduce the cost of operations. The existence of the high potential for renewable energy generation, especially solar and biogas need to be exploited to drive the attainment of energy security for the Port of Banjul.

## 1.8 OUTLINE OF THE STUDY

The dissertation is structured into seven chapters. Chapter one contains the introduction, problem statement, aims and objectives, research question, methodology, scope, justification, outline, limitations and assumptions of the study. Chapter two contains the literature review – dilating into existing research in port energy management, efficiency, planning and monitoring while also looking at the environmental requirements when dealing with energy issues in ports. Chapter three contains the regulatory frameworks governing energy efficiency from global to local perspectives, certification and best practices from industry. Chapter four contains the energy management strategy and processes. Chapter five contains a brief outline of The Gambia's energy situation and about the Port of Banjul. Chapter six contains case study for the establishment of an energy management system in the Port of Banjul, analysing the available data and discussion of results and cost analysis, and finally, Chapter seven contains the conclusions and recommendations based on the observed issues in the study to align them with the objectives of a good Port Energy Management Plan for the Port of Banjul.

## 1.9 LIMITATIONS AND ASSUMPTIONS

There are limitations on the ability to validate the accuracy of the data received due to its complexity and in some areas incompleteness. This may somehow affect the conduct of this research. However, every effort will be made to ensure a credible result is obtained and recommendations are drawn therefrom.

Key assumptions of this study include a moderately low level of awareness of energy efficiency and management measures in the Port of Banjul.

# Chapter 2

## 2.0 LITERATURE REVIEW

### 2.1 OVERVIEW

Energy management in seaports has of recent attracted close attention with port authorities trying to improve their environmental profiles (Lam & Notteboom, 2014) through innovative methods of energy production, use, consumption and conservation to curb rising consumption, cost and manage negative externalities (Benacchio et al, 2001). With ports getting closer to communities and cities, improving port-city relations (Dooms & Verbeke, 2007) to enhance competitive advantage (Adams et al, 2009) and respond to the demands of the shipping industry (OECD, 2011) is becoming embedded in ports' strategic management processes. Ports and terminals are now directing focus on energy efficiency and management issues (Acciaro, Ghiara, & Cusano, 2014), as a way of reducing energy consumption through the integration of innovative technologies, renewable energy utilisation and new operational processes.

Environmental impact of port operations ranging from vessel and cargo handling operations, industrial activities within the ports, port constructions and dredging operations, waste handling and port extension (Lam & Notteboom, 2014), has come under sharp scrutiny for compliance with regulations and guidelines. Ports are required nowadays to improve their environmental footprints (ESPO, 2017) as part of their Corporate Social Responsibility (CSR) because most ports are located close to communities, which are directly or indirectly affected by their operations. Some investment decisions hinge on the environmental performance of ports (Lee & Lam, 2012). Greenhouse gas (GHG) emissions from port operations have been seen as an environmental concern, contributing to rising global temperatures and its associated effects of respiratory and cardiovascular diseases, lung cancer and premature deaths.

In a sustainability report released by the European Sea Ports Organization (ESPO) in 2017 (ESPO, 2017), 80% of EU ports are monitoring energy consumption, which reveals an increase of 15% over the 65% in 2013, thus attaching great importance to the issue. Among the top ten environmental priorities of EU ports for 2017, energy consumption is ranked second position (ESPO, 2017; Lam & Notteboom, 2014). This ranking calls for proactiveness instead of reactiveness in tackling energy issues in ports through self-regulation and proper international, national and local legislative guidelines and policies. As a follow-up to fulfilling the objectives of the Paris Agreement, energy transition policies are being adopted and implemented by ports to address the issue of climate change (ranked second among the top ten EU ports' environmental priorities in 2017) through energy efficiency, GHG emissions reduction and adaptation. Reductions in energy consumption are closely related to improving air quality as it improves the carbon footprint of the ports.  In most African countries, energy policies are focussed more on availability than conservation as the institutional and market arrangements are such that efficiency and conservation are far below the ladder as access is of importance. However, the Economic Community of West African States (ECOWAS) drafted an energy policy with the aim of ensuring efficient use of the region's resources to modernise and drive the green economy mentality, reduce energy bills and reduce negative environmental externalities (ECOWAS, 2013).

Port agenda has in recent times encompassed green and sustainable initiatives (Adams et al, 2009) as compliance measures to environmental laws and regulations. (Bunse et al, 2011) In their study on gap analysis between industrial needs and scientific literature in Integrating Energy Efficiency Performance in Production Management, identified rising energy prices, new environmental regulations and externality cost of pollution and behavioural changes towards green and energy efficient products as drivers for energy improvement measures. As well as improving environmental profiles and conformity to regulations, (Acciaro, 2015) also identified Corporate Social Responsibility (CSR) as another driver emanating from ecological and environmental pressures (from port communities and lobby groups like NGOs) and legitimacy from local communities (licence to operate). Regulations are seen as the most effective tool as it ensures a level playing field while also ensuring a broad scale adoption of new technologies that reduce emissions through energy efficiency improvements. However, along with the above drivers, there are barriers to their implementation which includes segmented responsibilities wherein responsibility is decentralised and holding people accountable becomes difficult, difficulty in accounting for improvements as a result of measurement complexities, lack of adequate training and deficient commitment from management (Johnson & Andersson, 2016).

Regulations and standards such as IMO and US EPA regulations and EU Directives are drivers for adoption of energy efficiency and management measures in ports. According to studies conducted by IMO on emission control and energy efficiency measures for ships in port area (IMO, 2015), EU air quality legislation (Directive 2008/50) indicates that local air quality limits have to be met and measures are put in place to control emissions if port expansion projects have to be undertaken. (Boile et al, 2016) Indicated that the EcoPorts Foundation is working on helping European ports to address their energy and environmental challenges through a five-prong approach, i.e. exemplifying, enabling, engaging, encouraging and enforcing mechanisms and strategies.

The adoption of relevant emission reduction technologies hinges on costs of technology, installation, operation and maintenance, project management, staff training and licensing requirements, emission reduction capability, awareness, the feasibility of integration with the existing system(s) and recordkeeping requirements. The US EPA in a study on Shore Power Technology Assessment at US ports (US – EPA, 2017), indicated that generally, OPS reduces emissions from ships at berth in the United Kingdom in the order of 92% NOx, 76% CO, 46% SOx and 25% $CO_2$ with power supplied from the national grid. Reductions are also estimated for $CO_2$ and PM in the order of 57% and 39% in Kaohsung, Taiwan (Chang & Wang, 2012). Pollution from port operations and threat caused to the port environment has been an international concern, notably from IMO. The IMO 3rd Greenhouse Gas Study (IMO, 2014) identifies pollutants like NOx, SOx, PM, $CO_2$ and VOCs as directly linked to international shipping, some of which are as a direct result of port operations. Control of these pollutants from port operations has now become a priority focus for regulators to minimise the effects on society because most ports are situated close to residential and commercial areas.

Nitrogen oxides (NOx) is produced as a result of burning fuel at high temperatures. Generally high efficient engines have high combustion temperatures, thus producing more NOx, which when combined with VOC causes ground-level ozone, resulting in respiratory problems, acid rain and nutrient overloads. Sulphur Oxides (SOx) comprises sulphur dioxide ($SO_2$), sulphur trioxide ($SO_3$) and sulphate ($SO_4$). SOx is released as a result of the burning of fossil fuels like coal and oil for ship propulsion and power generation in ports. The IMO and other international regulatory bodies are putting in place regulations controlling sulphur emissions through minimum sulphur content in fuel like the 0.5% global sulphur cap by 2020 for ships engaged in international trade (IMO, 2015) and the ECA 0.1% since 2015. Particulate Matter produced from SOx constitutes $PM_{10}$ and $PM_{2.5}$, which are solid particles and liquid droplets found in the air as a result of incomplete combustion of heavier fuels with high sulphur content. PM creates public health problems like respiratory and hyperactive lung infections and contributes to a range of chronic illness from long-term exposure.

IMO's agenda to combat the above air pollutants is outlined in its instrument of MARPOL Annex VI, Chapter 4. Increasing port/terminal operational efficiency through automated mooring systems, optimization of operations to reduce berth time of ships through deployment and use of efficient cargo handling equipment like electric gantry cranes, fast and efficient electric pumps for liquid bulk cargo and to speed up cargo delivery processes, can all contribute towards a considerable reduction in port emissions.

## 2.2 ENERGY MANAGEMENT

Energy management is focussed on the implementation of energy efficient technologies and replacement of inefficient equipment and maintenance of technology (Backlund et al., 2012), systematic use of organizational methods and technology to reduce energy use while maintaining production and comfort levels (Carbon Trust, 2010) and the efficient utilisation of energy to maximize profits (minimize costs) and enhance competitiveness (Capehart et al., 2008). According to the ISO 50001:2011 certification system, Energy Management System (EnMS) is a combination of processes and procedures that establish an energy policy with clear objectives and targets of reducing energy consumption (ISO, 2011).

Maritime Energy Management (MEM) is a study of the overall energy system - supply, storage, conversion, production, use and consumption in the maritime domain (ships, ports and shipyards) to achieve utilization and cost reductions, thus improvements in environmental profiles, through effective measures which should be analysed, monitored, reported and continually improved (Ölçer et al, 2017). Energy management systems can reduce energy cost by up to 20% (Carbon Trust, 2010) and implementation of energy efficiency programs have a potential system improvement of about 16 - 40% (Thollander et al., 2007). Reductions in energy consumption as a direct result of low fuel consumption in ports due to various fuel-saving measures leads to reductions in externality costs like medical treatment due to respiratory disease, arising from air pollution in the port (F. Ballini & Bozzo, 2015). It is therefore essential that all employees and stakeholders utilise awareness and monitoring of energy use and saving activities in the port. (Acciaro et al., 2014) characterise ports as energy hubs, i.e. areas of high energy demand and supply and further divided energy use in ports into energy required for direct port operations, e.g. operating E-RTGs and lighting system, energy for ship supplies, i.e. Onshore Power Supply (OPS) and energy required for port induced activities, e.g. small industries.

Proactiveness in energy efficiency and management activities (as demonstrated by Port of Hamburg - Germany), as well as the promotion of the utilisation of renewable energy sources (as in the Port of Genoa - Italy), are currently preoccupying ports in their energy management strategies and policies (Hossain, 2018). Sustainability of port operations entails strategies and activities that meet the port's current and future operational needs while protecting the resources that are required for these needs (Degens, 2008). These strategies could be achieved through proactive development, execution and monitoring practices and strategies aimed at reducing or minimising environmental impacts at all levels (Acciaro, 2015).

(Burns & McDonnell Engineering Company, Inc., 2014) Highlighted that ports must ensure secure and reliable electricity supply for their operations in order to maintain competitiveness. The growth of world seaborne trade, primarily through containerised cargo is forcing ports into the yard, and infrastructure expansions thus increased energy consumption (Wilmsmeier & Spengler, 2016). Most port and terminal operators still face the problem of awareness of the importance of energy efficient infrastructure as they embark on the adoption of energy efficient technologies in their operations (Wilmsmeier et al., 2014). Awareness of energy sources and usage among stakeholders in port operations will significantly help the success of the implementation of energy efficiency and management strategies. A coordinated approach is therefore necessary. Energy-intensive industries like the ports have to adopt new ways of coping with the energy price increases, i.e. investments in alternative sources of electrical energy (supply-side management) and a greater focus on energy efficiency and management measures (demand-side management) (Thollander & Ottosson, 2010).

## 2.3 DRIVERS AND BARRIERS TO ENERGY EFFICIENCY AND MANAGEMENT

The development of sustainable port infrastructure is premised on the reduction of overall energy consumption alongside achieving economic growth and reduced emissions and pollution (Pavlic et al., 2014). Key driver for port energy efficiency is the mitigation of climate change to meet international obligations under the UNFCCC, meet supranational and national emission requirements and achieving ports' economic development and competitiveness through reduced operational costs, increase affordability and the provision of value added services (Ng et al, 2013; Li, Liu, & Jiang, 2011; Perez-Labajos & Blanco, 2004). Other drivers for energy efficiency is the achievement of energy security for port operations through increased reliability of energy services and control of energy demand growth and the reduction of pollution and its externality health costs to society.

Investments in energy efficient technologies alongside continuous energy management strategies are the most cost-effective way to improve energy efficiency (Backlund et al., 2012). However, there are discrepancies (gaps) between requirements and actual implementation due to prevailing barriers. High project development costs and dispensed benefits, the perception of energy efficiency investments as complicated and risky ventures and the lack of awareness of financial benefits on the part of financial institutions all provide market and financial barriers to the growth of energy efficiency. Insufficient information and the involvement of workers in energy efficiency decision making coupled with negative behaviours and perceptions of workers provide social barriers (Kitada & Ölçer, 2015). Regulatory and institutional deficiencies result in energy tariffs that discourage energy efficiency investments or biased policies that tend to favour either producers or consumers. Lack of technical capacities to identify, develop, implement and maintain energy efficiency technologies provides serious impediments against the adoption of cost-effective and efficient technologies (Acciaro et al., 2013).

# Chapter 3

## 3.0 ENERGY EFFICIENCY REGULATORY FRAMEWORKS, CERTIFICATION AND BEST PRACTICES

### 3.1 OVERVIEW

With climate change mitigation been at the forefront of global agenda recently, economic development and achieving energy security, adoption of energy efficiency measures is a critical response strategy, which requires a coordinated and regulated combination of technology development, market mechanisms and government policies. Energy efficiency governance involves the combination mentioned above of technology, market and government through legislative frameworks, funding mechanisms and institutional arrangements for the effective implementation of energy efficiency strategies, policies and programs (OECD/IEA, 2010).

Air pollution is considered a grave environmental risk (WHO, 2016) and the emissions of GHG, mostly from anthropogenic activities (including in port areas) is also being highlighted by the IPCC (IPCC, 2014). It is therefore imperative that energy management and efficiency be utilised according to international and national guidelines to reduce energy consumption, pollution and GHG emissions. Sustainability agendas are challenging port authorities to strategise the port-city interface as a way of improving productivity through economic, social and environmental means (Daamen & Vries, 2013). Ports by their roles as interfaces between land and sea demand a high amount of energy for their operations.

The adoption of the 2015 Sustainable Development Goals (SDGs) by the UN and in particular goal 7, which aims at providing accessible, affordable, reliable, sustainable and modern energy for all and the combating of climate change (Goal 13) (Ölçer et al, 2017), as well as the EU 2020 Energy Strategy requires the adoption of broad energy management and efficiency measures. Reducing energy usage and consumption in ports through Port Energy Management Plan contributes significantly towards enhancing the availability of energy services and reducing emissions from port operations.

## 3.2 INTERNATIONAL LEGAL FRAMEWORKS

As environmental and energy-related policies and regulations increases, energy efficiency and management practices are becoming very crucial in the response and compliance drive (Ölçer et al., 2017). The European strategy for Energy and Climate Change proposed a 20% reduction in GHG emissions below 1990 levels by 2020 through the adoption of energy efficiency measures to reduce energy consumption by 20% and increase the share of renewables in the generation mix by up to 20% (da Graça Carvalho, 2012).

EU Directive 2012/27/EU on energy efficiency which requires the efficient utilisation of energy at all stages of the energy chain by all member states and incorporating the directive in their national laws establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020 (EU, 2016). The promotion of liberalisation of the electricity market in the EU and the "Green Port" slogan in the US resulted in the campaign and promotion of energy efficiency and renewable energy in ports. Some EU ports have started implementing PEMP and Smart Port - including the Port Authorities of Genoa and Hamburg implementing the Port Energy and Environmental Plan (PEEP) and the Smart Port Energy Plan respectively, aimed at improving the energy and environmental profiles of the ports (Delponte, Pittaluga, & Schenone, 2017). The installation of Onshore Power Supply (OPS) in EU ports by 2025 as per Directive 2014/94/EU (EU, 2014) is a way of reducing air pollution in port areas.

## 3.3 IMO REGULATION ON AIR EMISSION (MARPOL ANNEX VI)

Regulations are an essential driver to reduce emissions at open sea, ship-port interface and within ports and terminals. Implementation of Clean Air Act regulations has brought in so many changes in improvements in relations between regulators, ports and the maritime community (IMO, 2015). MARPOL Annex VI is the main IMO instrument designed to combat air pollution. Chapter 3 of MARPOL Annex VI indicates requirements for control of emissions from Ozone Depleting Substances (ODS), Sulphur Oxides (SOx), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOCs) and Particulate Matter (PM). Chapter 4 of the same Annex VI deals with prevention of emission of GHGs through regulations on the energy efficiency of ships. Sulphur Emission Control Areas (SECAs) are declared in specific sea regions including the Baltic Sea, North Sea, North America, United States and Caribbean Sea ECA, where sulphur content in fuels used in the above areas dropped from 1.5% in 2008 to 0.10% in 2015 and beyond (IMO, 2015), as shown in the table below.

***Table 1. IMO Fuel Quality Requirements to Limit SOx Emissions***

| Fuel Sulphur Content | 2008 | 2010 | 2012 | 2015 | 2020 |
|---|---|---|---|---|---|
| SECA | 1.5% | 1% | | -0.10% | |
| World wide | 4.5% | | 3.5% | | 0.5% |

***Source: IMO, 2015***

NOx Emission Control Areas (NECAs) are also established in waters within 200 nm from North American coast and within 50 nm off the coast of Puerto Rico and the US Virgin Islands.

## 3.4 REGIONAL AND LOCAL REGULATORY CHALLENGES

The technical nature and complexity of IMO and other international conventions, inadequate legal capacity and deficient requisite expertise is posing serious challenges to some developing countries’ capacity to draft proper domestic legislation to give effect to these conventions (Karim, 2015), added to the non-utilisation of the few who have been adequately trained and equipped with requisite skills. West and Central African ports are obliged to implement and enforce IMO conventions and other regional agreements but are beset with capacity challenges in formulating adequate policies at national levels (as the conventions and agreements have to be harmonised with national legislation). It is therefore crucial that relevant policies and national laws be developed to regulate the industry in line with international obligations.

The Economic Community of West African States (ECOWAS) has issued a directive on Energy Efficiency Policy and Action Plan for Implementation of the policy requiring member states to ensure that building designs incorporate energy efficiency to improve their energy performance based on climate zone (ECOWAS, 2013). The Gambia has ratified the MARPOL convention, thereby committing itself to the prevention of pollution from ships and by extension from port operations. The electricity generation and distribution in the Port of Banjul is still inadequate to meet the demands of eco-compatibility, and this is exacerbated by the lack of innovation to meet new environmental and energy goals. With the adoption of energy management, energy efficiency and renewable energy requiring mapping or charting a new course in the utilisation of electrical energy in ports, the lack of clear-cut regulatory guidelines and policies frustrates this drive, thus resulting in an uncoordinated and unsupervised situation (Parise et al., 2016).

The lack of capacity in the Public Utilities Regulatory Authority (PURA) and the National Environment Agency (NEA) of The Gambia, leaves the coordination and oversight supervision of the energy and environmental issues in the port's energy sourcing and utilisation minimally supervised, resulting in inefficiencies.

## 3.5 ISO CERTIFICATION, EU (EMAS) AND PERS (ESPO)

ISO 50001: 2011 certification is a vital and useful tool which can help Energy Managers deliver on their goals of reducing energy consumption through gap identification in an energy audit, pinpointing weaknesses and directing at energy saving opportunities (Ballini & Ölçer, 2018). As with other ISO management standards, ISO 50001:2011 and 14001 certifications are voluntary processes. Institutions like ports opt for certification to boost their image and show customers and regulators that they have implemented Energy and Environmental Management Systems (Marimon & Casadesús, 2017). Green Port concept is the establishment of sustainable environmental policies in ports and their application in port operations on a voluntary basis to improve ports' environmental footprints (Akgul, 2017).

Port Environmental Review System (PERS) assists ports in implementing their Environmental Management Systems. It is a tool used by ESPO to monitor activities like development of sustainable logistics chain, grassroots engagement, sustainable technologies, collaboration with regulators, proper environmental policies and practices and monitoring and reporting of same through effective communication channels. It is a tool developed by ports - for ports.

The evaluation of environmental performance, feedbacks and improvements in port operations is done in the EU through the Eco-Management and Audit Scheme (EMAS). About 70% of European ports are certified under the European Eco-Management and Audit Scheme (EMAS) and the European Port Environmental Review System (PERS) and the adoption of the ISO 14001 and 50001:2011 standards in some ports, which shows the importance attached to energy efficient technologies and renewable energy (ESPO, 2017).

## 3.6 BEST PRACTICE CASE STUDIES

In encouraging the Port of Banjul to consider setting up an EnMS, it is vital that reference is taken from other ports which have already set up the system and continue to improve upon it. In this study, the ports of Genoa, Gothenburg and Hamburg who have demonstrated exemplary strides in energy management and efficiency as a result of relevant policies and implementation, are reviewed.

### 3.6.1 Port of Genoa

With ports as areas of high energy demand and supply (energy hubs), the Genoa Port Authority has set up a comprehensive plan aimed at boosting its energy supply and reduce usage and consumption, thereby reducing costs. For this purpose, it has developed a Port Energy Environmental Plan (PEEP) to stimulate energy production activities especially from renewable sources, which ultimately boosts energy efficiency in the port.

With the Port of Genoa located very close to the city (as shown in figure 2), Port-City relations is therefore fundamental. The port needs to handle its operations innovatively and efficiently that it has a little negative impact on the communities within the port vicinity. To this end, adoption of pollution and emission reduction strategies are essential, which is the objective of the PEEP.

*Figure 2 Location of Port of Genoa*


***Source: Port of Genoa, 2018***

Table 2 below shows the specific objectives, action plans and focus areas for the implementation of the PEEP and table 3 shows the energy profile of the port's various terminals.

*Table 2. Specific Objectives, Plans and Focus Areas for the Port of Genoa*

| Specific Objectives of PEEP | Action Plans to achieve the objectives | Focus areas | Possible investment | Reduction of $CO_2$ emission (t/a) |
|---|---|---|---|---|
| 1. Emission reductions of 20 000 $tCO_2$/year<br>2. Promotion of renewable energy sources and converting the port to a Green Port and<br>3. Increase energy efficiency in the port area | 1. Regulatory framework (analysing the laws and regulations)<br>2. Environmental assessment<br>3. Consumer survey<br>4. Guidelines<br>5. Documentation of activities and results relying on modern document handling techniques | 1. Onshore wind energy<br>2. Solar thermal and photovoltaic energy<br>3. Biomass energy<br>4. Geothermal energy - hydrothermal energy<br>5. Waves power<br>6. Improvement of energy efficiency of buildings, public lighting and cargo transport<br>7. Shore side electricity<br>8. Electrical mobility | 1. Wind power plants €20 110 000.00<br>2. Photovoltaic systems €24 427 422.00<br>3. Solar energy €405 000.00<br>4. Electrification of quays €13 000 000.00<br><br>**TOTAL €57 942 422** | 6000<br>3600<br>100<br>10000<br><br>**19700** |

***Source: Port of Genoa, 2018***

*Table 3. Energy Profile of the Port of Banjul*

| Terminal | Consumption (kWh) | Emission VAlues |
|---|---|---|
| VTE | 19 000 000 | Emission values of $CO_2$ associated with the production of electricity is about 0.49 kg/kWh (about 25 000 ton $CO_2$) |
| Messina | 5 000 000 | |
| Sech | 4 500 000 | |
| Other terminals | 4 600 000 | |
| Passenger Terminal | 6 300 000 | |
| Oil terminal | 2 500 000 | |
| Bulk terminal | 3 000 000 | |
| Various | 5 000 000 | |
| **TOTAL** | **49 900 000** | |

***Source: Port of Genoa, 2018***

### 3.6.2 Port of Gothenburg

Gothenburg port is the largest in Scandinavia, and 70% of the Nordic countries' industry is located within 500 km from the port. It has an annual turnover of SEK742 million in 2016, and it is the only Swedish port that can accommodate the world's largest container vessels, with 130 direct connections to the world and over 40 million tonnes of goods per year passes through the port (Gothenburg Port, 2016).

The port takes a proactive approach in its energy management to minimise environmental impacts of its operations through investments in alternative energy sources, onshore power supply and charging stations and offsetting carbon emissions. Like in Genoa, Gothenburg Port is located close to the city; thus the environmental initiatives of the city drive that of the port too. It has an energy consumption of 6100 MWh/year, which is produced from good environmental choice - supplied by Gothenburg Energy. It had a total GHG emission of 200 $tCO_2$ in 2016. The figure below shows the close location of the port to the city.

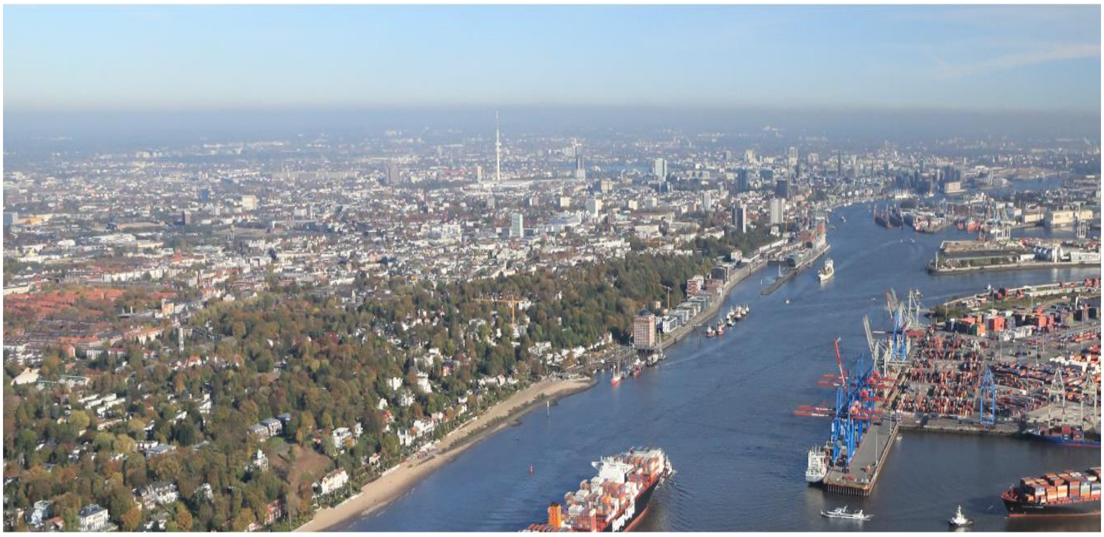
*Figure 3. Location of Port of Gothenburg*

***Source: Port of Gothenburg, 2018***

### 3.6.3 Port of Hamburg

The Port of Hamburg has set itself ambitious climate goals and assigned extraordinary priority to environmental protection. The port is very much focussed on sustainability in its operations to reduce environmental impacts, thus the adoption of the SmartPORT Energy Plan for the development of sustainable energy solutions and improving the energy profile of the port. Like in previous cases of Genoa and Gothenburg, Port of Hamburg is located close to the city of Hamburg. Its sustainability programs are aligned to that of the city. The port handled 136.5 million tons of general and bulk cargo in 2017 with 8.8 million TEU. Electricity supply from renewable sources has been a successful strategy for Hamburg Port, with wind energy the dominant source, with 52.75MW capacity installed in the port area and two 6000 kW capacity installed close to Altenwerder Terminal. Roof-top solar PV has also been undertaken with an installed generation of 500,000 kWh/yr (Acciaro et al., 2014). The port is a significant energy consumer, with demand over 3 GWh/yr. Figure 4 below shows the location of Hamburg Port.

*Figure 4. Location of Port of Hamburg*



***Source: Port of Hamburg, 2018***

Energy efficiency measures like OPS and E-mobility are also being championed by the port backed by awareness campaigns among its employees. The close relation between the city and the port creates a smooth path for environmental action plans implementation. The port's energy management is incorporated in the city's energy management and the two compliments each other. Like Gothenburg, sustainability initiatives show proactiveness in reducing or optimising their energy process, and that requires a collaborative effort from the port, energy companies and communities.

The port serves as an energy management promoter through proper planning, regulation and monitoring of energy use within its premises and implementation of new policies and changes where necessary.

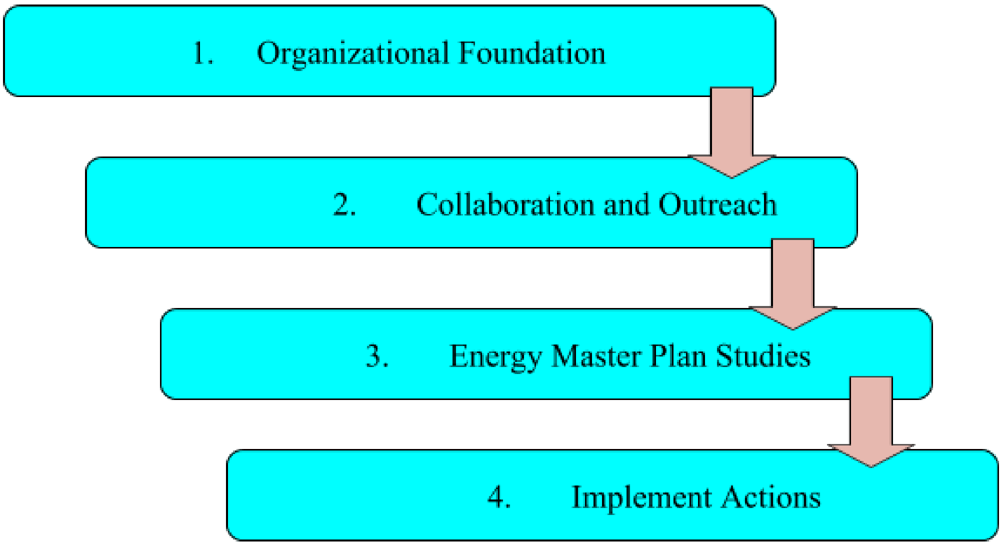
# Chapter 4

## 4.0 OVERVIEW OF PORT ENERGY MANAGEMENT

### 4.1 PORT ENERGY MANAGEMENT STRATEGY

Port Energy Management Strategy is aimed at formulating processes and strategies geared towards realising appropriate energy savings (through reduced consumption and costs) and advancing the consolidation of those gains (maximising profitability of ports) while also complying with environmental regulations (Ölçer et al, 2017). (Burns & McDonnell Engineering Company, Inc., 2014) Indicated that studies, projects and programs that improve a port's energy profile and place it in a competitive position form the core of a Port Energy Management Strategy. These studies, projects and programs hinge on laying down a robust organisational foundation, stakeholder engagement through collaboration and outreach activities, feasibility studies and assessments that lead to the development of an energy master plan and projects and program execution that supports the earlier highlighted energy pillars. The above process is illustrated in figure 5 below.

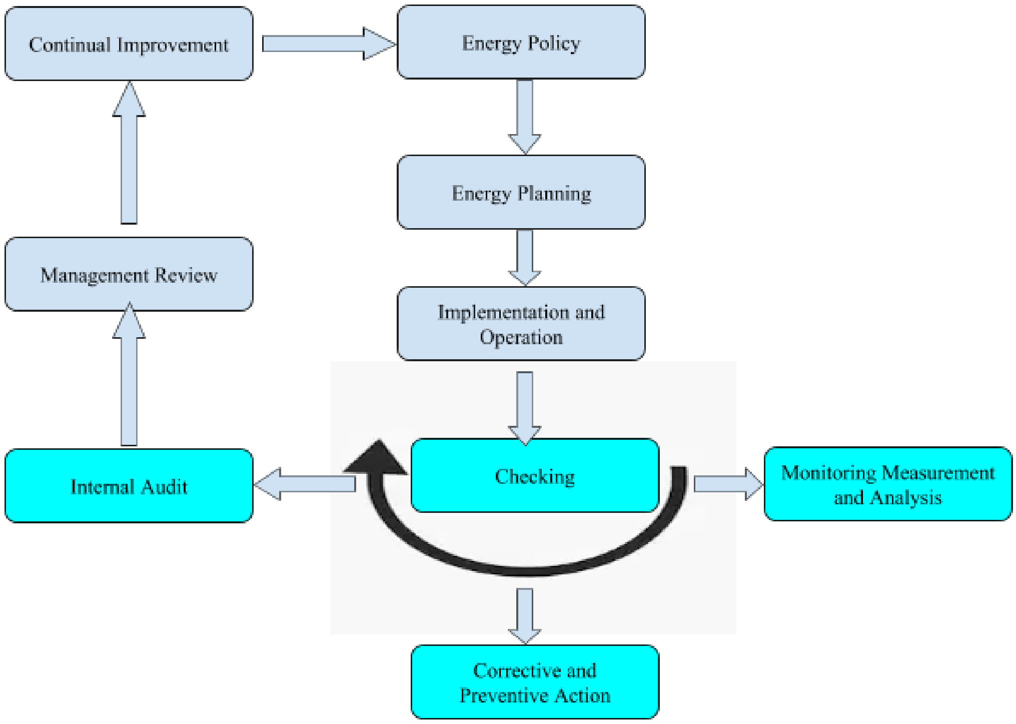
*Figure 5. Overview of Energy Management Strategy*




***Source: Port of Los Angeles, 2014***

Enhancing a port's energy profile for reductions in consumption and effectively cost should be centred around exemplifying, enabling, encouraging, engaging and enforcing energy efficiency and improvement measures (Boile et al, 2016). Various ports have made some inroads in their energy management strategies by incorporating it in their operations and facilities, a case in point is the Port of Hamburg (Acciaro et al, 2014). Energy Management Systems (EnMS) comprises management commitment and responsibility, energy policy, training and audit plans, implementation and execution, evaluation and management review (ISO, 2011). This EnMS utilises the PDCA (Plan-Do-Check-Act) cycle for systemic identification, controlling, monitoring and recording of all the activities to ensure continuous system improvement, as highlighted in figure 6 below.

*Figure 6. PDCA Cycle for an Energy Management System*



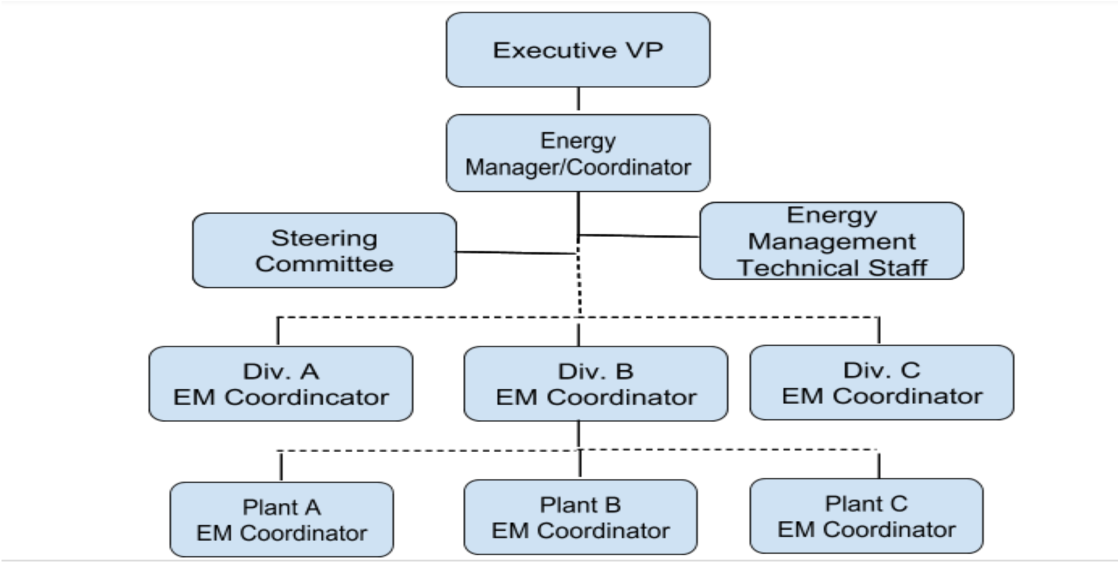

***Source: ISO 50001 (2011)***

The PDCA cycle of an Energy Management System incorporates EnMS program of establishment, the commitment of top management through formulating energy policy, energy planning, identifying legal requirements, establishing an energy baseline for benchmarking of improvements, defining performance indicators and setting out objectives and targets. The planning function can be used broadly to develop energy action plans and programs to achieve them with clear objectives and targets. The established action plans are then implemented through assigning roles and responsibilities, training people on specialised skills, development of work procedures, involving employees in the action process, effectively communicating to all concerned, proper documentation and innovation in the design of facilities and procurement processes. The implementation should be monitored, measured, analysed, legal requirements factored to ensure compliance with rules and standards, audited and nonconformities rectified through corrective and preventive actions. The final process needs to be reviewed for continued improvements to ensure adequate system operation and address changes that may be made to the EnMS (ISO, 2011).

## 4.2 PLANNING - PREPARE AND STRATEGIZE

For a port energy management plan to be set up, top management must exhibit will and commitment in providing leadership and resources to implement studies, projects and programs and the integration of energy management function in the port's organisational structure (Capehart et al, 2008). Planning and its processes shall be guided by the energy policy and shall be focused on continual improvement in energy performance (ISO, 2018). Energy management should not be seen only as a technical function (left to operational technicians to deal with) but should be recognised as a managerial activity. An energy management program includes organisational structure, policy, audits, training, reporting system and a strategic plan. Fig. 7 below shows the organisational design for an energy management program.

***Figure 7. Organizational Design for an Energy Management Program***




***Source: Capehart et al, 2008***

The design of a Port Energy Management Program following top management's commitment encompasses the establishment of a Port Energy Policy, appointing an Energy Manager with responsibility of managing the energy management program and the formation of a Technical Committee comprising people with technical background i.e. electrical, mechanical, chemical and civil engineers who will be responsible of providing technical assistance to the Energy Manager. A Steering Committee shall guide the energy management program activities through communication and awareness creation, and the Departmental and Unit Coordinators are then chosen to make sure energy management and efficiency measures are directly implemented at the plant and operational levels.

The above lays the foundation for the EnMS in conjunction with the design and procurement of environmentally compliant structures and materials.

### 4.2.1 Energy Policy

Top management shall show its commitment towards the establishment of an Energy Management System by designing an Energy Policy that provides the institutional guidance and direction for the development, implementation, maintenance and continual improvement of energy management (Howell, 2014). The policy document shall show resolve from the management to work with relevant stakeholders in the formulation and implementation of studies, programs and projects geared towards improving energy resiliency, availability, reliability, efficiency and sustainability (ISO, 2011).

The energy policy shall include intentions in the utilisation of renewable energy to increase production capacity, and the use, design and procurement of energy efficient processes in its operations, products and services and satisfy applicable legal requirements (ISO, 2018). The policy shall spell out objectives and targets of the management plan and ways to achieve them. The targets shall be Specific, Measurable, Achievable, Realistic and Time-bound (SMART) and shall be in the form of percentage improvements in critical areas like port operations, meeting future energy demands, minimisation of disruptions, improved productivity of energy use and percentage of renewable generation as the contribution to the generation mix.

The Energy Policy shall be available as a documented information within the port and to interested parties and shall be reviewed annually or biannually and updated according to progress or shortcomings from the previous year's implementation outcomes.

### 4.2.2 Energy Manager

An Energy Manager shall be appointed to oversee the implementation of the energy management program for the port. He/she shall be the focal person in the setting up of an Energy Team whose role shall be directed at supporting the development, implementation and evaluation of the energy management plan (Ballini & Ölçer, 2018). This shall be done in coordination with energy coordinators at the plant/floor level. The Energy Manager shall be a person with multidisciplinary skills with economic, legal, technological and scientific background and should have high managerial skills as his work involves more of management. The terms of reference of the Energy Manager shall include: -

- Setting up the Port Energy Management Plan
- Conducting periodic energy reviews
- Drawing up energy budgets and recommend possible funding avenues
- Communicate periodically with top management
- Serves as a focal person for implementation, monitoring and evaluation of energy programs and activities
- Be the liaison officer on energy matters between the energy team and management
- Draws up communication strategies on energy matters

- Documentation of records of meetings, energy activities and management review documents
- Actively support and coordinate with all departments and stakeholders of the port on energy matters

Conducting an energy audit shall be the priority of the Energy Manager, followed by establishing an energy accounting (keeping track of energy consumption and costs) monitoring and documenting energy use and performance improvements.

### 4.2.3 Energy Team

A team comprising individuals with multidisciplinary backgrounds ranging from planning skills, understanding of modern technologies, economic evaluation skills like calculation of payback, Life Cycle Cost and Levelized Cost of Electricity (LCOE) analysis and excellent communication and motivational skills, shall be selected from various departments of the port and shall be headed by the Energy Manager to form the Energy Team.

The energy team shall have the following terms of reference: -

- Responsible for the day-to-day energy management activities
- Planning developing and implementing energy infrastructure development
- Undertake stakeholder consultative programs
- Work with national and regional/municipal regulatory agencies on energy management requirements and guidelines
- Provides the link between the port and utility service providers
- Drafts training guidelines on awareness programs for broader port employees and users
- Develop energy management requirements and best practices

- Recommend the execution and implementation of energy projects that facilitate achievement of the port's energy management goals and targets
- Reports to and advice top management through the Energy Manager on innovative energy management practices and technologies.

### 4.2.4 Education and Training

For improvements in the energy profile of a port, education and training for key stakeholders in the port business is a fundamental step (Burns & McDonnell Engineering Company, Inc., 2014). The training should highlight energy conservation measures by utilising modern technology while also accommodating/inviting suggestions from employees and stakeholders.

Target groups should be top management, energy team and other employees (Doty & Turner, 2004). Due to their tight schedules and engagements, training for top management may be delivered through a day's presentation on what energy management entails and through concise periodic reports. Much attention should be given to training the energy team members adequately through in-house training, short training courses delivered by recognised organisations like International Organisation of Standardization (ISO) and classification societies, training institutions and universities, and workshops and seminars with keynote speakers and resource persons from industry and academia.

Employees of the port should also be sensitised on energy efficiency and management techniques to increase overall awareness levels, thus boosting the chances of success of the implementation. General employee training may take the form of introductory home energy conservation methods, energy sources and analysis of home utility bills. A training plan should be developed and implemented gradually to achieve its desired results.

### 4.2.5 Stakeholder Consultation and Outreach

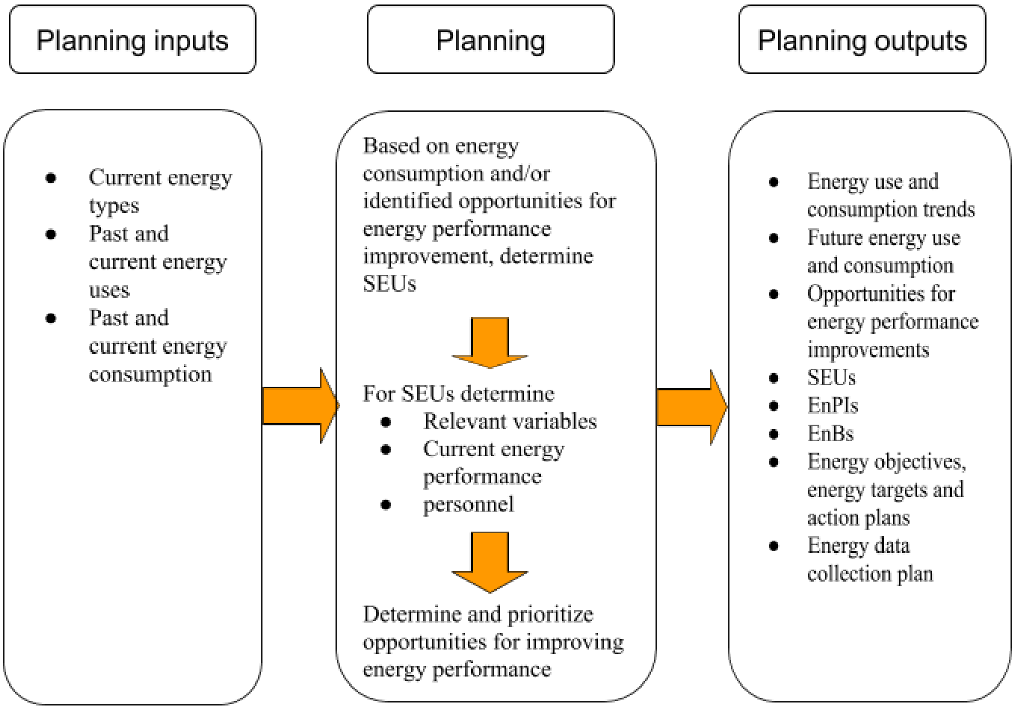
As energy issues are cross-cutting, the engagement of relevant stakeholders is an essential component to facilitate improvements in the energy profile of the port. The strategic contribution of the port to the national economy is overwhelming, and this is hinged on the availability of reliable energy for its operations. Therefore, there need to be regular consultation and outreach with institutions like the Banjul City Council, National Water and Electricity Company (NAWEC), Public Utility Regulatory Authority (PURA), National Environmental Agency, Shipping Agencies, National Security Institutions like the Police, Customs and Immigration (who have representation in the port) and community representatives in the vicinity of the port.

Since installation and operation of some technologies have to get clearance and license from some of the bodies mentioned above, their engagement in the planning stage is very much relevant.

### 4.2.6 Energy objectives, targets and planning to achieve them

The objectives shall include overall improvements to the EnMS and the targets shall be specific and measurable energy performance improvements (quantitative, e.g. 5% reduction in energy consumption by year end and qualitative e.g. level of change in consumption behaviours). Figure 8 below maps out an understanding of the energy planning process.

*Figure 8. Energy Planning Process*




***Source: ISO 50001, 2018***

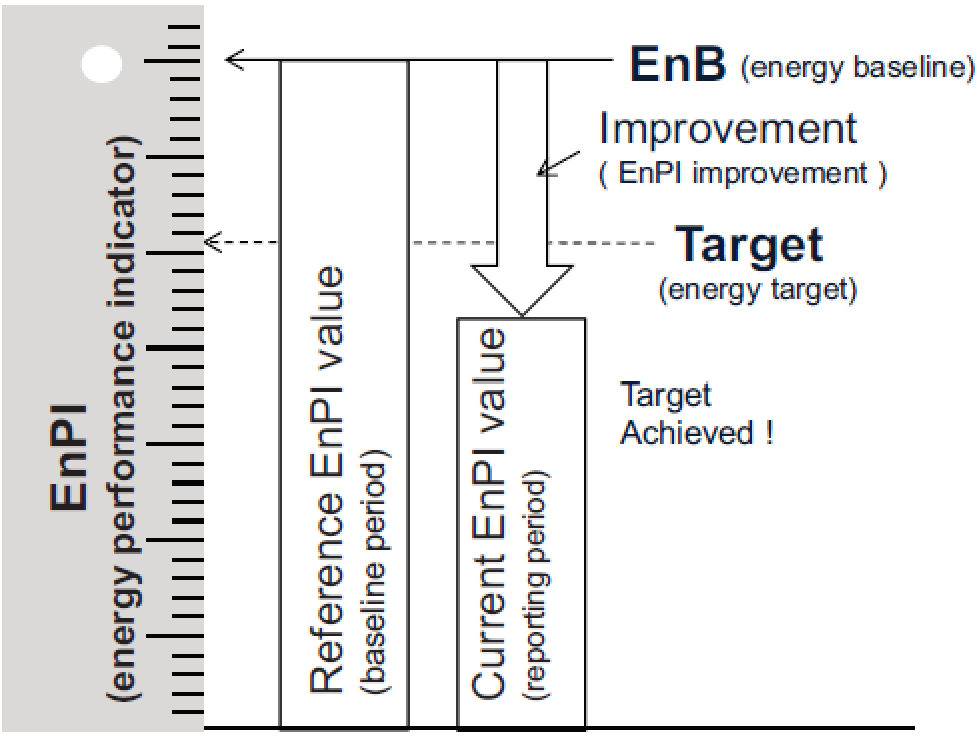
From the figure above, assessment of the current energy type, past and present usage and consumption information shall be obtained. Significant energy uses (SEUs) shall be identified through an audit on the various functional areas of the port, e.g. the main administrative building, reefer power points, amongst others alongside their performance improvement opportunities. The need for improvement activities like replacing degraded equipment and improvements in technology and techniques shall be captured in the energy audit. The output of the analysis shall guide towards establishing an energy baseline (EnB) for benchmarking the performance of applied efficiency measures, energy use and consumption trends (projecting future energy use), EnPIs and data collection plan.

This will assist in building up a case for the energy program which aims at future reductions in consumption and cost. Alternate generation methods like solar PV, wind, biomass and storage systems can be considered on individual merits to determine their viability for the Port of Banjul. The Energy Manager shall scout out possible funding for alternate energy generation from international and local agencies interested in investing in improving the environmental profile of ports through renewable energy generation and utilisation.

### 4.2.7 Energy Performance Indicators

The Energy Manager and the team shall prepare and define a list of Energy Performance Indicators (EnPIs) which shall be used for benchmarking analysis. Setting up Energy Performance Indicators (EnPIs) provides a mechanism to benchmark existing scenarios with baseline data to quantify energy performance, identify any existing gaps (as shown in figure 9 below) so that the institution can take action to improve the system.

*Figure 9. Energy Performance Indicators*




***Source: ISO 50006, 2017***

EnPIs can be expressed as simple units of consumption (kWh, kW), specific energy consumption (kWh/$m^2$) and percentage change in efficiency. Examples of EnPIs shall include those indicated in table 4 below.

*Table 4. Sample Energy Performance Indicators*

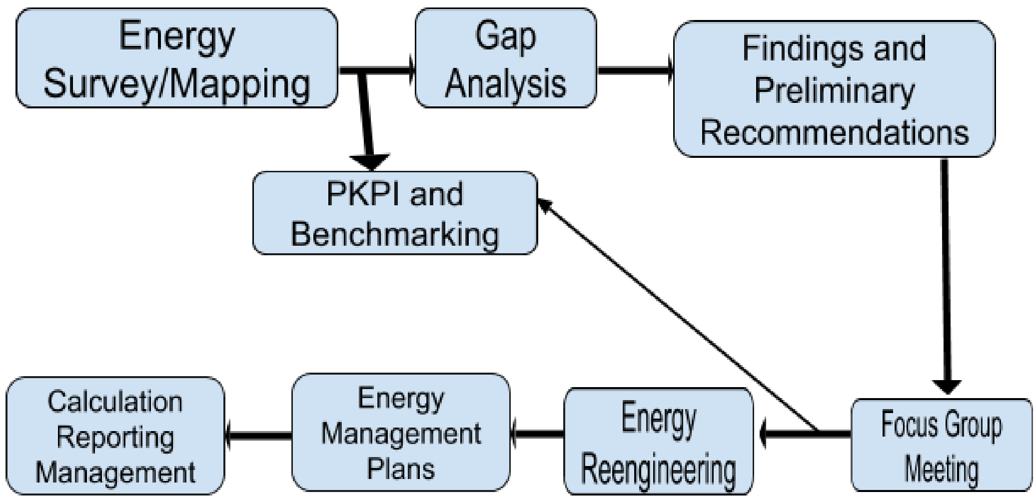
| EnPI | Calculation formula | Unit |
|---|---|---|
| Energy consumption | Power * Time | kWh |
| Efficiency in internal energy conservation | Output / Input | % |
| $CO_2$ Emission | Tons / Year | t/year |
| Share of energy cost in revenue | Specific energy costs / Revenue (per product) | % |
| Employees Specific Energy Consumption | Total Energy Consumption / No. of Employees | % |
| Area-specific energy consumption | Total Energy Consumption / Heated area | kWh / $m^2$ |
| Contribution of each energy carrier | Energy carrier / Total Energy | % |

***Source: Javied, T., Rackow, T., & Franke, J. (2015)***

### 4.2.8 Port Energy Management Plan (PEMP)

Following the energy review and assessment, the process for the development of the port energy management plan then begins, as shown in figure 10 below.

*Figure 10. Process for Developing Port Energy Management Plan*




***Source: Boile et al, 2015***

Energy consumption of port operations and facilities shall be mapped out by the Energy Manager through an energy audit considering EnPIs, which identifies gaps and requirements for setting up a PEMP while also considering changes in variables like traffic volumes, cargo portfolio, expansion projects and demand and supply balances (Javied T et al, 2015; Ölçer et al, 2017). Mechanisms to overcome the gaps are then formulated according to the vision, strategy and objectives of PEMP, which are shared with relevant stakeholders for deliberations and consensus. Action programs are then drawn up in an energy reengineering process with cost estimates, time frames and roles and responsibilities of stakeholders. Energy consumption shall be measured, documented and compared with set targets. Results shall be reported periodically for performance monitoring and improvement activities.

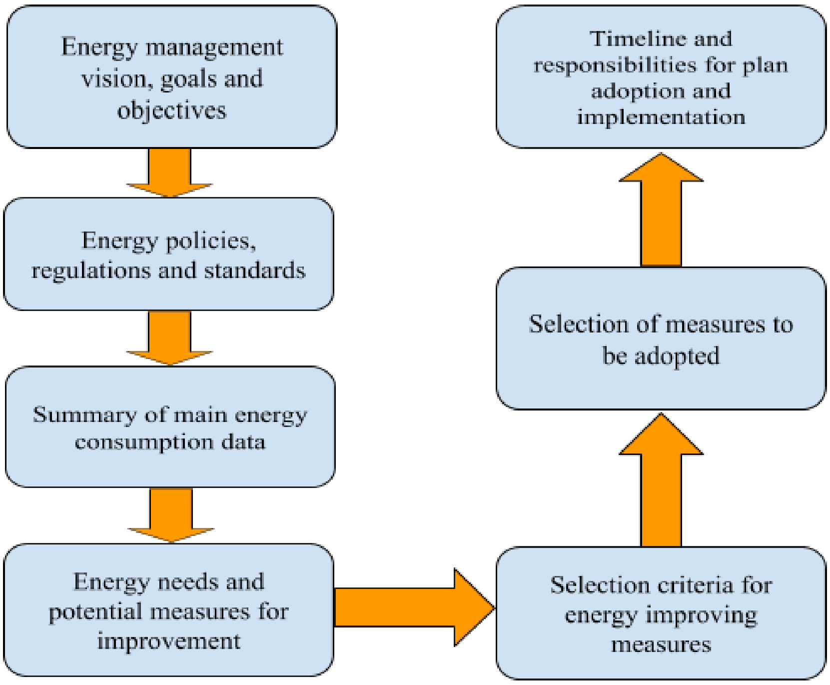
A port energy management plan shall have as part of its energy action plans, mechanisms that provide improvements in the overall energy management. These improvements shall be achieved through increased employee awareness in the efficient utilisation of energy throughout the port's operations, procurement of energy efficient equipment, compliance with international and national regulations and guidelines and aligning the energy management program towards the above objectives.

### 4.2.9 Structure of a Port Energy Management Plan

As a follow-up to top management committing itself to set up an EnMS, it shall clearly outline what its vision, goals, objectives and targets are - all built around the energy pillars of resilience, availability, efficiency, reliability and sustainability. The energy targets shall include a percentage reduction in energy consumption and contribution of renewable energy towards the energy demand of the port. Energy management objectives shall be inclined towards ensuring energy security through strategies like reliability, efficiency, low-cost funding and awareness (Doty & Turner, 2004b).

Since departmental policies like Energy Policy of the port are shadowed by national and municipal energy policies, regulations and standards, these need to be reviewed and understood to put the port’s energy policy in line with such regulations and standards. Figure 11 below shows the structure of a port energy management plan.

*Figure 11. Structure of Port Energy Management Plan*




***Source: Boile et al, 2016***

As earlier highlighted in the energy review, energy types need to be identified, consumption patterns and significant consumers are known to pave the way for identifying the gaps and improvement opportunities. These potential improvement measures are ranked in terms of priority, cost and implementation time frame. With the push for clean energy sources by regulations, renewables may top the list followed by technologies that suit the need of the port, e.g. battery storage systems. Finally, an analysis is done to draw up an implementation timeline and assign roles and responsibilities to energy team members and other concerned parties.

### 4.3 ENERGY DEMAND ASSESSMENT AND INFRASTRUCTURAL NEEDS

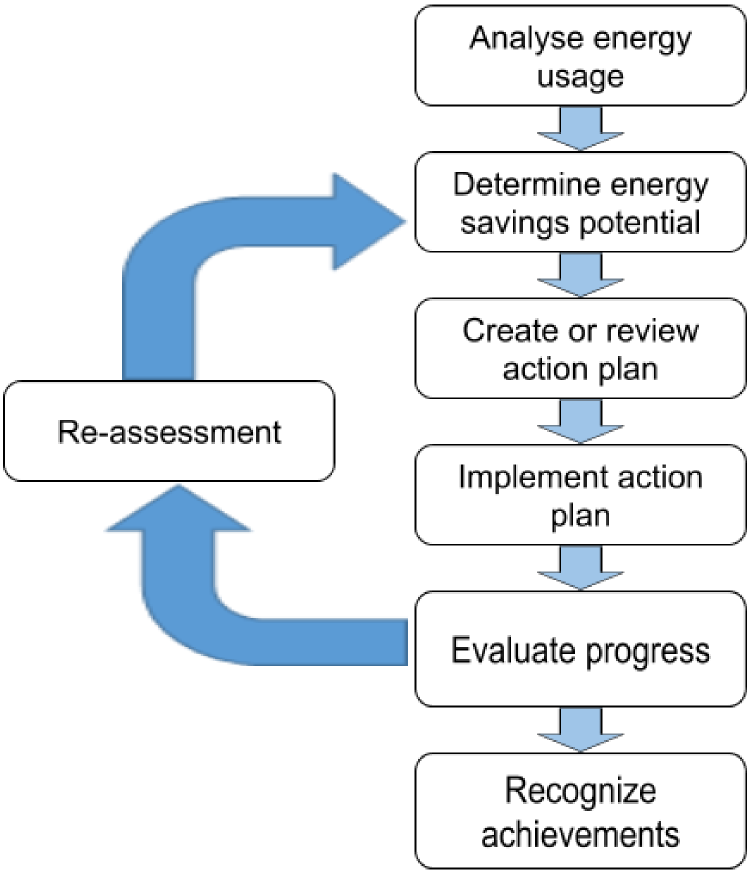
At the end of the planning stage, which lays the foundation for the energy management strategy, the energy needs/requirements of the port shall be assessed to enable management to strategise the needed infrastructure to support this need. These energy needs of the port should be prioritised in terms of direct importance to operations and survival of the port, and the follow-up infrastructural/technological decision should also be based on cost and feasibility of the technology. The result could lead to the development of an Energy Master Plan detailing prioritised infrastructural projects with timelines and funding strategies.

## 4.4 IMPLEMENTATION OF AN ENERGY MANAGEMENT PLAN

Understanding the energy profile of the port facilities and operations is a crucial first step, followed by considering potential energy saving measures while gauging the cost of the various measures. Action plan for implementation of the measures is drawn up, and specific cost-effective measures like replacement of inefficient equipment with energy efficient ones are implemented.

Performance of the new equipment needs to be evaluated against the set performance criteria like low consumption, which is the objective. Continuous evaluation is required to decide whether to continue using the new processes/equipment or not. Finally acknowledging and recognising the achievements in consumption and cost reductions is a morale booster to the equipment/plant operators as well as management. Figure 12 below illustrates the above processes.

*Figure 12. Steps in the Implementation of an Energy Management Plan*




***Source: Author***

For effective implementation of an energy management plan, the following action shall be performed: - action plans implementation, employee involvement, communication strategy (internal and external), documentation of energy activities and managing those records, operational energy performance control, innovative design, construction and renovation of facilities, equipment, system and processes and procurement of energy efficient equipment.

Management commitment and awareness through investments in energy efficient equipment and new technology is a prerequisite for the proper functioning of an energy management program. Awareness programs for the employees shall include information about the energy policy, procedures and legal requirements while also providing competence training for technicians through exposing them to objectives and targets of the EnMS, technical manuals, energy flow and consumption records, regulatory documents, architectural drawings and designs and internal and external communications to handle the installation, operation and maintenance of facilities. The EnMS activities shall be adequately and effectively documented and stored both in hard and soft copies for ease of reference, controlled, reviewed and updated periodically.

For achievement of the EnMS objectives and targets, operational controls shall be instituted in the form of setting criteria for effective operation and maintenance of equipment and processes and communicating them to all employees. Operational instructions and manuals shall be developed and discussed with the energy team members and employees for their inputs to produce a final document for equipment operators. The Energy Manager and the team shall devise a clear communication strategy to coordinate the activities with the employees internally and also transmit the messages to other external stakeholders and suggestions/feedbacks solicited from the employees and stakeholders for a better system.

The results of the energy review shall be considered in the design of new, modified, and renovated facilities, equipment, systems and processes of specific projects and activities. Energy saving shall be incorporated at all levels of design and procurement of energy services/equipment. Proper scheduling of usage and switching off of machines shall also be considered.

### 4.4.1 Implement efficiency measures and increase reliability

Direct operational cost reduction measures resulting from reducing the energy demand through the adoption of energy efficiency measures like LED fittings on the high mast lights should be given priority consideration. Shifting some loads to lesser peak hours and proper sequencing of utilisation of machinery and the use of motion and occupancy sensors in offices to switch off lights when facilities are not occupied can save cost considerably.

Using reliable and adequate cogeneration from renewable sources can enhance the security and reliability of energy sources and supply which directly assures the port of uninterrupted operations, thus increasing the performance and competitiveness of the port.

## 4.5 MONITORING AND TRACKING ENERGY PERFORMANCE

Energy consumption should be measured and compared with set management goals/targets and other relevant standards and regulations (Visvikis & Panayides, 2017). These measurements shall be guided by the use of relevant EnPIs and shall be reviewed periodically to monitor the progress of performance improvements and gauge nonconformities (Bunse et al, 2011). Through monitoring and progress reviews, cost savings can be verified and also advances made in improving environmental profiles. Strict measuring and reporting guidelines shall be developed and followed. Use of instruments like data loggers, energy meters and integrated data collection and dissemination software helps in the information gathering process. As part of the monitoring process, energy usage in the port and its facilities, energy cost and an improvement program in processes and equipment to achieve cost savings shall be conducted through an energy audit.

## 4.6 MANAGEMENT REVIEW

In ascertaining the effectiveness of an Energy Management System, periodic review is required to ensure continuous improvement. (Abdelaziz, Saidur, & Mekhilef, 2011). The energy performance indicators (EnPIs), energy saving measures and set targets all need to be reviewed and fine-tuned for better results as per changes in the energy demand of the port (Prashar, 2017). The overall EnMS shall be reviewed by top management to ensure its stability and continued functioning. All the reviews shall be documented and record appropriately kept.

As a result of the management review, some EnPIs may be maintained while others are modified, and the overall energy policy may be updated and realigned with current circumstances.

# Chapter 5

## 5.0 COUNTRY CASE AND ABOUT THE PORT OF BANJUL

### 5.1 COUNTRY ENERGY PROFILE

The Gambia is located along the West Coast of Africa, bounded on three frontiers by Senegal and the fourth - the Atlantic Ocean. It has an estimated population of 2 million, annual GDP of US$ 0.96 billion, GDP growth of 2.2%, land area of 10,689 sq. km stretching 450 km along the Gambia River and is one of the most densely populated countries in Africa (World Bank, 2016). It is the smallest country in mainland Africa, see attached map in figure 13 below.

***Figure 13. Map of The Gambia***


***Source: Google***

The Ministry of Energy is the central government agency overseeing all energy matters in the country. With the small size of the electricity market, there are a few players - the National Water and Electricity Company (NAWEC) is responsible for the generation, transmission and distribution of electricity in The Gambia with few Independent Power Producers (IPP) - GAMWIND (operating a 150 kVA wind turbine), Global Electrical Company (operating a thermal plant) and KARPOWER (operating a shipboard power plant). The Public Utilities Regulatory Authority (PURA), established under the PURA Act, 2001 is the regulatory body for the electricity sector to protect and safeguard the interest of all the stakeholders, notably the consumers as per the Electricity Act, 2005.

The Gambia has a high mixture of energy sources including biomass (i.e. fuelwood, which is abundantly available locally and accounting for about 60% of energy supply, petroleum products (LPG for household cooking) and gasoline, diesel and heavy fuel oil for generating electricity and transportation services, accounting for about 36% and the remaining - renewable energy (solar and wind) (IRENA, 2013). With power generation of only 313 GWh in 2016 (Gambia Bureau of Statistics, 2016) as opposed to a projected demand of 800 GWh by 2020 (IRENA, 2013), Gambia faces serious electricity generation challenges with demand far outweighing the available generating capacity, thus leaving only about 47.757% of the population access to electricity as at 2016 (World Bank, 2018). Currently, the available generation is only 147.9MW and available capacity of 136.4MW, with available imports of about 2MW from neighbouring Senegal (PURA, 2018), as indicated in table 5 below.

*Table 5. State of Electricity Generation in The Gambia*

| | Project | Detail | Installed Capacity MW | Availaible MW | Remarks |
|---|---|---|---|---|---|
| Gen | Brikama G1 | Running | 6.0 | 5.1 | |
| | Brikama G2 | Running | 6.0 | 5.1 | |
| | Brikama G3 | Running | 6.0 | 5.1 | |
| | Brikama G4 | Running | 6.0 | 5.7 | |
| | Brikama G5 (NAWEC) | Running | 6.0 | 5.7 | |
| | Brikama G6 (NAWEC) | Overhaul (Breakdown) | 6.0 | 5.7 | |
| | Brikama G7 | Replacement (GESP) | 6.0 | 5.7 | |
| | *Kotu G1 (LFO)* | Breakdown | 3.0 | 2.1 | |
| | Kotu G3 (WB) | Overhaul (Breakdown) | 3.0 | 2.6 | |
| | Kotu G4 (NAWEC) | Running | 6.0 | 5.5 | |
| | Kotu G6 (NAWEC) | Overhaul (Breakdown) | 6.0 | 5.5 | |
| | Kotu G7 | Running | 6.0 | 5.0 | |
| | Kotu G8 (WB) | Running | 6.0 | 5.7 | |
| | Kotu G9 (NAWEC) | Overhaul | 6.0 | 5.5 | |
| | BADEA OFID 11MW | NEW | 11.0 | 10.5 | commissioing |
| | Wartsila (B2) (WB) | Running | 8.9 | 8.5 | |
| | Brikama 20MW (IDB) | NEW | 20.0 | 19.0 | under construction |
| | Power Rental (Karpower) | Running | 30.0 | 28.5 | IPP |
| | | | | | |
| | | TOTAL MW* | 147.9 | 136.4 | |
| Import | Senegal - Farafenni (30KV) | Running | 10 | 2 | 10MW is the max |
| | Senegal - Amdalai | Running | 10 | 0 | |
| | Senegal - Basse | Import | | 0 | |
| | OMVG | Import | 0 | 0 | |

**Legend: Running Maintenance New/under construction Import**

***Source: PURA (2018)***

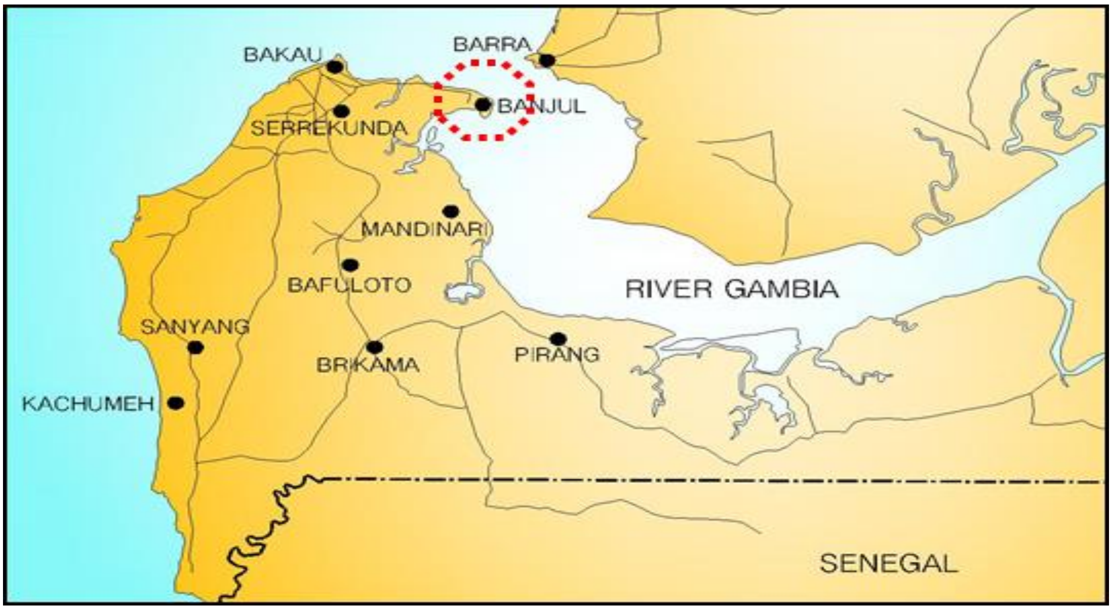
As could be seen from table 5 above, the generation system consists of 17 small generating sets (each 6MW average) installed in various power stations in Kotu and Brikama. The coordination of the operation and maintenance of these many small generators pose a challenge to the utility company, thus the many cascaded tripping effects, improper maintenance, instability and inefficiency of the power system. However, the power rental from KarPower and imports from neighbouring Senegal have alleviated the situation in terms of power availability and reliability, but quality remains a problem.

The Gambia's electricity sector is confronted with challenges of quantity, quality, reliability, high initial capital outlay, long lead times from feasibility studies to project implementation, inadequate funding, low human resource capacities, weak institutional policies, low level of research and governance bureaucracy (Ministry of Energy, 2014). Continued reliance on imported fossil fuels for electricity generation in The Gambia is unsustainable in the long run. There is immense potential for renewable energy use, and this should be harnessed diligently to narrow the gap between supply and demand for electricity to power up the economy, thus facilitating sustainable economic and social development aspirations. Alongside the harnessing of renewable energy, energy efficiency and management measures should be adopted broadly, especially in high energy demanding sectors like the Port of Banjul, to save energy and reduce costs.

## 5.2 PORT OF BANJUL

The Port of Banjul is Gambia’s only port that connects it to international shipping (import/export of seaborne cargo) and was set up by an act of parliament in 1972. It is located on latitude 13.4425° and longitude -16.5765° along the Atlantic Ocean and serves as the country’s logistic hub for seaborne cargo and also engages in transhipment trade to neighbouring countries in West Africa - see figure 14 below. It is administered by the Gambia Ports Authority and is purely state-owned, overseen by the Ministry of Works, Transport and Infrastructure.

*Figure 14. Location of Port of Banjul*

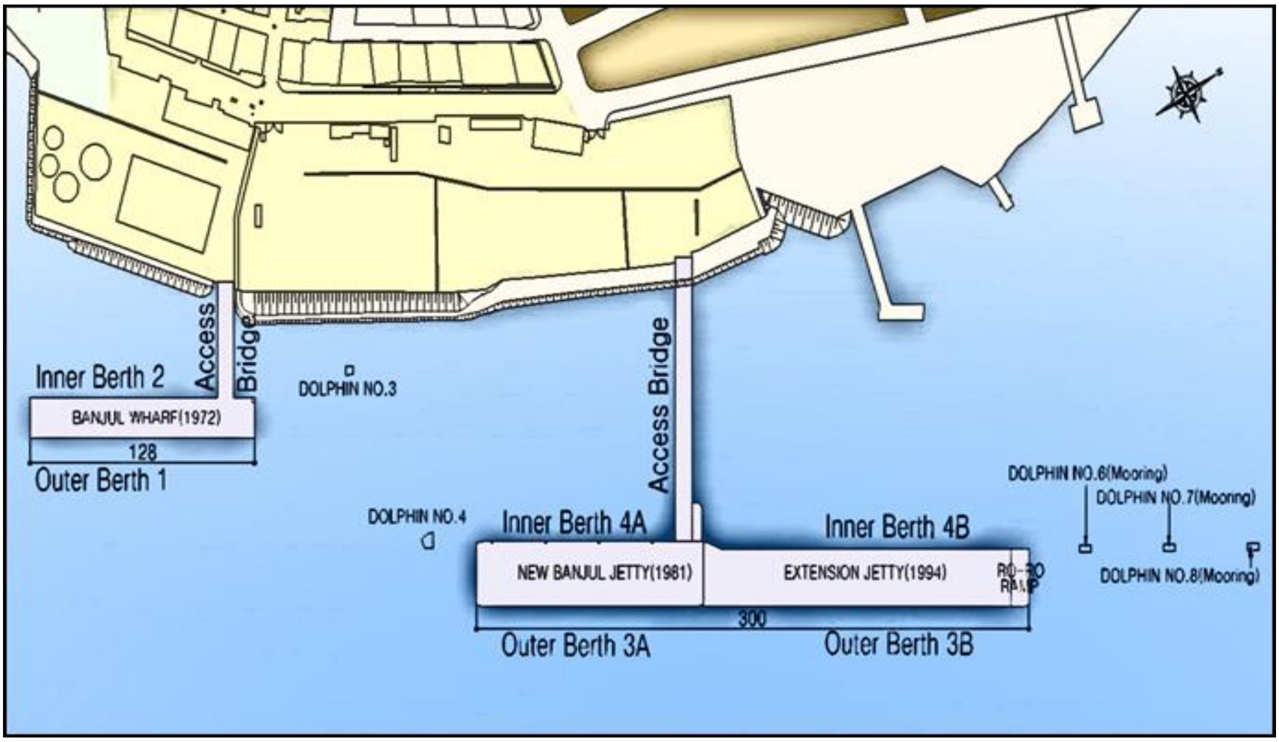



***Source: GPA (2018)***

The Gambia Ports Authority - shortly GPA, has overall responsibility of harbours and rivers, Ferry Services, Banjul Shipyard, Banjul Fisheries Jetty and partly contributes to the functioning of the Gambia Maritime Administration (GMA) who is responsible for ensuring the safety of navigation in Gambian waters (Vrancken & Tsamenyi, 2017). The Port of Banjul is a critical asset that is vital to the national economy, as it is the only international sea connection for the country, receiving goods and fuel. It is of utmost importance that the port has a reliable, secure and resilient supply of electricity to ensure business continuity.

The cargo area of the port is about 69,000$m^2$ comprising North Terminal - 20,000$m^2$, South Terminal - 8,000$m^2$, P.W.D - 19,000$m^2$ and New Container Terminal 22,000$m^2$. As shown in figure 15 below, the GPA utilises two jetties - the Banjul Wharf constructed in 1972 with inner berth of 120m length and 6.0m draught, outer berth of 120m length and 9.0m draught and an access bridge of 45m X 9m equipped with pipelines for liquid bulk, and the new Banjul Jetty constructed in 1981 with extensions to it constructed in 1994 with outer berth of 300m length X 12m draught, inner berth of 120m length X 6m draught and an access bridge of 120m X 9m. The extension is 177m X 25.5m and consists of a RoRo facility equipped with several dolphins.

*Figure 15. Identification of Berths*




***Source: Port of Banjul, 2018***

As a maritime logistics centre, the GPA's core activity is the provision of marine and maritime services ranging from pilotage, maintaining of approach channels in the port area for appropriate water depths, dry docking of small vessels (due to limited capacity of the shipyard), towing, provision and maintenance of navigational aids, stevedoring and handling of vessels and cargo (containerised, general cargo and liquid or dry bulk). The GPA owns and operates all its facilities and works hand-in-hand with various stakeholders including shipping agents, customs and immigration, amongst others in its daily activities. Fig. 16 below shows an aerial view of the port.

*Figure 16. Aerial View of Banjul Port*

***Source: GPA (2018)***

Further to its mandate, the GPA operates a fleet of ferries in the territorial and inland waters of The Gambia through the Ferry Services (as shown in fig. 17 below) at strategic locations linking the northern and southern parts of the country (because the country is divided into north and south along its length by the River Gambia). These ferries equally serve as a vital link for passenger and vehicular movements between the northern and southern regions of neighbouring Senegal.

*Figure 17. Ferry Services in The Gambia*

***Source: GPA (2018)***

The GPA owns a small fleet of tug and pilot boats and alongside the ferries, these vessels need a maintenance and repair yard for their upkeep. The Banjul Shipyard, though with limited capacity, provides these M&R services to the tugs, pilot boats and ferries together with services to fishing vessels and pleasure crafts.

## 5.3 DRIVERS AND BARRIERS TO ENERGY EFFICIENCY IN THE PORT OF BANJUL

Reduction of energy usage, consumption levels and costs can be achieved through developing a sustainable port infrastructure and putting in place a robust and well-functioning energy management system to better handle energy sources, conversion, usage and conservation. The Port of Banjul need to reduce its energy usage, consumption and cost as it grapples with high energy costs and insecurity, thus the need for an EnMS.

With the adoption of energy efficient technologies and effective energy management strategies seen as the most cost-effective way of reducing emissions from port operations and reduction of externality costs to nearby communities, the Port of Banjul is trying to invest in technology and management practices, albeit at a slow pace.

In the face of the above drivers, the Port of Banjul in its pursuit of an ISO 50001: 2011 Energy Management System, faces serious challenges and bottlenecks. There is a general lack of awareness among the employees as well as the top management on energy management and efficiency dynamics, thus the low level of commitment and failure to communicate to the employees the numerous benefits of an EnMS. Changing people’s mindset from the old ways of doing things and making improvements to the status quo is a significant issue. The uncertainty of the benefits of an EnMS leaves management in an indecisive situation. Quite often, lack of resources as well as budgetary constraints makes it difficult for management to invest in new equipment and technologies.

## 5.4 ELECTRICITY PROFILE OF BANJUL PORT

The port has two power sources - NAWEC (11kV/415V/220V) and from two standby diesel generators - 750 kVA (Cummins) and 500 kVA (Caterpillar) respectively, which supplies about 25% of the electricity to the port, with total energy demand of 575.639 kW (about 646.785 kVA) (Banjul Port, 2018). Each of the generators has adequate capacity to handle the peak load of the port.

Energy use in the Port of Banjul is projected to increase considerably in the next decade due to expansion projects and modernisation activities of port operations through introduction of electric cranes and automation of some aspects of the port’s operations as a result of an anticipated increase in throughput. In light of the above, the existing port infrastructure, operation and energy use need to be redesigned and cost-effective energy management measures that meet the port’s energy resiliency, reliability and sustainability should be implemented.

## 5.5 PORT ENERGY PILLARS

The current energy situation is analysed relative to the five port energy pillars - resiliency, availability, reliability, efficiency and sustainability, which shall form the basis of energy management evaluations. The Port of Banjul is expected to be able to maintain the smooth running of port businesses during power outages from the national supplier (which is very common). The port's resiliency regarding the ability to maintain business continuity with proper backup power sources during power outages currently faces challenges. Even though standby diesel generators are in place, frequent breakdowns, lack of proper maintenance and spare parts makes them unavailable for service when they are needed.

With continued reliance on the national supplier for present (575 kW) and future (excess of 700 kW) demands for the port's operations and cognizant of the inability of NAWEC to meet national power needs, due to limited generation, transmission and distribution capacities (currently 147 MW nationally) (PURA, 2018), the continuous availability of power in the port is a matter of uncertainty.

Occasional fluctuations in system voltages due to ageing control equipment and transformers and physical disturbances to the transmission and distribution infrastructure affect power quality and reliability. Severe disruptions are occasionally experienced due to voltage instabilities. Reduction of energy demand and maximising profits through reduced energy costs as a result of management practices and technology is currently not widely practised in the Port of Banjul because there is no formal Energy Management System. Therefore, unnecessary energy use resulting in unnecessary operational costs and undue stress on the electric system is what presently exists.

From the foregoing, the port currently lacks a sustainable energy policy. There is greater need to harness the potentials in renewable energy, thereby reducing the complete reliance on fossil fuel generation as well as instilling sustainability in the energy system.

# Chapter 6

## 6.0 CASE STUDY FOR THE ESTABLISHMENT OF AN ENERGY MANAGEMENT SYSTEM IN THE PORT OF BANJUL

### 6.1 ANALYSIS

The analysis involves critically looking at the status quo of the energy management situation of the Port of Banjul and map out improvement measures and analysing what benefits the port can gain by adopting an EnMS modelled on the ISO 50001:2011 guidelines. Currently there is no formal energy management system in the Port of Banjul and equally no well-functioning Environmental Management System (EMS). The analysis in table 6 below depicts the situation from policy, operational, technological and institutional points of view.

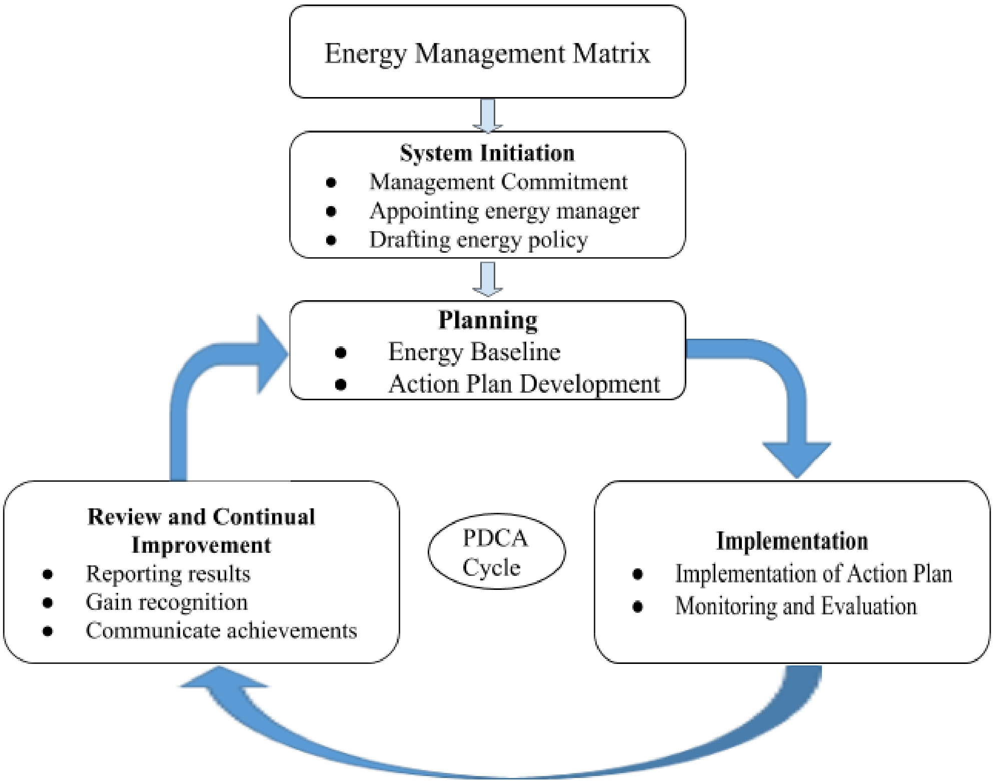
*Table 6. Analysis of the Policy, Operational, Technological and Institutional Situation of the Port of Banjul Regarding Energy and Environmental Management*

| Area | Aspect | Situation | Analysis |
|---|---|---|---|
| Policy | Departmental Energy Policy | No formal energy policy | • With a well-structured and functioning energy policy, energy issues can be on a sound footing |
| | National Energy Policy | Existing but not quite specific on port energy issues | • Could have been more specific and give room for more interaction between port and city on energy and environmental issues |
| | ISO 14001: 2015 - Environmental Management System | At its infancy with slow progress towards real implementation | • Effective implementation could provide a better environmental protection system<br>• Could level the ground for adoption and implementation of an energy management system |
| | ISO 50001: 2011. Energy Management System | No formal EnMS - energy issues handled by the Estate and Civil Engineering Department | • Could provide a better system of energy supply, use and consumption<br>• Could provide cost reduction through efficient use of energy<br>• Reduce emissions<br>• Paves a way of conforming to some environmental and energy regulations. |
| Operation | Monitoring of electricity consumption | Inadequate monitoring of consumption and usage of electricity within the port. There is no sub-metering, the port is billed from only two energy meters | • Proper monitoring using data loggers and Supervisory Control and Data Acquisition (SCADA) system can provide real-time data and information for decision making<br>• Sub-metering can help to properly and independently monitor the consumption of various functional areas in the port and give signal to which areas need close monitoring and attention |
| | Monitoring and measuring emission levels | There is no current pollution and emission measuring mechanism | • This could provide the platform for the port to gauge the impacts of its operations on the environment<br>• Use of low sulphur fuels in the port and immediate surroundings can be enforced |
| Technologies | State of the art technology | Highly sophisticated cargo handling equipment are not used in the Port of Banjul.<br>Most of the cargo handling equipment are diesel driven | • Use of electric cranes and other cargo handling equipment can increase the port throughput through high rate of movement of cargo and can also minimise pollution<br>• Use of low sulphur generators in the port can also minimise emissions of SOx and NOx and PM |
| Institutional | Capacity levels | Inadequate capacities to implement energy and environmental management systems.<br>Employee awareness on energy savings and environmental protection is low.<br>Weak legal and regulatory frameworks | • Capacity building is in progress and will subsequently generate a pool of qualified people who can champion the establishment of an energy and environmental management programmes.<br>• Proper legal and regulatory set up is required to give legal backing to the energy and environmental initiatives of the port. |

***Source: Author***

The establishment of a Port Energy Management System in Banjul Port will require a new energy vision from management with objectives, commitment and responsibility towards an efficient and environmentally friendly energy utilisation. Key issues to consider are shown in figure 18 below.

***Figure 18. Elements of Energy Management System***




***Source: Dušan et al, 2010***

From the figure above, the establishment of an energy management system (EnMS) requires a set of well-planned processes, procedures and mechanisms aimed at reducing an institution's energy costs and increase productivity. The process starts with the energy management matrix, followed by an initiation stage where top management shows its commitment by first adopting an Energy Policy and appointing an Energy Manager to oversee the energy management program. Energy action plans shall be developed following baseline studies, and these plans are then implemented, monitored, evaluated and finally reviewed to ensure continual improvement.

Critical elements at the inception have to be assessed which include energy policy, management commitment, awareness and staff motivation, monitoring and reporting system, training, outreach and investment. The energy situation of Banjul Port vis-a-vis the above elements are highlighted in the Energy Management Matrix (Table 7) and the summary below.

***Table 7. Energy Management Matrix - Port of Banjul***

| Level | Energy Management Policy | Organization | Staff Motivation | Tracking, Reporting and Monitoring | Staff Awareness Promotion and Training | Investment by Management |
|---|---|---|---|---|---|---|
| 4 | Formal Energy Management Policy with management backing as part of corporate energy reduction strategy | Clear delegation of responsibilities | Establishment of communication channels by energy Manager and unit representatives | Consumption targets set, implementation tracked and savings monitored | Promotion of energy management within the organisation | Substantial investment in energy saving schemes and upgrading of facilities |
| 3 | Energy Management strategy from Estate Department but no management policy | Identification of representatives in all consumption centers | Representatives engage consumers and users | Energy Manager gathers reports from various units | Awareness creation and training | Appraisal of energy saving measures |
| 2 | The Deputy Director - Estate and Civil Engineering issues memos on energy issues | Electrical Manager acting as Energy Manager | Contacts with end users through memos after consulting the Deputy Director | Monitors energy use and report to Deputy Director | Start some staff training on energy efficiency and management | Short term investments by management |
| 1 | Electrical Manager oversees electrical energy issues | Informal end user contacts | Reporting energy bills as cost data | Compiles information for internal estate department use | Informal contacts to instil responsible energy consumption | Very low investment |
| 0 | No formal EMS | No end user contact | No communication | No tracking and/or monitoring | No energy efficiency promotion | Minute investment in energy efficiency |

***Source: Author***

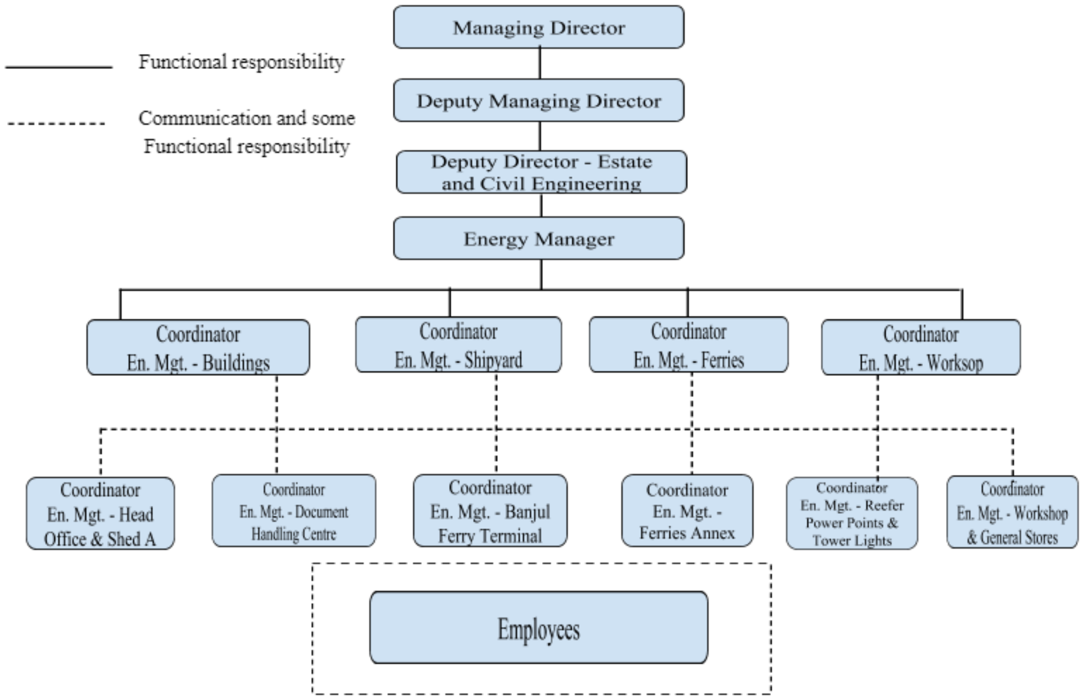
The energy management matrix above shows the correlation between different levels of energy management and lines of actions in managing the energy activities in Banjul Port. It shows insights into the current state of non-availability of a formal energy management system and moving towards development of a functional system. It shows that the drafting of a formal Energy Policy, the appointment of an Energy Manager, raising the level of awareness of employees and investments are key to a successful EnMS. Below is a summary of events: -

a. There is no formal EnMS in the Port of Banjul, the responsibility of electrical issues is with the Estate and Civil Engineering Department.
b. In the absence of a formal EnMS, there is no Energy Manager, the Electrical Manager performs the role of Energy Manager and is answerable to the Deputy Director - Estate and Civil Engineering.
c. No formal energy efficiency forums.
d. Monitoring electricity use and consumption is done by the Electrical Manager and assistants while the mechanical department takes care of fuel consumption of the backup generators.
e. Informal sensitisation contacts are used by the Electrical Manager and team to talk to employees about responsible energy consumption and related issues.
f. The absence of a formal EMS in the port leads to low investment in energy management measures. These are mostly funded as part of the civil engineering department's annual budget.

## 6.2 ENERGY MANAGEMENT SYSTEM INITIATION

As earlier highlighted, management's commitment through the allocation of resources, the appointment of an energy manager and assigning roles and responsibilities to the energy team members are necessary prerequisites. Figure 19 shows a proposed EnMS organizational structure for the Port of Banjul where the position of energy manager is high in the hierarchy as he/she shall have the functional responsibility of supervising the energy management program and report regularly to top management. Energy coordinators shall have direct contact with employees in each functional unit and disseminate relevant energy information to them.

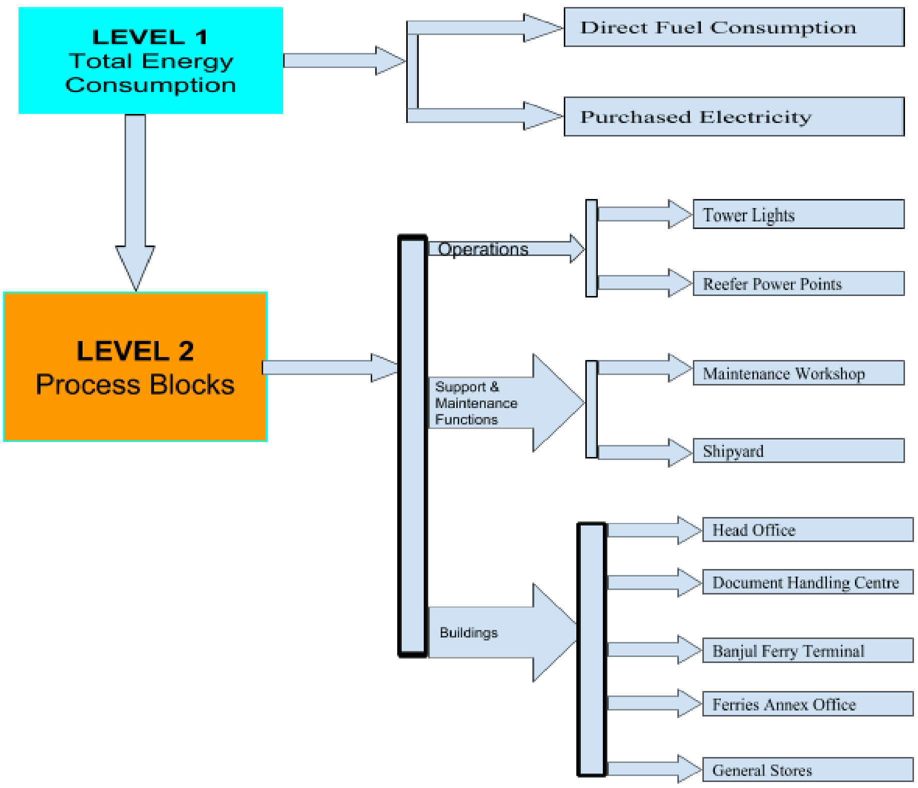
*Figure 19. Proposed EnMS Organizational Structure for the Port of Banjul*




***Source: Author***

As part of the inception activities, a comprehensive energy review of critical functional areas of the port has been conducted to map out an energy baseline, as shown in figure 20 below.

*Figure 20. Energy Mapping and Consumption Assessment Methodology for the Port of Banjul*




***Source: Author***

As per the above figure, the electrical needs of the buildings and facilities were reviewed for meeting planning requirements for energy projects. The electrical loading profile was assessed to determine the necessity for cable resizing and replacement and a detailed mapping of the port's energy consumption in the form of direct fuel consumption of the backup generators and electricity costs from the national utility supplier was carried out. The layout of the electrical system of the port shall be developed for ease of reference and problem solving (as illustrated in Appendix 1) and Appendix 2 shows the electrical distribution layout of the Port of Banjul. All the above information shall be properly documented.

Table 8. below shows the approximate consumption of each of the two generators as well as the translated cost (based on the current market price of diesel).

***Table 8. Consumption of Diesel Generators and Associated Costs***

| Generator | Capacity | Consumption | Total diesel cost @US$1.06/litre |
|---|---|---|---|
| Caterpillar | 500 kVA | 100.0 ltrs/hr | US$106.0/hr |
| Cummins | 750 kVA | 120.0 ltrs/hr | US$127.2/hr |
| **TOTAL** | **1250 kVA** | **220 ltrs/hr** | **US$233.2/hr** |

***Source: GPA (2018)***

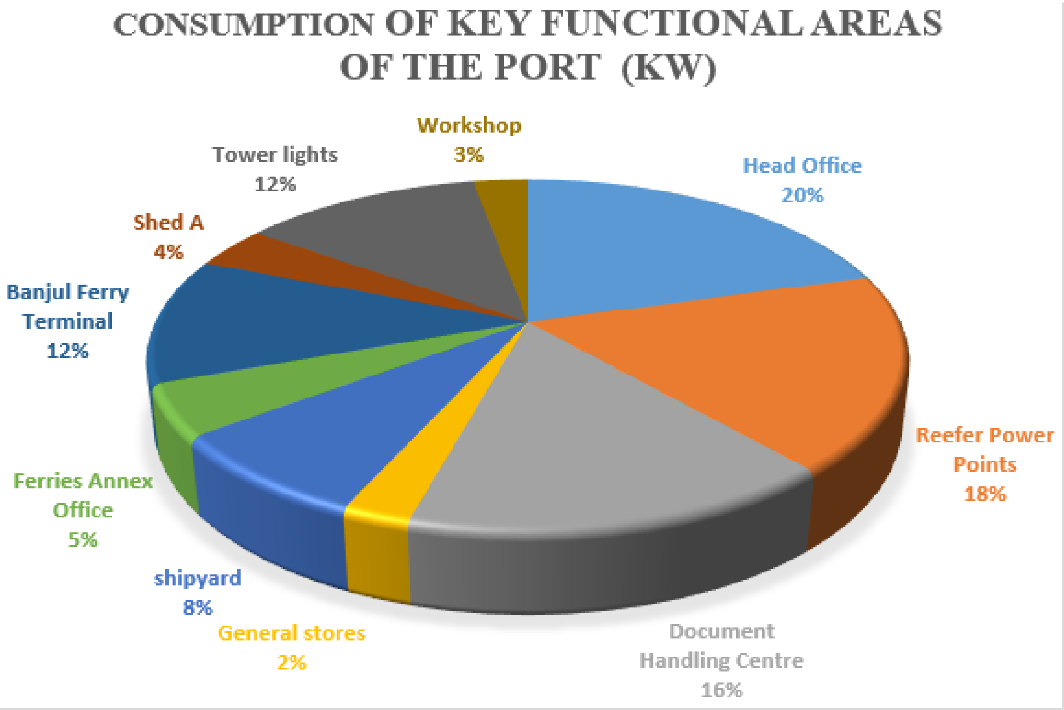
The generators supply about 25% of the port's electricity need. From the cost figures above, running one generator even for about 4 hours a day costs over US$500/hr. The situation is compounded by the fact that the diesel is imported and prices hinge on fluctuations in the world market. Innovative energy solutions and alternate energy could be more cost-effective. Table 9 below and figure 21 also shows the consumption of critical functional areas of the port and its corresponding percentage breakdown.

*Table 9. Segmented Electricity Consumption in GPA*

| Average consumption by different areas of the port as at 30th June 2018 | | | | |
|---|---|---|---|---|
| **No.** | **Consumption Centre** | **Apparent Power (VA)** | **Real Power Consumption (kW)** | **Remarks** |
| 1 | Head Office | 113370 | 119.055 | Air Conditioning accounts for 60% of consumption |
| 2 | Reefer Power Points | 117600 | 104.664 | Compressors for the reefer containers |
| 3 | Document Handling Centre | 101920 | 90.7088 | Lighting system |
| 4 | General Stores | 16170 | 13.3913 | Lighting system |
| 5 | Shipyard | 47485 | 46.2617 | Inefficient machinery accounts for the high consumption |
| 6 | Ferries Annex Office | 30870 | 27.4743 | A/Cs are the major consumers |
| 7 | Banjul Ferry Terminal | 75605 | 67.2885 | A/Cs the biggest consumers |
| 8 | Shed A | 25235 | 22.4592 | HPS lighting system is the major consumer |
| 9 | Tower lights | 80000 | 71.2 | HPS lights the major consumers |
| 10 | Workshop | 18130 | 16.1357 | Compressor machines account for the bulk of the consumption |
| **TOTAL** | | | **575.639 kW** | |

***Source: Port of Banjul, 2018***

*Figure 21. Chart showing percentage electricity consumption of key functional areas in the port*




***Source: GPA, 2018***

As indicated in table 9 above, critical functional areas of the port were sampled for their energy consumption and analysis revealed that the head office bears the highest percentage of consumption (20%), followed by the reefer power points (18%) while the general stores recorded the lowest (2%). A large number of stand-alone air conditioning units in the head office was identified as the most significant contributor to the high consumption (accounting for about 60%) and similar trends exist in other buildings in the port as cooling requirements are high in a tropical climate.

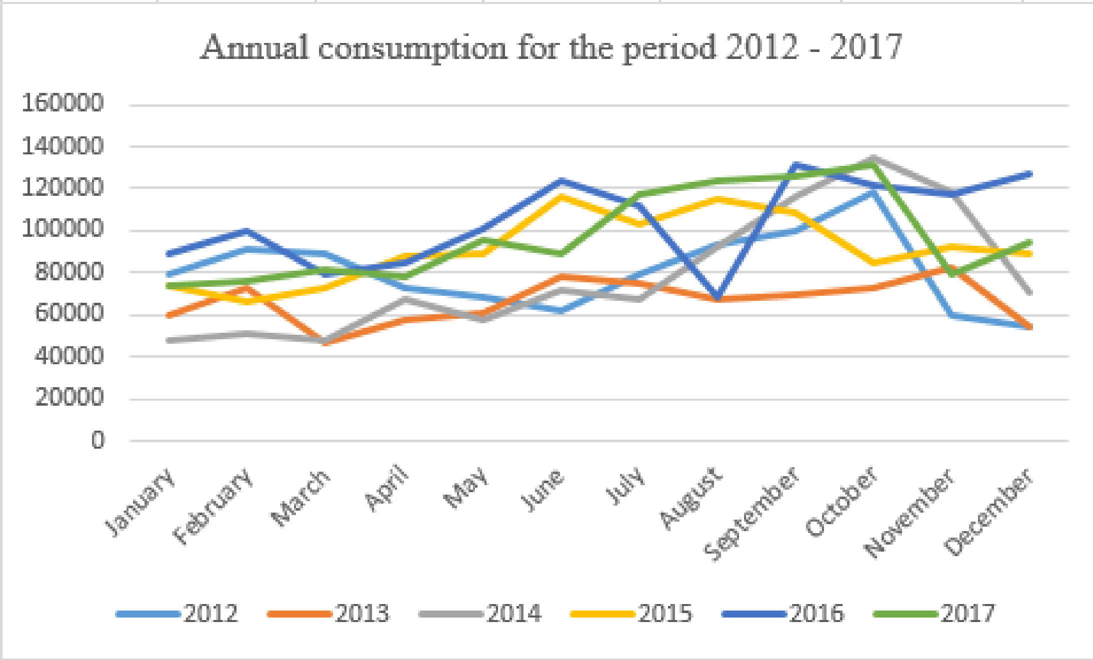
The use of very inefficient and relatively old machinery in the Shipyard serves as a burden on the electrical system. The use of high-pressure sodium lights for the high mast lights is also a concern as their electric consumption, and failure rates of the bulbs are high. Inefficient electrical cabling and switch gears also account for significant system losses and are at times the culprits for blackouts. Table 10 shows the consumption between the periods 2012 - 2017.

***Table 10. Electricity Consumption (kWh) and Costs (US$) Between The Period 2012 – 2017***

| MONTH/YEAR | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total consumption for the period 2012 - 2017 | Total cost @ 0.233 US$/kWh |
|---|---|---|---|---|---|---|---|---|
| January | 79124 | 60010 | 47960 | 73570 | 89510 | 74500 | 424674 | 98949.042 |
| February | 91270 | 72480 | 50710 | 66850 | 99432 | 75660 | 456402 | 106341.666 |
| March | 89325 | 47100 | 47790 | 72490 | 79455 | 81390 | 417550 | 97289.15 |
| April | 73000 | 58220 | 67050 | 87620 | 84590 | 78190 | 448670 | 104540.11 |
| May | 68850 | 61500 | 58210 | 89570 | 100530 | 95325 | 473985 | 110438.505 |
| June | 61950 | 78240 | 72230 | 115780 | 123950 | 89640 | 541790 | 126237.07 |
| July | 79540 | 74520 | 67970 | 103030 | 111560 | 117160 | 553780 | 129030.74 |
| August | 93350 | 67380 | 92900 | 114950 | 68260 | 123750 | 560590 | 130617.47 |
| September | 100250 | 69650 | 116020 | 108570 | 130930 | 125900 | 651320 | 151757.56 |
| October | 118900 | 72850 | 134140 | 85040 | 121567 | 130930 | 663427 | 154578.491 |
| November | 59520 | 82440 | 118870 | 92570 | 116940 | 79100 | 549440 | 128019.52 |
| December | 54860 | 54370 | 70290 | 89150 | 126700 | 94500 | 489870 | 114139.71 |
| | | | | | | | | |
| **TOTAL** | **969939** | **798760** | **944140** | **1099190** | **1253424** | **1166045** | **6231498** | **US$ 1 451 939.034** |
| | | | | | | | | |
| **Current elecrtricity tariff** | | **0.233** | **US$/kWh** | | | | | |

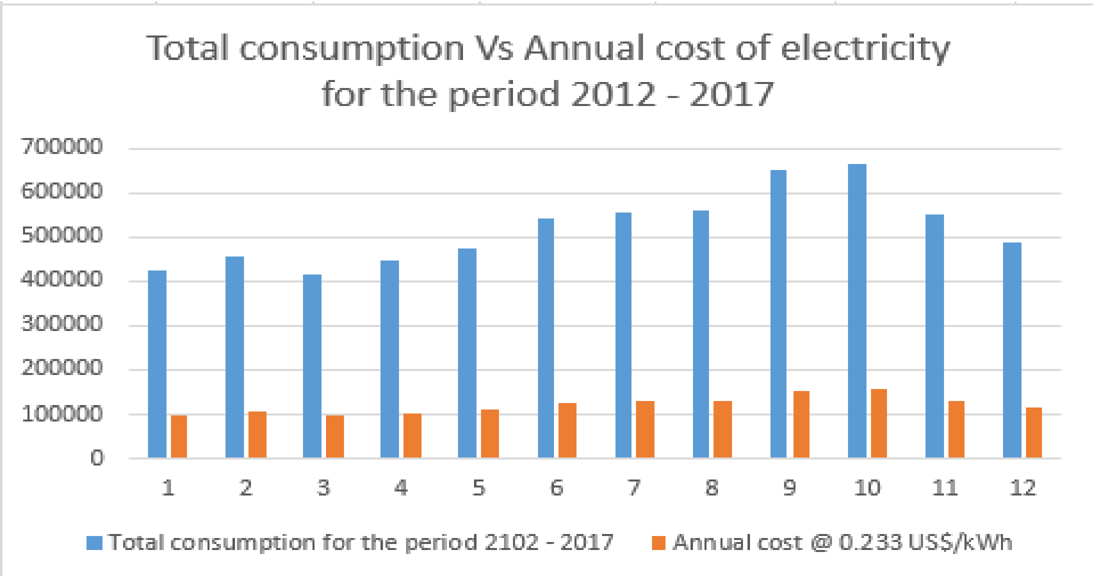
***Source: GPA (2018)***

*Figure 22. Graphical representation of the consumption (kWh) between the period 2012 - 2017*




***Source: GPA (2018)***

*Figure 23. Total Consumption (kWh) Vs Annual Cost ($/kWh) of electricity for the period 2012 - 2017*




***Source: GPA (2018)***

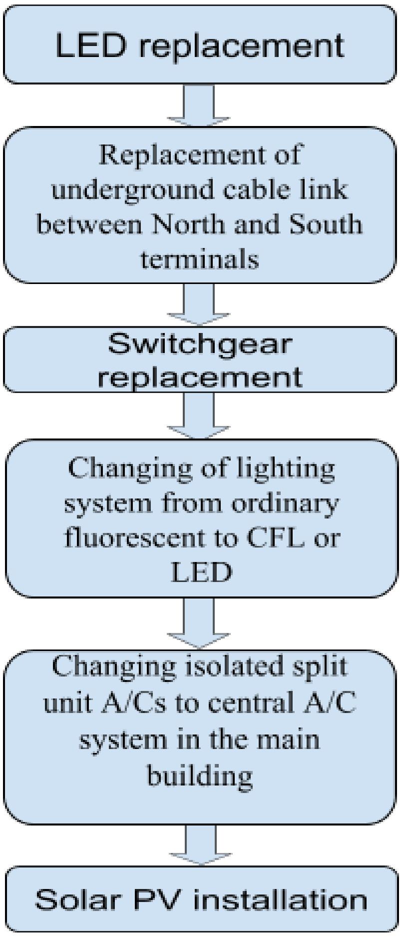
It could be observed from table 10 and figures 21 and 22 that electricity consumption and cost has increased by 16.81% for the period under review with peak consumption realised between June to November (fig. 23) when peak temperatures are realised. The increased consumption from 2015 is attributed to yard expansions and additional office buildings, with the inauguration of an extended portion of the container terminal in 2016 where additional power points and lighting facilities were provided. Uncontrolled and undesirable usage and consumption behaviours are also identified as a contributor to the increment.

With the Port of Banjul responsible for the management and terminal operations of the port and been the principal investor in port expansions and infrastructure, its actions in performing its mandate has a direct impact on energy use and consumption and environmental performance. Consumption and cost figures reveal a deficiency in the management of energy consumption and the overall energy chain requires more improvement.

## 6.3 ACTION PLAN DEVELOPMENT

Following the energy review, areas that require improvement are being identified, costed and prioritised. Top of the priorities was the replacement of the high-pressure sodium lights with LED and the replacement of the underground cable link between North and South terminals (see appendix 3). This shall be followed by replacing the switch gears (see appendix 4). Furthermore, it has been highlighted that the lighting system should all be changed from ordinary fluorescent to CFL or LED and also the main administrative building should be fitted with a central air conditioning system (even though the initial investment is high). The action plan also includes the introduction of renewable energy sources like roof-top solar PV for sections of the port to solely provide power for some of the facilities. Figure 24 below shows the flow chart of the intended action plan.

*Figure 24. Flow Chart of the Action Plan*




***Source: Author***

## 6.4 IMPLEMENTATION, MONITORING AND EVALUATION

The Electrical Manager in overseeing the implementation of the action plans draws up the implementation budget and ask for funding from management. Low-cost projects like replacing the HPS lights with LED is being financed by the port as highlighted hereunder. The proposal and costing for replacing the switchgear (appendix 3) and the North-South terminals underground cable link (appendix 4) have also been put to management for consideration. Proper monitoring of the project implementation considering the performance indicators like kWh consumption and savings

(US$/kWh) to rate success or otherwise is an important step. Successes or failures shall be evaluated to determine the rate or level, and these should all be adequately documented and reported.

### 6.4.1 LED Lighting Program

In ensuring all-around smooth cargo handling in the port, high mast lighting is a critical element, and this has been manifested in the Port of Banjul. As seen in the chart in fig. 20 above, the high mast lights consume about 12% of the electricity of the port. Currently, there are about 44 towers (with 4 lights on each tower) using 1500W High-Pressure Sodium (HPS) lights. The Port of Banjul is currently embarking on replacing these HPS with 600W LED lights, specially adapted for port environment.

Associated benefits of using the LED include longer lifespans (approximately 10 - 15 years), high energy savings - up to about 60%, as shown in Box 1 below, reasonable payback periods, faster to full illumination, reduced maintenance costs, increased light quality, high durability (resistant to adverse weather conditions), emits less heat and can be easily used with motion sensors. Box 1 below shows the calculation justifying the LED program.

*Box 1. Calculation Justifying Investment in LED High Mast Lighting*

**Present High Pressure Sodium (HPS) lamps**
No. of high masts = 44
No. of lights on each mast = 4
Total lights = 176
No. of hours of lighting per day = 12
Energy consumption per hour per bulb = 1500Wh
Emission factor = 0.713 $tCO_2/yr$ (with reference to The Gambia's electricity generation) (UNFCCC, 2015)

**LED alternative**
Energy consumption per hour per LED bulb = 600Wh
Price of one LED bulb = US$2023.5
Price per kWh of electricity supply = US$0.233
Lifetime of LED bulb = 50,000 hrs, approx. 11.4 years (with daily operation of 12 hrs)

**Economics of replacement**

**Energy savings per hour**
Energy savings per hour = No. of masts * bulbs per mast * (kW by HPS bulb - kW by LED bulb) * one hour
= 44*4*(1.5-0.6) *1
**= 158.4 kWh**

**Energy cost saving per hour**
Energy cost savings per hour = energy savings per hour * cost of electricity ($/kWh)
= 158.4 * 0.233
**= US$ 36.9072**

**Lifetime savings**
Lifetime savings = savings per hour * Lifetime - Investment cost
= savings per hour * lifetime - No. of masts * bulbs per mast * cost per LED bulb
= 36.9072*50000 – 44*4*2023.5
= 1845360-356136
**=US$ 1 489 224.00**

**Savings per year**
Savings per year = lifetime savings/lifetime (years)
= 1489224/11.4
**= US$ 130 633.6842**

**Return on investment**
Return on investment = investment cost/savings per year
= (44*4*2023.5)/130633.6842
= **2.7262 years**

**Reduction in $CO_2$ emission per year**
Reduction in $CO_2$ emission per year = (emission factor) * savings in MW per hour * working hour per year
= 0.713*44*4*(1.5-0.6)/1000*12*365
**= 494.6737 $tCO_2$/year**

***Source: Author***

It could be deduced from above that switching from High-Pressure Sodium (HPS) to LED high mast lighting could lead to annual savings of US$130 633.6842 in electricity cost, which is as a result of cuts in consumption levels of about 60%. The investment could be recouped in just under 3 years, with a $CO_2$ footprint improvement of 494.6737 $tCO_2$/year. The adoption of LED is both economically and environmentally beneficial. The envisaged cost and environmental savings potentials from the LED program shall be communicated to top management and employees to gain more appreciation for energy efficiency and management measures and expand the program to other areas of the port. The results of the evaluation shall serve as a springboard for further review and improvements and can be communicated to external partners. This can make the port serve as an energy management promoter to other institutions.

# Chapter 7

## 7.0 CONCLUSION AND RECOMMENDATION

### 7.1 CONCLUSION

This dissertation examined the adoption of a Port Energy Management Plan for the Port of Banjul. An analysis was conducted on the current energy (electrical) situation in the Port of Banjul from all aspects - management commitment and policy, regulatory and institutional framework, awareness and capacity levels of employees likewise technical and operational measures. From the analysis, effective technical and operational measures, bounded by equally effective legal and institutional frameworks are required for the Port of Banjul to improve its energy performance, efficiency, security, use and consumption. An ISO 50001:2011 led PEMP for Port of Banjul could provide the port with opportunities of savings in energy use, consumption and emission, boost overall productivity and competitiveness, increase awareness of energy use and consumption among its employees, improves the “green” image of the port and reinforces compliance with regulations.

For the port to meet its energy targets and ensure continuous improvement, management should show commitment through developing a clear energy policy, effective regulations, institutional, technical and operational measures and a well-informed employee. To this end, an EnMS structure was proposed for Banjul Port in which the position of the Energy Manager is high in the hierarchy to oversee the energy management program. Energy coordinators at facility and unit levels and their interactions with employees at the energy end use levels was also highlighted.

Adherence to international instruments and national laws governing port environment and related energy issues need to be safeguarded to enable the Port of Banjul succeed in its energy sector improvements. Regulatory oversight from national regulators - PURA and NEA need to be beefed up but this is currently beset with capacity deficiencies. It has been observed that management of the energy resources is mostly limited to endeavours in energy services (electricity) provision (with shortage from the national grid a common occurrence) but far from efficiency and conservation measures. With increasing environmental pressures and the need to enhance the competitiveness of the port, energy efficiency and management measures in the port's operations and supply chain can provide some possible strategic improvements. The port's energy review reveals insecurity of the system because there are considerable gaps in the reliability, efficiency, availability, sustainability and resiliency of energy services and these need to be filled through innovative energy vision and strategy.

The environmental management system in the Port of Banjul is at its infancy and should be nurtured well to lay the foundation for a robust environmental protection system. Capacity challenges are besetting the progress so far as the organisational structure, mandate and resources are unprepared to support the development of an effective and functioning environmental and energy management initiatives. With the Port of Banjul embarking on replacing 176 units of 1500W HPS high mast lights with 600W LED lights, as shown in Box 1 above, it is envisaged that it will accrue an hourly consumption savings of about 60% and annual energy cost savings of about US$130 633.6842 with considerable improvements in $CO_2$ footprint. In the face of high initial capital outlay, the management of the Port of Banjul was somehow cagey in investing in the project, but the enormous economic, technical and environmental benefits laid a solid case in support of the investment. Lack of awareness and budgetary constraints hamper energy management and efficiency measures and investments in renewables. Facilities need to be modernised to bring them in tune with current prevailing situations in port business, as shown in the case studied ports.

The Port of Banjul stands to improve its energy performance, lower costs and enhance its energy security while overcoming technological, human, economic and institutional barriers if it diligently pursues a broad PEMP. Furthermore, the port stands to be an energy efficiency and management promoter to other institutions if it can consolidate the envisaged cost and $CO_2$ savings from its endeavours.

This dissertation contributes to assisting the Port of Banjul to adopt an EnMS based on ISO 50001:2011 guidelines to better manage its energy system through energy efficiency and management practices. Further investigation is required in energy management in ports, especially African Ports as there are so many grey areas worth highlighting. Properly investigating and documenting the inherent benefits obtained from various Port Energy Management models and practices would be an excellent contribution to the research in this area. The environmental and energy infrastructure and the general port development policies require thorough insight to instil better and effective measures.

## 7.2 RECOMMENDATIONS

As a cornerstone to this study, the Port of Banjul shall be encouraged to undertake proactive measures to tackle its energy challenges, reduce costs, enhance competitiveness and meet its overall climate change mitigation goals of reducing energy-related greenhouse gas emissions. Among the measures that can be undertaken is the adoption of a Port Energy Management Plan (guided by ISO 50001:2011 standards). This shall be manifested in a systematic and proper management commitment, capacity building and awareness creation among its employees, proper monitoring, analysis, auditing and reporting of energy use and consumption, economically and technically feasible technologies deployment, as well as creating an effective energy materials/services procurement strategy and better building and facility designs to improve their energy performance.

It is recommended that the Port of Banjul should consider reforming its environmental programs to align them with international standards like the ISO 14001, which could pave a way for the smooth adoption of the ISO 50001:2011 backed Port Energy Management Plan. Similar to the earlier mentioned ports, Banjul Port is also located close to the city and is a high energy consumer too. It should therefore, work closely with the city of Banjul in its energy planning and environmental issues so that efforts can take a collective approach.

With electricity supplies from NAWEC to the Port of Banjul accounted for through only two energy meters, the lack of a proper monitoring system for critical functional areas leaves the direct identification of high end-consumers an impossibility and discrepancies in the energy bills cannot be easily spotted. To this end, sub-meters and real-time monitoring equipment like power loggers should be installed on the feeder lines of critical functional areas to enable provision of accurate data for comparison with the energy bill and to guide further decision making on improvement measures.

It is further recommended that the port look beyond conventional fossil fuel generation of electricity and actively consider substantial investments in renewable energy - notably solar PV as co-generation mechanisms. This could help to instil reliability, efficiency, availability, resiliency and sustainability in its electrical energy supplies. The utilisation of technology in the form of occupancy sensors in office buildings and facilities could seriously cut down energy wastage thereby reducing consumption. The fuel efficiency of the standby generators should be ascertained to avoid unnecessary fuel consumption levels, and maintenance schedules followed to put the generators in appreciable working condition.

Training of employees in energy-related areas can close the capacity gaps for future implementation of a functional EnMS. The Port of Banjul further needs to consider demand-side management of its electricity. With annual demand of 3.11MWh/year and expected to increase in the years ahead, the port need to embark on promotion of energy saving measures through effective and broad sensitisation of its employees and port users, while inviting opinions and ideas on improvement mechanisms because "every little effort counts" towards lowering of energy consumption, cost and environmental protection.

## References


Abdelaziz, E. A., Saidur, R., & Mekhilef, S. (2011). A review of energy saving strategies in industrial sector. *Renewable and Sustainable Energy Reviews, 15*(1), 150-168.

Acciaro et al (2013). The energy efficiency gap in maritime transport. *Journal of Shipping and Ocean Engineering 3 (2013) 1-10*

Acciaro, M. (2015). Corporate responsibility and value creation in the port sector. *International Journal of Logistics Research and Applications, 18*(3), 291-311.

Acciaro, M., Ghiara, H., & Cusano, M. I. (2014). Energy management in seaports: A new role for port authorities. *Energy Policy, 71*, 4-12.

Adams et al (2009). Environmental issues in port competitiveness. *Dalhousie University,*

Akgul, B. (2017). Green port/eco port project - applications and procedures in turkey. *IOP Conference Series: Earth and Environmental Science, 95*, 42063. doi:10.1088/1755-1315/95/4/042063

Backlund et al (2012). Extending the energy efficiency gap. *Energy Policy, 51,* 392-396.

Ballini, F., & Bozzo, R. (2015). Air pollution from ships in ports: The socio-economic benefit of cold-ironing technology. *Research in Transportation Business & Management, 17*, 92-98.

Ballini, & Ölçer. (2018). *Trends and challenges in Maritime Energy Management* (1st ed. 2018 ed.). DE: Springer International Publishing.

Benacchio et al (2001). (2001). On the economic impact of ports: Local vs. national costs and benefits. Paper presented at the *Forum of Shipping and Logistics, Special Interest Group on Maritime Transport and Ports International Workshop,* 8-10.

Boile, M., Theofanis, S., Sdoukopoulos, E., & Plytas, N. (2016). Developing a port energy management plan: Issues, challenges, and prospects. *Transportation Research Record: Journal of the Transportation Research Board,* (2549), 19-28.

Bunse et al (2011). Integrating energy efficiency performance in production management – gap analysis between industrial needs and scientific literature. *Journal of Cleaner Production, 19*(6), 667-679. doi:10.1016/j.jclepro.2010.11.011

Burns & McDonnell Engineering Company, Inc. (2014). *Energy Management Action Plan - Port of Los Angeles.* Los Angeles, CA:

Capehart et al (2008). *Guide to Energy Management;* (Sixth ed.). Lilburn, GA 30047: Fairmont Press, Inc.

Carbon Trust. (2010). Energy Management: A comprehensive guide to controlling energy use.

da Graça Carvalho, M. (2012). EU energy and climate change strategy. *Energy, 40* (1), 19-22.

Daamen, T. A., & Vries, I. (2013). Governing the European port–city interface: Institutional impacts on spatial projects between city and port. *Journal of Transport Geography*, *27,* 4-13.

Degens, S. (2008). *Sustainable Port Development: A practitioner's perspective.*

Delponte, I., Pittaluga, I., & Schenone, C. (2017). Monitoring and evaluation of sustainable energy action plan: Practice and perspective. *Energy Policy, 100*, 9-17.

Dooms, M., & Verbeke, A. (2007). Stakeholder management in ports: A conceptual framework integrating insights from research in strategy, corporate social responsibility and port management. Paper presented at the *IAME 2007 Annual Conference,*

Doty, S., & Turner, W. C. (2004). *Energy management handbook* CRC Press.

ECOWAS. (2013). *ECOWAS Energy Efficiency Policy*

ESPO. (2017). *Sustainability report, 2017.* ESPO.

Directives, (2014). Retrieved from http://www.oxfordreference.com/view/10.1093/acref/9780199976720.001.0001/acref-9780199976720-e-528

EU. (2016). Evaluation for the review of directive 2012/27/EU on energy efficiency. *Environmental Law Review, 16*(2), 87-90. doi:10.1350/enlr.2014.16.2.207

Fawkes, S. (2013a). *Energy Efficiency: The definitive guide to the cheapest, cleanest, fastest source of energy*. Farnham, Surrey: Routledge. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=nlebk&AN=637167&site=eds-live&scope=site&custid=ns056238

Fawkes, S. (2013b). *Energy Efficiency: The definitive guide to the cheapest, cleanest, fastest source of energy*. Farnham, Surrey: Routledge. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=nlebk&AN=637167&site=eds-live&scope=site&custid=ns056238

GPA. (2013). *Gambia Ports Authority, 2013 Accounts*

GPA (2018). Electricity consumption and cost

Hossain, M. T. (2018). Assessment of sustainability initiatives in port operations: An overview of global and Canadian ports.

IMO. (2014). Third IMO GHG Study, 2014. London. Retrieved from http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx

IMO. (2015). *Emission Control Based Energy Efficiency Measures in Ship Operations; International Maritime Organization (IMO) London, UK.* Retrieved from www.imo.org

IPCC. (2014). Impacts, adaptation, and vulnerability. part B: Regional aspects. contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. *Cambridge University Press, Cambridge, United Kingdom and New York,*

IRENA. (2013). *Renewable readiness assessment - Gambia.*

ISO. (2011). ISO 50001:2011 *Energy Management Systems–Requirements with Guidance for use.*

ISO. (2018). *ISO 50001:2018 Energy Management System.*

Johnson, H., & Andersson, K. (2016). Barriers to energy efficiency in shipping. *WMU Journal of Maritime Affairs, 15*(1), 79-96. doi:10.1007/s13437-014-0071-z

Karim, M. S. (2015). *Prevention of pollution of the marine environment from vessels: The potential and limits of the international maritime organisation*. Cham: Springer International Publishing. doi:10.1007/978-3-319-10608-3 Retrieved from http://hdl.handle.net/2078/ebook:63848

Kitada, M., & Ölçer, A. (2015). Managing people and technology: The challenges in CSR and energy efficient shipping. *Research in Transportation Business & Management, 17*, 36-40. doi: 10.1016/j.rtbm.2015.10.002

Lam, J. S. L., & Notteboom, T. (2014). *The greening of ports: A comparison of port management tools used by leading ports in Asia and Europe*. Great Britain: Taylor & Francis. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=edsbl&AN=RN350825069&site=eds-live&scope=site&custid=ns056238

Lee, C. K. M., & Lam, J. S. L. (2012). Managing reverse logistics to enhance sustainability of industrial marketing. *Industrial Marketing Management, 41*(4), 589-598.

Li, J., Liu, X., & Jiang, B. (2011). An exploratory study on low-carbon ports development strategy in China. *The Asian Journal of Shipping and Logistics, 27*(1), 91-111. doi:10.1016/S2092-5212(11)80004-0

Ministry of Energy. (2014). *Energy Policy (2014 – 2018).*

Ng et al (2013). Climate change and the adaptation strategies of ports: The Australian experiences. *Research in Transportation Business & Management, 8*, 186-194. doi:10.1016/j.rtbm.2013.05.005

OECD. (2011). *Environmental impacts of international shipping the role of ports: The role of ports* OECD Publishing.

OECD/IEA. (2010). Energy efficiency governance. Retrieved from http://energieclimat.hypotheses.org/764

Ölçer et al (2017). *Shipping operations management*. Cham: Springer. doi:10.1007/978-3-319-62365-8 Retrieved from https://ebookcentral.proquest.com/lib/[SITE_ID]/detail.action? docID=5098691

OPEC. (2017). *World oil outlook 2040.* Vienna: OPEC.

Parise et al (2016). Wise port and business energy management: Port facilities, electrical power distribution. *IEEE Transactions on Industry Applications, 52*(1), 18-24. doi:10.1109/TIA.2015.2461176

Pavlic et al (2014). Sustainable port infrastructure, practical implementation of the green port concept. *Thermal Science, 18*(3), 935-948. doi:10.2298/TSCI1403935P

Perez-Labajos, C., & Blanco, B. (2004). Competitive policies for commercial seaports in the EU. *Marine Policy, 28*(6), 553-556. doi: 10.1016/j.marpol.2004.05.003

Prashar, A. (2017). Adopting PDCA (plan-do-check-act) cycle for energy optimization in energy-intensive SMEs. *Journal of Cleaner Production, 145,* 277-293. doi: 10.1016/j.jclepro.2017.01.068

Thollander, P., Danestig, M., & Rohdin, P. (2007). Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs. *Energy Policy, 35*(11), 5774-5783.

Thollander, P., & Ottosson, M. (2010). Energy management practices in Swedish energy-intensive industries. *Journal of Cleaner Production, 18*(12), 1125-1133.

US - EPA. (2017). *Shore power technology assessment at U.S. ports.*

Visvikis, I. D., & Panayides, P. M. (2017). *Shipping operations management*. Cham: Springer. doi:10.1007/978-3-319-62365-8 Retrieved from https://ebookcentral.proquest.com/lib/[SITE_ID]/detail. action? docID=5098691

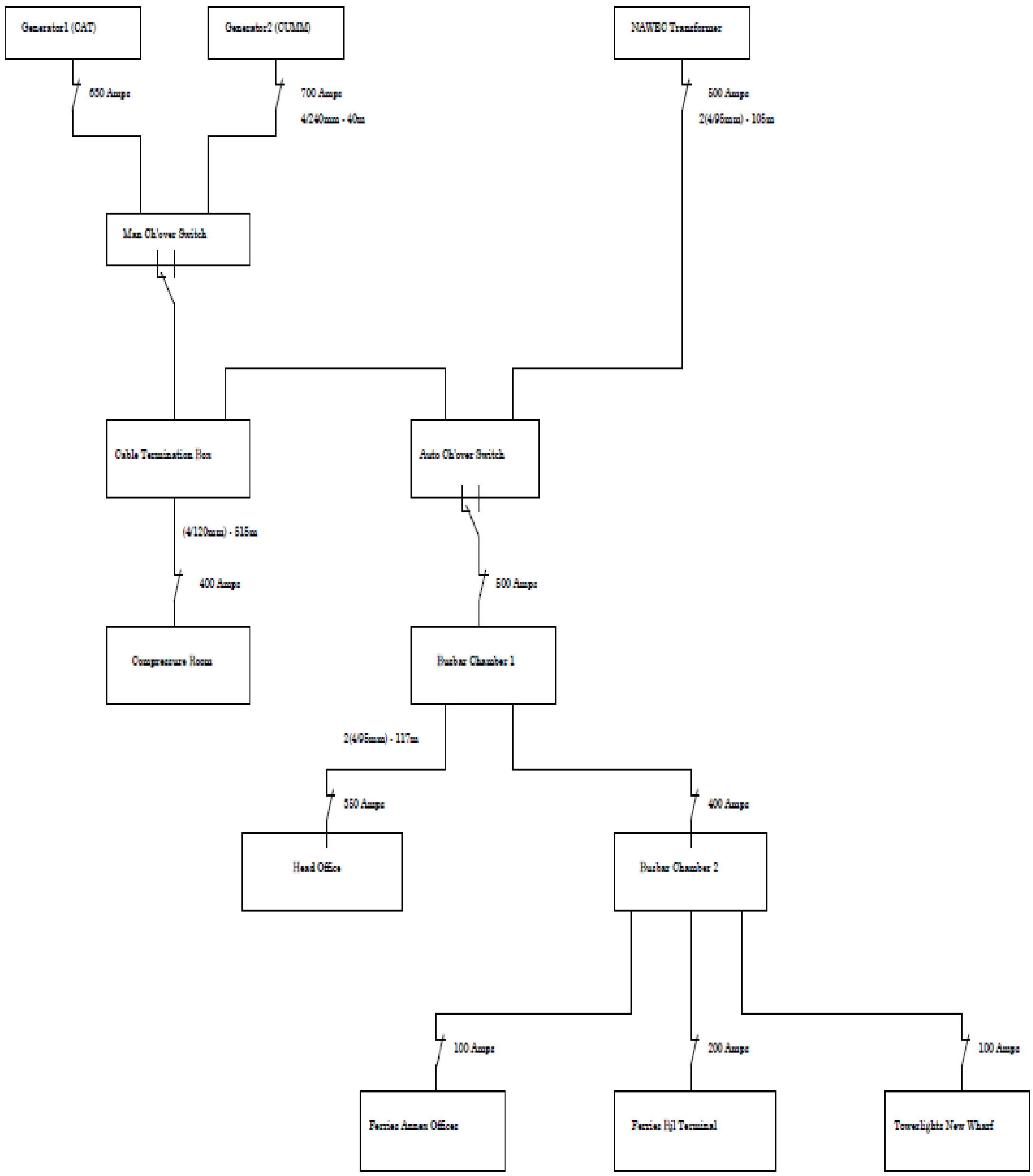
Vrancken, P. H. G., & Tsamenyi, M. (2017). *The law of the Sea: The African Union and its member states* Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=cat03608a&AN=WMU.79782&site=eds-live&scope=site&custid=ns056238

WHO. (2016). WHO releases country estimates on air pollution exposure and health impact. *World Health Organization: Geneva, Switzerland,*

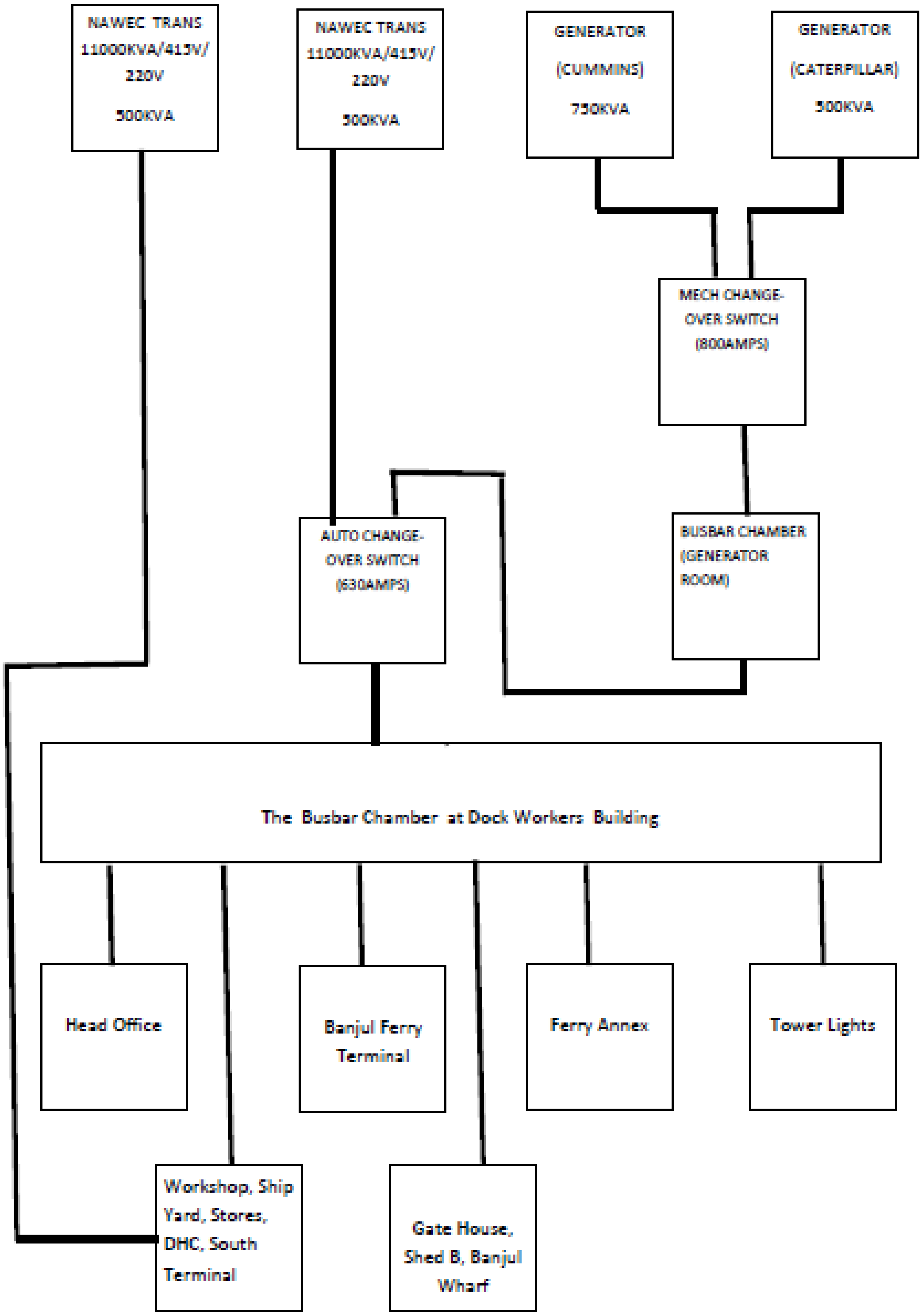
Wilmsmeier et al (2014). Energy consumption and efficiency: Emerging challenges from reefer trade in South American container terminals.

Wilmsmeier, G., & Spengler, T. (2016). Energy consumption and container terminal efficiency.

## Appendix 1. Electrical layout of the Port of Banjul



## Appendix 2. Port of Banjul Electrical Distribution Layout



**Appendix 3. Cable link for South/North Terminal of Banjul Port**

Gambia Ports Authority
MEMORANDUM

| | |
|---|---|
| TO: | **DTS Thru DDECE** |
| FROM: | **Elect Manager** |
| DATE: | May 14, 2018 |
| CC: | SCEM |
| SUBJECT: | **CABLE LINK FOR NORTH/SOUTH TERMINALS OF THE GPA** |

Please in a bid to trigger implementation of the budgetary provision for the cable link between the two subject terminals, I here submit specifications for subject cable.

In terms of **procurement** of the cable and the works to **lay/install** it, I would like to submit two proposals to Authority for approval. Management can tender for contract both processes – the **procurement** aspect and the **laying/installation** or In-house both.

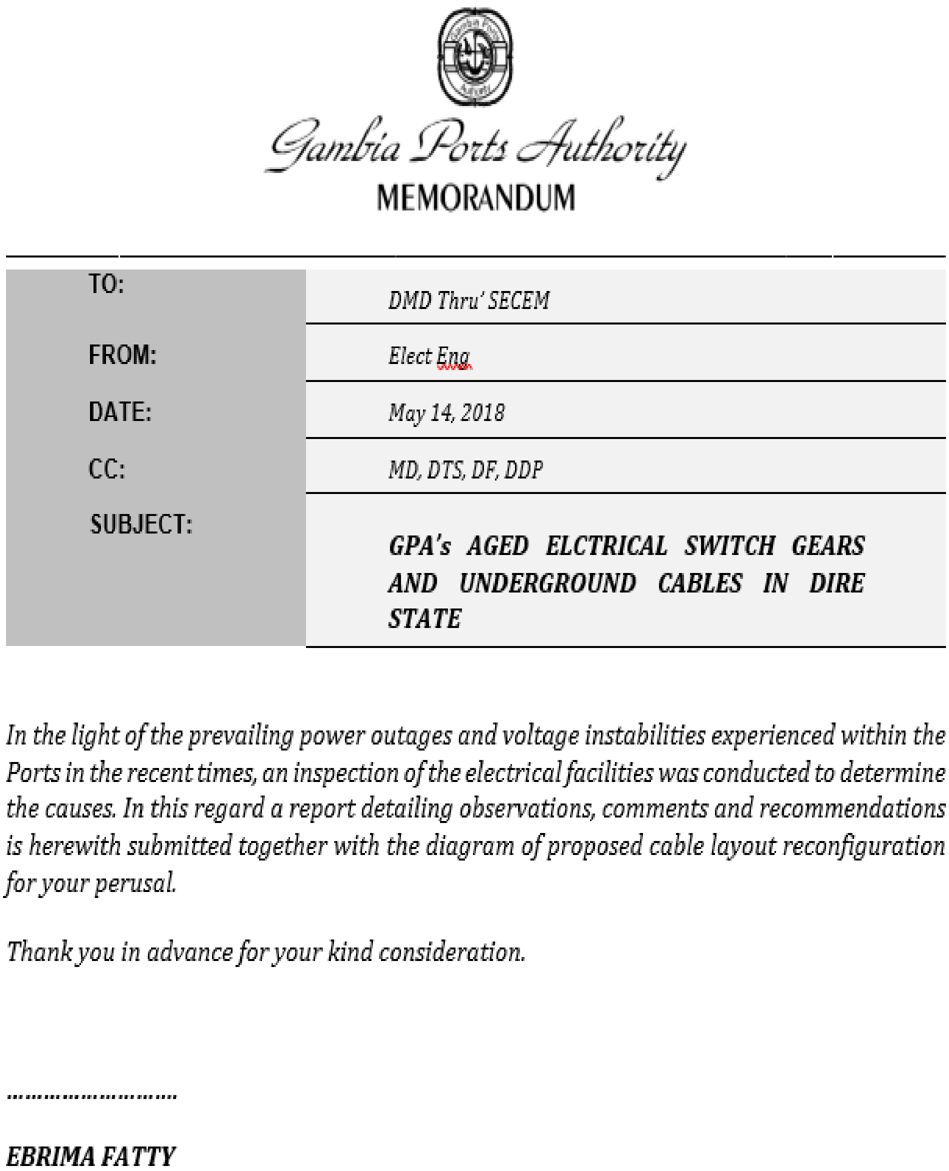
If management should decide on the latter (In-House), Estate is assuring management that they have the capacity to do the job to perfection.

However, in case management decides to contract the said processes terms of references for the works is here attached to this memo.

Thank you.

…………………
EBRIMA FATTY

## Appendix 4. GPA's aged electrical switch gears



Gambia Ports Authority

MEMORANDUM

| | |
|---|---|
| TO: | *DMD Thru' SECEM* |
| FROM: | *Elect Eng* |
| DATE: | *May 14, 2018* |
| CC: | *MD, DTS, DF, DDP* |
| SUBJECT: | ***GPA's AGED ELCTRICAL SWITCH GEARS AND UNDERGROUND CABLES IN DIRE STATE*** |

*In the light of the prevailing power outages and voltage instabilities experienced within the Ports in the recent times, an inspection of the electrical facilities was conducted to determine the causes. In this regard a report detailing observations, comments and recommendations is herewith submitted together with the diagram of proposed cable layout reconfiguration for your perusal.*

*Thank you in advance for your kind consideration.*

………………………

***EBRIMA FATTY***