



**DURBAN CONTAINER TERMINAL ROLE IN ACHIEVING NATIONAL
DEVELOPMENT PLAN GOALS ON SUSTAINABLE DEVELOPMENT**

BY

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DECLARATION

This dissertation, except where indicated in the text, is the candidate's own work and has not been submitted in part or in whole to any other University or University of Technology.

This research was conducted at the Durban University of Technology under the supervision of Professor Dhiren Allopi.

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ABSTRACT

Durban Container Terminal (DCT) operations contribute significantly to emission release. DCT operations directly threaten sustainable development and South Africa's Sustainable National Development Plan (NDP) goals. Sustainable port development aims to create scenarios for "Ports of the Future" that are green, sustainable and have minimal or no impact on the environment.

The problem statement is defined as DCT's role in failure to achieve sustainable development targets set by the NDP and the United Nations (UN). The current DCT operation setup promotes an increase in cargo handling coupled with numerous socio-economic activities, which is a constant source of increasing pressure on the limited natural resources and a continuous threat to sustainable development in the Durban areas. The aim and objectives are to investigate and explore the reasons why DCT fails to achieve sustainable development goals set up by the NDP and the UN. The quantitative research method helped to answer questions on relationships within measurable variables to explain, predict, and control a phenomenon concerning sustainable development goals for the container terminal.

The findings presented challenges and a threat to DCT if the current position concerning service requirements, costs and demands for sustainability is not addressed. The literature, studies and engineering reports illustrate the available technologies that respond to sustainable development requirements. The theory supports the critical role played by the dry port, terminal layout, and operating system in mitigating emissions release during operations. The engineering and DCT electricity consumption annual reports confirm the high consumption of energy during operations. The results from the port equipment, infrastructure, road and rail integration, and dry port explain why DCT fails to achieve the sustainable development goals set by the NDP and the UN.

DCT depends on the main grid energy supply originating from fossil energy sources. This has led to 58 967tCO₂e for DCT operation from equipment and electrical infrastructure. The poor rail conditions have increased temporary speed restrictions

(TSRs). The lack of investment in the rail infrastructure, rail maintenance, and TSR takes away the opportunity to have a dry port and reduces the number of containers travelling by road. The DCT integrated logistics system is missing the possibility of reducing CO₂ emission release by 30 085.4tCO₂e. The simulating model confirmed the dominance of trucks and was followed by port equipment concerning CO₂ release. The results illustrate the impact of the ineffective role of rail freight. It indicates that if the number of wagons is increased, the number of trucks on the road will decrease, resulting in a CO₂ release reduction. The DCT integrated operating model assessment results explain why DCT is not realizing the national development plan's objectives for sustainable development goals.

DCT consumes high amounts of energy and contributes to CO₂ emissions, primarily through road and rail freight. Ineffective operational planning and poor rail conditions significantly impact CO₂ release. The DCT terminal operation itself contributes only 10% of the integrated operation's CO₂ emissions, with road and rail freight releasing 90%. The simulated model highlights the dominance of trucks in CO₂ emissions, followed by port equipment, and poor rail conditions preventing DCT from achieving sustainable development goals. The introduction of a dry port as an intermodal hub could promote economic growth and reduce road congestion and carbon emissions. However, the poor rail conditions make the proposed Cato Ridge/Camperdown dry port unviable. DCT's main challenges in achieving sustainable development goals are categorized into three focus areas: Affordable and Clean Energy, Decent Work and Economic Growth, and Climate Action. This analysis will help provide the best operating and sustainable development scenario for DCT, which could include the introduction of hybrid equipment, energy-saving technology, and improved rail infrastructure. Adopting a reconfigured DCT-integrated operating model is recommended since it has no significant operational changes within the DCT terminal. The reconfigured DCT integrated operations introduce a dry port and a rail infrastructure upgrade to accommodate 150 wagon trains. The reconfigured DCT integrated operating model promotes the reduction of container trucks calling for a DCT terminal, unlocking decent work and economic growth, sustainable cities, and communities within the Midlands region.

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TABLE OF CONTENTS

DECLARATION	II
ABSTRACT	III
ACKNOWLEDGEMENTS	V
TABLE OF CONTENTS	VI
LIST OF TABLES	VIII
LIST OF FIGURES	VIII
LIST OF APPENDICES	VIII
LIST OF ACRONYMS	IX
CHAPTER 1	- 1 -
INTRODUCTION	- 1 -
1.1 BACKGROUND	- 4 -
1.2 PROBLEM STATEMENT	- 6 -
1.3 AIM OF STUDY.....	- 8 -
1.4 RESEARCH OBJECTIVES	- 8 -
1.5 RESEARCH METHODOLOGY	- 9 -
1.6 RESEARCH LIMITATIONS.....	- 11 -
1.7 STUDY CONTEXT OVERVIEW	- 11 -
1.8 OVERVIEW OF CHAPTERS	- 14 -
CHAPTER 2	- 15 -
LITERATURE REVIEW	- 15 -
2.1 SUSTAINABLE DEVELOPMENT.....	- 15 -
2.1.1 <i>Affordable and Clean Energy</i>	- 16 -
2.1.2 <i>Sustainable Cities and Communities</i>	- 17 -
2.1.3 <i>Climate Action</i>	- 19 -
2.1.4 <i>Decent Work and Economic Growth</i>	- 20 -
2.1.5 <i>Industry, Innovation and Infrastructure</i>	- 21 -
2.2 CONTAINER PORT SUSTAINABLE DEVELOPMENT IMPACTS	- 24 -
2.3 CONCLUSION	- 27 -
CHAPTER 3	- 29 -
METHODOLOGY	- 29 -
3.1 DATA COLLECTION.....	- 31 -
3.2 DATA ANALYSIS	- 33 -
3.2.1 <i>Estimation of Energy Consumption</i>	- 33 -
3.2.2 <i>Estimating CO₂ Emissions</i>	- 36 -
3.2.3 <i>Characteristics of Container Terminal Layouts</i>	- 39 -
3.2.4 <i>Characteristics of Dry Ports and Logistics Integration</i>	- 42 -
3.3 SIMULATION DESIGN	- 44 -
3.3.1 <i>Data Simulation Application</i>	- 46 -
3.4 VALIDATION OF OPERATING MODELS.....	- 47 -
3.5 LIMITATIONS	- 48 -
3.6 CONCLUSION	- 50 -
CHAPTER 4	- 51 -

FINDING AND SIMULATION RESULTS	- 51 -
4.1 TERMINAL OVERVIEW	- 52 -
4.1.1 <i>Operations Systems</i>	- 53 -
4.1.2 <i>Fuel Contribution to CO₂ Emission</i>	- 54 -
4.1.3 <i>Electricity Contribution to CO₂ Emission</i>	- 56 -
4.2 ROAD & RAIL INTEGRATION OVERVIEW (INCLUDING DRY PORT)	- 59 -
4.2.1 <i>Train Operation</i>	- 60 -
4.2.2 <i>Train Fuel Contribution to CO₂ Emission</i>	- 63 -
4.2.3 <i>Trucks Operation</i>	- 64 -
4.2.4 <i>Trucks Fuel Contribution to CO₂ Emission</i>	- 65 -
4.3 CURRENT CARBON EMISSION PROFILE	- 67 -
4.4 SUSTAINABLE DEVELOPMENT SCENARIO SIMULATION	- 68 -
4.4.1 <i>Full Hybrid Equipment</i>	- 70 -
4.4.2 <i>Indirect Operation with Hybrid Haulers</i>	- 72 -
4.4.3 <i>Direct Operation with Green Zone and Hybrid Haulers</i>	- 74 -
4.5 OPERATING SIMULATION MODEL	- 75 -
4.5.1 <i>Simulation Result</i>	- 77 -
4.5.2 <i>Scenario One</i>	- 78 -
4.5.3 <i>Scenario Two</i>	- 80 -
4.5.4 <i>Scenario Three</i>	- 81 -
4.6 CONCLUSION	- 83 -
4.6.1 <i>Overview Results</i>	- 84 -
4.6.2 <i>Simulation Results</i>	- 87 -
CHAPTER 5	- 89 -
RECOMMENDATION	- 89 -
5.1 DRY PORT PRIVATE PARTNERSHIP	- 90 -
5.2 RAIL UPGRADE PRIVATE PARTNERSHIP	- 90 -
5.3 INVESTING IN RENEWABLE ENERGY TECHNOLOGIES	- 91 -
5.4 RAIL NETWORK AGENCY	- 91 -
REFERENCE	- 92 -
LIST OF APPENDICES	- 98 -

LIST OF TABLES

Table 3.1: Emission factors	- 39 -
Table 4.1: Terminal equipment emission release based on fuel.....	- 54 -
Table 4.2: Container train wagon emission release based on fuel	- 64 -
Table 4.3: Container truck emission release-based fuel	- 65 -
Table 4.4: Hybrid equipment consumption impact	- 69 -
Table 4.5: Electricity consumption adjustment.....	- 70 -
Table 4.6: Scenario one estimated capital investment summary	- 79 -
Table 4.7: Scenario three estimated capital investment summary.....	- 83 -

LIST OF FIGURES

Figure 3.1: Port operational process.....	- 33 -
Figure 3.2: DCT Operational layout.....	- 41 -
Figure 3.3: Function of port-integrated logistics system	- 42 -
Figure 4.1: Port operational process.....	- 53 -
Figure 4.2: Straddle carrier operating system.....	- 53 -
Figure 4.3: Port equipment fuel consumption	- 55 -
Figure 4.4: Peak shaving method	- 56 -
Figure 4.5: Port equipment and operation electricity consumption.....	- 59 -
Figure 4.6: eThekwin Metro transportation and logistics routes.....	- 61 -
Figure 4.7: DCT Port capacity utilisation and Rail handling capacity utilisation.....	- 62 -
Figure 4.8: DCT Integrated operation CO ₂ emissions profile	- 68 -
Figure 4.9: Direct operation layout	- 71 -
Figure 4.10: Indirect operation layout	- 73 -
Figure 4.11: Direct operation, with green zone layout	- 74 -
Figure 4.12: DCT integrated operation proposed model	- 76 -
Figure 4.13: CO ₂ contribution summary and Scenario summary results	- 77 -
Figure 4.14: Scenario one CO ₂ summary and Scenario one CO ₂ reduction results.....	- 78 -
Figure 4.15: Scenario two CO ₂ summary and Scenario two CO ₂ reduction results.....	- 80 -
Figure 4.16: Scenario two CO ₂ summary and Scenario two CO ₂ reduction results.....	- 81 -
Figure 4.17: Scenario CO ₂ summary comparison	- 87 -

LIST OF APPENDICES

Appendix 1: Transported containerised cargo.....	- 98 -
Appendix 2: DCT 3 Years Diesel Consumption	- 102 -
Appendix 3: DCT 3 Years Electricity Consumption	- 103 -
Appendix 4: Summary Truck Visit for 2020/21 Financial Year	- 104 -
Appendix 5: Truck Visit for 2020/21 Financial Year	- 105 -
Appendix 6: Weekly Truck and Trains Visits 2022.....	- 141 -
Appendix 7: Simulation Model Results	- 142 -

LIST OF ACRONYMS

COVID 19	- Coronavirus Disease 2019
CO ₂	- Carbon Dioxide
DCT	- Durban Container Terminal
EMS	- Energy Management System
ESS	- Energy-recovery and Storage Systems
FC	- Fuel Consumption
GCETNP	- Group Chief Executive Talent Naturing Programme
GW	- Gigawatt
IMO	- International Maritime Organisation
ITF	- International Transport Forum
IPCC	- Intergovernmental Panel on Climate Change
KG	- Kilogram
KM	- Kilometre
KWH	- Kilowatt Hours
L	- Litre
LED	- Light-Emitting Diode
Mt	- Million Ton
NatCor	- Natal Corridor
NDP	- National Development Plan
OWE	- Oceanic Wave Energy
RES	- Renewable Energy Sources
RSSB	- Rail Safety and Standards Board
RMG	- Rail-Mounted Gantry
PRASA	- Passenger Rail Agency of South Africa
SA	- South Africa
SANRAL	- South African National Roads Agency Limited
SC	- Straddle Carrier
STS	- Ship-to-Shore
SDGs	- Sustainable Development Goals
tCO ₂ e	- Tons of Carbon Dioxide Equivalent

TEU	- Twenty-Foot Equivalent Unit
TFR	- Transnet Freight Rail
TNPA	- Transnet National Ports Authority
TPT	- Transnet Port Terminals
TQI	- Track Quality Index
TSR	- Temporary Speed Restrictions
TW	- Terawatt
TWh	- Terawatt-Hour
UT	- Utility Time
UN	- United Nations
ZPMC	- Zhenhua Port Machinery Company

CHAPTER 1

INTRODUCTION

The Port of Durban is one of Africa's largest container ports. It is the fourth-largest container port in the Southern Hemisphere. Durban Container Terminal (DCT) plays a vital role in trade between Southern Africa and the rest of the world. The Durban Container Terminal's throughput volumes have been growing over the years. The global container trade has been growing worldwide. The growth has caused a rapid increase in vessel size over the last decade, which has forced ports to keep up with larger draughts and increased containerised trade (Transnet 2017).

The Durban Container Terminal has a combined capacity of 3.6 million twenty-foot equivalent units (TEU) per annum. The berth capacity will increase to four million TEU after the berth extension. The Durban Container Terminal operates as two terminals, Pier 1 and Pier 2. They handle approximately 75% of South Africa's (SA) container volumes. It is perfectly located to serve as a container hub for vessels travelling to Southern Hemisphere countries and continents. This research focuses on Durban Container Terminal Pier 2, with a capacity of 2.9 million TEU per annum. DCT has six (6) berths and a 12.2m draught, which will be increased to 14.5m after the berth-deepening project. The proposed berth extension will strain the container terminal excessively and increase containerised cargo entering the terminal (Transnet 2017).

The current container logistics system has introduced a new paradigm to the present transport system. With berth extension on the cards, this paradigm can be worsened. The proposed project will increase traffic congestion and energy consumption. The release of emissions is significantly high, and despite increasing energy consumption and costs, few energy efficiency measures or strategies are in place in today's ports and terminals (Kidere 2017). The threat to sustainable development and SA's sustainable National Development Plan (NDP) goals is increasing if it is not well managed. This research focuses on five of the 17 sustainable development goals published by the United Nations (UN). Container ports play a vital role in promoting sustainable development and reducing energy consumption, as highlighted by the 17 Sustainable Development Goals (SDGs) established by the United Nations. These goals are crucial in advocating for sustainable practices and minimizing the

environmental impact of port operations. Here's a container port sustainable view of the 17 SDGs in the context of container ports:

1. No Poverty: Container ports contribute to poverty reduction by creating jobs and promoting economic growth in surrounding communities.
2. Zero Hunger: Container ports ensure efficient and sustainable transportation of food products, thereby supporting food security.
3. Good Health and Well-being: Container ports reduce air and noise pollution and provide safe and healthy working conditions.
4. Quality Education: Container ports offer training and development opportunities for port workers.
5. Gender Equality: Container ports ensure equal opportunities for women and men and promote work-life balance.
6. Clean Water and Sanitation: Container ports reduce water consumption, promote wastewater treatment, and recycling.
7. Affordable and Clean Energy: Container ports adopt energy-efficient practices and renewable energy technology.
8. Decent Work and Economic Growth: Container ports create jobs, ensure fair employment practices, and support sustainable economic growth.
9. Industry, Innovation and Infrastructure: Container ports adopt new technologies and promote sustainable urban development.
10. Reduced Inequalities: Container ports ensure equal opportunities for all and promote diversity and inclusion.
11. Sustainable Cities and Communities: Container ports adopt green port practices and reduce environmental impact.
12. Responsible Consumption and Production: Container ports reduce waste and promote resource efficiency.
13. Climate Action: Container ports reduce greenhouse gas emissions and adopt low-carbon practices.
14. Life Below Water: Container ports reduce water pollution and protect marine ecosystems.
15. Life on Land: Container ports reduce land pollution and protect natural habitats.
16. Peace, Justice and Strong Institutions: Container ports ensure transparency, accountability, and promote social responsibility and ethical practices.

17. Partnerships for the Goals: Container ports collaborate with stakeholders to promote sustainable practices and reduce environmental impact.

The five (5) sustainable development goals on which the research focuses are:

1. Affordable and clean energy
2. Decent work and economic growth
3. Industry, Innovation and Infrastructure
4. Sustainable Cities and Communities
5. Climate action

These SDGs are particularly applicable to integrated freight container terminals operating models as they align with the terminal's core business objectives, such as reducing operational costs, improving efficiency, and enhancing sustainability. Additionally, by focusing on these SDGs, the terminal can contribute to the broader global goals of sustainable development and help create a better future for all. Rationale for selecting these specific Sustainable Development Goals (SDGs) for an integrated freight container terminal operating model.

1. *Affordable and Clean Energy*: Port container terminals require a significant amount of energy to operate. By focusing on affordable and clean energy, the terminal can reduce its operational costs while also minimizing its carbon footprint. This can be achieved through the use of renewable energy sources, energy-efficient equipment, and waste heat recovery systems.
2. *Decent Work and Economic Growth*: The port container terminal industry provides employment opportunities for a significant number of people. By focusing on decent work, the terminal can ensure that its employees are treated fairly and provided with safe working conditions. This not only improves the lives of the employees but also contributes to economic growth by increasing productivity and reducing turnover.
3. *Industry, Innovation and Infrastructure*: Port container terminals are a critical part of the global supply chain and require reliable infrastructure to operate efficiently. By focusing on innovation and infrastructure, the terminal can ensure

that it remains competitive by adopting new technologies, such as automation and digitization, and by maintaining and upgrading its physical infrastructure.

4. *Sustainable Cities and Communities*: Port container terminals are often located in urban areas and can have a significant impact on the surrounding community. By focusing on sustainable cities and communities, the terminal can contribute to the development of sustainable and livable communities through the use of low-emission vehicles, the reduction of noise pollution, and the improvement of public transportation options.
5. *Climate Action*: Port container terminals are significant contributors to gas emissions. By focusing on climate action, the terminal can reduce its carbon footprint through the use of renewable energy sources, the adoption of energy-efficient equipment, and the implementation of strategies to reduce emissions, such as carbon pricing and offsetting.

1.1 Background

A container terminal can be defined as the link between different modes of transport. It is also a point where various parties are involved in the carriage of goods, interchange of containers, information, and funds (Schröder 2013). DCT is a link between big cities within SA and neighbouring countries. DCT handles approximately 60% of containerised goods entering the country, distributed through road and rail.

The modern port aims to reduce congestion on the roads leading to the port's vicinity and the time spent in the port. DCT operate with various integrated systems. The system made up of four components, ship-to-shore, transfer (hauler and trailer), storage and container carriers (straddle carrier and trucks/train) (Schröder 2013). The port subsystems integrate with the inland logistics system to transport container cargo in SA. Approximately 15% of the container cargo is transported by rail, and the balance is on the road system. The high number of container cargoes transported by road is imposing pressure on the Durban city transport system and creating a constant threat to sustainable development due to its high increase in CO₂ release.

The container terminal operation is the highest energy-consumption operations. The container terminal industry is pressured to meet economic and environmental

standards. The high energy consumption levels in industry and the resulting emissions are significant. Container terminals worldwide are working hard to shift from fossil electricity sources to renewable energy within the port boundary (Froese 2014). Terminals worldwide have voluntarily invested in renewable energy technologies, but DCT is not one of them. DCT still does not recognize the importance of green energy ports. They lack sound strategies for measuring their energy consumption and using energy-efficiency indicators (Wilmsmeier & Monios 2016).

A dry port is an essential part of an inland trade distribution system. A dry port is an inland terminal located as an inland container hub connecting different types of transport. A dry port is the most significant contributor to the handling, storage and regulatory inspection of goods moving in local trade. A dry port creates a relief mechanism for the inland logistics system of the container cargo. The effective use of a dry port can potentially reduce traffic in the logistics system. The Natal corridor and Durban city logistics system are missing the opportunity to reduce traffic congestion in the region. DCT has introduced the automated containerised goods booking system and short-haul to back-of-port operations. Both initiatives are trying to reduce the traffic congestion leading to the terminal, but these initiatives are not addressing the increasing traffic to the Durban city logistics system.

The current DCT conditions do not support the sustainable development goals. This research emphasises the concept of sustainability in the following:

- The development, processing and transporting of natural resources in synchronized systems. This reduces waste and increases the efficient use of natural resources.
- Minimising the use of non-renewable resources, such as petroleum and scarce minerals and replacing them with environmentally-friendly substitutes. The substitutes help to extend the supply of natural resources.
- Goods transportation contributes heavily to pollution. By reducing these effects, natural resources will be less impacted. The use of technologies that have minimal impacts on the surrounding land use.
- More efficient use of energy and the production of power using non-fossil fuels can reduce the environmental impacts of energy development on the atmosphere, water and land.

The theoretical framework explored the port benchmarking report (Ports Regulator of South Africa 2016) and the port handbook (Bose & Pirhonen 2011) and the National Development Plan (South Africa. National Planning Commission 2014). The research exposed container terminal operation threats to sustainable development, finding conceptual Port of Durban layouts or technologies that advocate and encourage sustainable development goals.

1.2 Problem Statement

The research problem is defined as DCT's role in failure to achieve sustainable development targets by the NDP and the UN. Sustainable development is at the centre of the NDP. The current DCT operation setup promotes an increase in cargo handling coupled with numerous socio-economic activities, which is a constant source of increasing pressure on the limited natural resources and a continuous threat to sustainable development in the Durban areas. The biggest drives towards sustainable development are:

- The range of pollution emissions exceeds the assimilative capacity of the environment. This is a constant threat to climate action.
- Insufficient availability of natural resources to attract investors and prevent the movement of people to the cities. This creates unsustainable cities and communities.
- The negative impact of transportation growth and the non-existence of transportation/container cargo logistics systems that are environmentally friendly.
- The high number of road accidents is due to an increasing number of trucks on the road and inadequate cargo logistics alternatives.
- The absence of effective energy utilisation reduction systems for DCT, which includes a lack of regeneration energy equipment systems, solar systems and renewable energy. This is a direct misrepresentation of the affordable and clean energy setup in the sustainable development goals.

Despite the increasing importance of sustainable development, DCT is failing to achieve the SDGs in areas such as affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, sustainable cities and

communities, and climate action. This is a significant problem as freight container terminals are major contributors to gas emissions, consume large amounts of energy, and impact the surrounding communities. By failing to achieve these SDGs, DCT is missing an opportunity to reduce their environmental impact but is also failing to provide decent work and economic growth, sustainable cities and communities, and innovation and infrastructure. As a result, there is a need for DCT to develop and implement strategies that enable them to achieve these SDGs, while also maintaining their competitiveness and profitability.

The specific challenges that DCT is face in achieving these SDGs include:

1. *Affordable and Clean Energy*: DCT is struggle to reduce their energy consumption and transition to renewable energy sources due to high upfront costs and a lack of available technology.
2. *Decent Work and Economic Growth*: DCT is struggle to provide decent work and economic growth due to low income, poor working conditions, and a lack of training and development opportunities.
3. *Industry, Innovation and Infrastructure*: DCT is struggle to adopt new technologies and maintain their infrastructure due to high costs and a lack of expertise.
4. *Sustainable Cities and Communities*: DCT's impacting the surrounding communities through noise pollution, traffic congestion, and air pollution, making it difficult to achieve sustainable cities and communities.
5. *Climate Action*: DCT is struggle to reduce their greenhouse gas emissions due to a lack of available technology, high costs, and a lack of regulatory pressure.

To address these challenges, DCT need to develop and implement strategies that enable them to achieve these SDGs while maintaining their competitiveness and profitability. This may involve investing in renewable energy sources, improving working conditions, adopting new technologies, engaging with stakeholders, and

reducing their environmental impact. By doing so, DCT can contribute to a more sustainable and equitable future, while also maintaining their competitiveness and profitability.

1.3 Aim of Study

This research aim is to investigate and explore the reasons why DCT fails to achieve sustainable development goals set by the NDP and the UN. The reasons are linked to five of the UN's 17 sustainable development goals, which are:

- Affordable and clean energy
- Decent work and economic growth
- Industry, innovation and infrastructure
- Sustainable cities and communities
- Climate action

1.4 Research Objectives

The objective of this research is to find reasons why DCT is failing to achieve sustainable development goals by focusing on the following:

- Identifying key contributors to energy consumption at DCT and their impact on the operation;
- Exploring why the majority of container cargo is transported by road as opposed to rail;
- Investigating the impact and role of a dry port in the container cargo logistics sector;
- Identifying the best practice model that supports sustainable development for the container cargo logistics sector; and
- Investigating available technologies that promote sustainable development for the container handling operational model.

1.5 Research Methodology

The quantitative method was used. This involved using case studies, books and technical articles. The quantitative research method helped to respond and explain the measurable variables, predict and control measures concerning sustainable development goals for the container terminal. This research utilised the facts from first-hand sources and activities to do specific actions to stimulate the desired solution that advocates and encourages sustainable development goals.

The quantitative method is suitable for studying the 5 Sustainable Development Goals (SDGs) for an integrated DCT operating model for several reasons.

1. *Objectivity*: Quantitative research is characterized by objectivity and rigor, which helps to ensure that the results are accurate and reliable. This is important for this complex study systems, such as integrated freight container terminal operating models, where there are often many variables to consider.
2. *Precision*: Quantitative research allows for precise measurements and calculations, which can help to identify trends and patterns in the data. This is particularly important when studying SDGs, as it enables the terminal to set specific targets and track progress towards achieving those targets.
3. *Comparability*: Quantitative research allows for easy comparison between different data sets, which can help to identify best practices and areas for improvement. By comparing the performance of different terminals, the terminal can identify the most effective strategies for achieving the SDGs.
4. *Statistical Analysis*: Quantitative research enables the use of statistical analysis techniques to identify significant relationships and correlations between variables. This help to identify the factors that have the greatest impact on the terminal's performance in relation to the SDGs.

5. Scalability: Quantitative research is scalable and can be applied to large data sets, which is important for complex study systems such as integrated freight container terminal operating models. The use of big data and advanced analytics techniques can help the terminal to identify trends and patterns in large data sets, which can inform decision-making and strategy development.

Longitudinal studies and field experiments were suitable data-collection models to inform this research (Rowan 2013). The associated data collection tools, probability sampling, terminal operating/models observation, document review and case studies for sustainable development concepts at container terminals were utilised. The research design focused on the best way a logistics center connects one or more modes of transport for the handling, storage and regulatory inspection of goods moving (Hodgkinson 2015). The study evaluated the high energy consumption levels during operation and the significant emissions and energy efficiency measures for DCT. The crucial variables to assess are:

- Different types of logistics used for transporting goods between ports and inland distribution depots;
- Observation and documentation of the current DCT operating model;
- The number of trucks leaving and entering the DCT;
- DCT's high energy contribution to the Natal corridor and the impact of port operations on energy-intensive activities; and
- Evaluate the dry port's impacts on utilisation in the cargo handling operation.

The outcome of the data collected during the evaluation of the areas mentioned above assisted in conducting a detailed analysis and measuring the current DCT contribution or impact on sustainable development goals. The results influenced the possible solutions to containerised cargo logistics and energy utilisation concerning the encouragement of sustainable development goals. The results provided a type of container operating model to adopt to reduce energy utilisation in DCT. It provide direction for the utilisation of dry ports and the best possible location to reduce the containerised cargo on Durban roads and improve sustainable development in Durban's surroundings.

1.6 Research Limitations

This research focused on DCT Pier 2 and excluded other terminals within the Port of Durban. The research examined container flow, excluding bulk and breakbulk cargo flow. These commodities also have road traffic and may have external effects on the data collected. The proposed solution concerning transported goods contributes to the high release of emissions and compromises climate action's sustainable development goal.

The unavailability of automated simulation tools made it difficult to create an accurate model. This research excluded automated simulator tools; instead, an Excel-based simulator was used, which may have an element of subjectivity depending on the Excel simulator creator. The detailed impact on the DCT terminal handling capacity was not evaluated. However, an impact assumption was provided. The study assumed the use of the current equipment with a new technology that promotes sustainable development for the container handling operational model without changing the existing equipment used at DCT. This research excluded the feasibility study of the dry port location. However, an assumption was made based on the applicability of the best practice model. The impact of the pricing model for road versus rail logistics was excluded. The assumption helped the research focus on the impact of infrastructure and sustainable development. The sample used was collected during the COVID-19 period and the sample may have reflected incorrect data.

1.7 Study Context Overview

The Durban Container Terminal is a significant contributor to the regional economy, handling approximately 3.6 million TEUs (Twenty-foot Equivalent Units) of container traffic annually. The terminal is equipped with modern infrastructure and technology, and employs approximately 1,500 people directly, with many more jobs being created indirectly. However, the terminal faces several challenges that need to be addressed in order to achieve the SDGs. These challenges include vulnerability to climate change, competition from other ports, environmental and social impacts, and community displacement. On the other hand, there are also numerous opportunities for the terminal to reduce its environmental impact, contribute to economic growth, enhance its competitiveness, and improve its relationships with stakeholders. These

opportunities include adopting renewable energy sources, improving working conditions, adopting new technologies, engaging with stakeholders, and reducing its environmental impact. To achieve the SDGs, the Durban Container Terminal needs to develop and implement integrated strategies that address its challenges while leveraging its opportunities. This will not only contribute to a more sustainable and equitable future but also maintain the terminal's competitiveness and profitability in the following areas:

Attributes:

- The terminal handles approximately 3.6 million TEUs (Twenty-foot Equivalent Units) of container traffic annually, making it one of the busiest container terminals in Africa. The terminal is located in the Port of Durban, which is the largest and busiest port in Africa, handling approximately 75% of South Africa's container traffic.
- The terminal is operated by Transnet Port Terminals, a state-owned enterprise, and employs approximately 1,500 people directly, with many more jobs being created indirectly.
- The terminal is equipped with modern infrastructure and technology, including 16 quay cranes, 111 straddle carriers, 2 rail-mounted gantry cranes, 71 hauler trailer combination, 10 empty container handlers and a sophisticated terminal operating system called Navis.

Challenges:

- The terminal is located in a region that is vulnerable to the impacts of climate change, such as sea-level rise, increased frequency of extreme weather events, and changes in precipitation patterns. This can impact the terminal's operations, infrastructure, and equipment.
- The terminal faces competition from other ports in the region, such as the Port of Ngqura and the Port of Cape Town, which can impact its competitiveness and profitability.
- The terminal operations can have a significant environmental impact, such as air and water pollution, gas emissions, and noise pollution, which can impact the health and wellbeing of the surrounding communities.

- The terminal operations can also have social impacts, such as traffic congestion, community displacement, and job losses, which can impact the quality of life of the surrounding communities.

Opportunities:

- The terminal can reduce its environmental impact by adopting renewable energy sources, such as solar and wind power, improving energy efficiency, and reducing waste. This can not only reduce the terminal's carbon footprint but also save costs in the long run.
- The terminal can contribute to economic growth and decent work by providing training and development opportunities, and safe working conditions for its employees. This can not only improve the employees' quality of life but also attract and retain skilled workers.
- The terminal can enhance its competitiveness by adopting new technologies, such as automation, digitalization, and big data analytics, which can improve efficiency, reduce costs, and provide better insights into customer needs and preferences.
- The terminal can engage with stakeholders, such as the surrounding communities, environmental groups, and government agencies, to understand their concerns and address them in a proactive and transparent manner. This can improve the terminal's reputation and relationships with key stakeholders, and also enhance its social license to operate.

To achieve the SDGs, Durban Container Terminal needs to develop and implement integrated strategies that address its challenges while leveraging its opportunities. This may involve investing in renewable energy, improving working conditions, adopting new technologies, engaging with stakeholders, and reducing its environmental impact. By doing so, the terminal can contribute to a more sustainable and equitable future, while also maintaining its competitiveness and profitability.

1.8 Overview of Chapters

A summary overview of the chapters of this study is presented below:

Chapter 1: Introduction and Background

This chapter introduces the study and discusses its background. It highlights the study's problem statement, aim, objectives, limitations and scope.

Chapter 2: Literature Review

The literature is summarised and linked to the research, relevant findings and conclusions in each chapter.

Chapter 3: Methodology

The research method is outlined, how the research is structured, and the approach used to obtain the required results is explained.

Chapter 4: Research Findings and Results

The research results containing the research findings are presented systematically to provide a comprehensive understanding of the study and its outcomes. This chapter includes the detailed results obtained from benchmarking outcomes and other sources, an analysis of the findings, and a simulation of their results using operating model results.

Chapter 5: Recommendations and Conclusions

In this chapter, based on the results of the simulation operation model, a viable solution is recommended based on the research outcomes linked to the aim and objectives explained in the introduction.

CHAPTER 2

LITERATURE REVIEW

The research focuses on the potential alignment between the Durban Container Terminal's operations and the NDP's sustainable development goals. The NDP is a long-term plan that outlines South Africa's development priorities up to 2030, with a focus on achieving sustainable development in various sectors of the economy. The research aims to assess the existing practices and initiatives at the Durban Container Terminal in relation to sustainable development goals such as energy efficiency, waste management, water conservation, and community engagement. The research also seeks to identify opportunities for the terminal to contribute to the NDP's objectives for sustainable development. The research findings highlight the potential for the Durban Container Terminal to contribute to sustainable development in South Africa, particularly in the areas of energy efficiency, waste reduction, and community engagement. The research also identifies the challenges and barriers that need to be overcome, including the need for increased collaboration with stakeholders, the implementation of innovative technologies, and the adoption of best practices in sustainable development. Overall, the research contributes to our understanding of the role that container terminals can play in realizing national development plan's objectives for sustainable development and provides practical recommendations for the Durban Container Terminal and other terminals seeking to align their operations with sustainable development objectives.

Reviews previous studies concerning sustainable development and port energy consumption reductions. This dissertation focuses on five areas of sustainable development goals set up by the NDP and the UN. These five areas are associated with most container cargo transported by road versus rail, the impact and role of a dry port in the container cargo logistics sector, and contributors to energy consumption.

2.1 Sustainable Development

Sustainable development is the overarching paradigm of the UN. The 1987 Bruntland Commission Report described the concept of sustainable development as “development that meets the needs of the present without compromising the ability of

future generations to meet their own needs (p.16)” (Commission on Environment 1987).

Sustainable port development means: "not only addressing problems in port areas, including safe handling of goods or environmental management, but also including the actual capacity development for the ports in the region, aiming to develop a port and the area surrounding the port through a systematic approach, working with the ports and addressing their specific needs" (Association of Southeast Asian Nations 2011). The green port development creates scenarios for “ports of the future” that are sustainable and no impact on the environment (Schipper 2019). This can be achieved by migrating to green ports as an integral part of sustainable development to balance economic growth and welfare with healthy ecosystems (Schipper 2019).

The UN has set 17 sustainable development goals to ensure that current development does not compromise future generations’ needs. Sustainable development and reduction of energy consumption in container ports are critical issues that have gained increasing attention in recent years. With the growing demand for container transportation, there is a need for ports to adopt sustainable practices and reduce their carbon footprint. The 17 Sustainable Development Goals (SDGs) adopted by the United Nations offer a framework for sustainable development worldwide. In the context of container ports, the five goals are relevant for promoting sustainable practices and reducing the environmental impact of port operations and can contribute to a more sustainable and equitable future for all.

This dissertation focuses on five of the 17 sustainable initiative goals.

2.1.1 Affordable and Clean Energy

The number of people accessing electricity has increased to approximately 2 billion in the past ten (10) years. The increase in access to electricity has created pressure for clean power generation. The biggest issue is how we migrate from fossil fuels that change the climate, leading to significant problems on every continent. Clean energy is about being more energy efficient. Renewable sources will meet electricity needs and protect the environment (United Nations 2015).

Engineering Infrastructure and Operational

Engineer's role is to develop and create infrastructure around the world. Port infrastructure problems are solved by engineers who apply their knowledge and experience to port infrastructure projects that meet human needs and clean up environmental problems (Boigne 2004). Engineer's essential role is to enhance sustainable development for port infrastructure projects that preserve natural resources. A closed-loop ecosystem can be used to illustrate the many activities of engineers that support sustainable development (Boigne 2004).

The container terminal industry is under tremendous pressure to meet economic and environmental standards. This industry's energy consumption levels and emissions release are significantly high (Kidere 2017). Port authorities and terminal operators have recognised the high energy consumption challenges and increasing emission profile concerns. With the growth of global container trade and port infrastructure development, ports have become significant energy consumers (Morales et al. 2013).

The engineering infrastructure is vital in the container terminal layout structure and influences the operating model. A perfect terminal layout yields high-performance results with less equipment than an inefficient layout, which could lead to sustainable development goals. Container terminals that have adopted the sustainable development strategy of shifting from fossil electricity sources to renewable energy sources within the port perimeter prefer the intermodal terminal. Container terminals worldwide are converting to intermodal terminals to maximise the import/export operation. This is done by reducing the transshipment and focusing on the import and export operations. This operation can potentially reduce the cargo travelling by road (Iris & Lam 2019a).

2.1.2 Sustainable Cities and Communities

The majority of the people live in cities. Two-thirds of the world's population lives in cities, with an estimated 20% increase by the year 2050. Cities are getting bigger. In 2014, there were 28 mega-cities, home to 453 million people. Communities love cities, living next to business and city life. We can upgrade informal settlements, improve

public transport and promote urbanisation decisions. This will enhance the attractiveness of the cities and sustainable change (United Nations 2015).

Dry Ports Role and Benefits

A dry port connects different modes of transport for the cargo handling, storage and inland depot distribution facility. The dry port drives economic growth and development and provides all other logistic services (Hodgkinson 2018). South Africa, however, faces significant growth and development challenges, and the country has not been able to connect successfully with the southern region sustainably. A dry port can reduce people's migration to developed cities and promote economic growth through the development of inland regions by developing new cities next to dry ports (Hodgkinson 2018).

The main functions of dry ports are:

- Container handling and storage,
- Container stripping and stuffing,
- Customs and other border control inspection and clearance,
- Container light repairs,
- Freight forwarding and cargo consolidation services,
- Transport booking/brokerage, and
- Value-added services (packaging, labelling and long-term warehousing).

A dry port allows the diversion of cargo movement from an inefficient to an efficient combination of transport, mainly supporting the road-to-rail transition. A dry port's has four main components:

- Reduction in logistic operating costs;
- Environmental damage net reduction;
- Public safety improvement (accident costs reduction); and
- Road infrastructure maintenance costs net reduction.

Dry ports create diversion of cargo movement between different sources of transport to more environmentally friendly modes of transport. A dry port has the capability of diversion and reduce the following:

- Greenhouse gas emissions,
- Noxious gas emissions, and
- Noise propagation.

2.1.3 Climate Action

Climate action means stepped-up efforts to reduce greenhouse gas emissions and strengthen resilience and adaptive capacity to climate-induced impacts. Every country in the world, some more than others, is now experiencing the effects of climate change. Reduction in climate change impact will help vulnerable regions become more resilient from loss of life and property. It is still possible to limit the increase in global mean temperature to two degrees Celsius above pre-industrial levels with political will and technological measures and thus minimise the worst effects of climate change. The sustainable development goals lay out a way for countries to work together to meet this urgent challenge (United Nations 2015).

a) Road to Rail

Road transport is the physical process of transporting cargo or people by road using motor vehicles. Rail transport is the physical process of transporting cargo or people by rail using trains. With several cargoes being transported by road, the freight transport sector faces an overwhelming challenge exacerbated by climate change. Several recent studies indicate a significant increase in carbon dioxide due to high emissions from cargo-carrying trucks travelling by road (Prince 2015a).

International Transport Forum (ITF) stats indicate that 25% of global carbon dioxide (CO₂) emissions come from the transportation sector, with road transport being the dominant source (Prince 2015a). The transport sector carries much of the burden of climate change adaptation. The transition of cargo movement from the road to rail creates an environmentally sustainable transport system. ITF Studies have proven that rail is the most energy-efficient mode of transport if regeneration power is utilised.

The rail benefits are magnified by the introduction of electric traction. The change of cargo traffic from road to rail reduces accident frequency as well as accident consequences. The reduction of truck traffic magnitude withdrawal from road infrastructure due to a change to rail will reduce traffic congestion and emissions (Iris & Lam 2019b).

The transport sector's failure to adapt to climate change challenges has compelled the port terminal to take on some responsibilities. The threat to sustainable development in the region is high, as indicated by the high level of traffic congestion and the proportion of energy usage. Ports are an essential physical infrastructure component, facilitating over 80% of global freight flows. Most port operations are energy-intensive activities thus, they should play an integral part in developing high-quality, reliable, sustainable and resilient infrastructure supporting future economic growth (Munim & Schramm 2018).

2.1.4 Decent Work and Economic Growth

Decent work and economic growth aim at ensuring inclusive and sustainable economic growth worldwide, notably by achieving full employment, decent and productive work for all, and equal pay for equal work. Economic growth is a core driver of job creation and improving the standard of living. The size of the middle class has grown in recent years worldwide and almost tripled in developing countries in the last 25 years, to more than a third of the population. Job creation ratio meeting job seekers demand. The current situation can be changed by promoting policies encouraging entrepreneurship and job creation (United Nations 2015).

a) Best Practice Model for Container Cargo Logistic

Due to globalisation, container traffic has been growing rapidly and it has been observed that the transshipment activities of many major ports are increasing at a faster rate. Ports worldwide have found unlocking capacity limitations and improving efficiencies difficult. Ports capacity assets are valuable. This has attracted strong interest from the private sector to invest in their development, as demonstrated in the world's largest port like, Singapore. The private sector is increasingly participating in new ports port infrastructure. This also brings wider dissemination of global best

practices, leading to increased quality of service, improved efficiency of operations and improved allocation of public funds (Zhu 2015).

The concept of “integrated intermodal transport” has been adopted worldwide to address port capacity constraint issues. Other port enhancements have also shown potential for enhancing the efficiency and smooth container operation and introducing best yard layout management strategies, which aim to improve land productivity while retaining the operational efficiency in ports (Zhu 2015). Innovative concepts are needed for designing the port of the future. This provides a reshaping mechanism for transport systems and the logistics industry. Simultaneously, economies of location, economies of scope, economies of scale, optimisation of production factors, and clustering of industries have triggered port regionalisation and inland integration of port services, especially those provided by container terminals. The integration of dry ports has emerged as a vital intermodal platform for the effective and efficient distribution of containerised cargo. Dry ports have enabled port and hinterland expansion, increasing container terminals' competitiveness at seaports. Consequently, container terminals and dry ports are establishing formal and informal relationships to strengthen their hinterlands' competitiveness and improve their role in the physical distribution of goods (Jeevan & Roso 2019).

2.1.5 Industry, Innovation and Infrastructure

Technology provides innovative ways to address big global challenges, such as job creation and reducing energy consumption. The world has become more interconnected and prosperous thanks to the internet (United Nations 2015). The more we invest in innovation and infrastructure, the better off we will all be. Bridging the digital divide, promoting sustainable industries, and investing in scientific research and innovation are all important ways to facilitate sustainable development (United Nations 2015).

a) Port Infrastructure and Equipment Technology

i. Yard Layout

The port yard layout plays a big role in the distance port equipment travels and the amount of carbon dioxide released. Container terminal design studies have used numerical simulation to compare parallel and perpendicular yard layouts (Kim & Park 2003). Simulation results emphasise the relationship between the yard layout and terminal performance and its impact on sustainable development (Kim & Park 2003). The study also elaborates on the relationship between travel and relocation costs (Kim & Park 2003). The parallel layout supports the reduction in carbon dioxide released during the operation due to its shorter travel distance within the yard layout parameters (Cobo 2016).

ii. Port Operation

The operational methods are the main energy focus for port operation planning. Reduction in equipment energy consumption, operating times and peak hours operations resulting in lower energy cost price (Jeevan & Roso 2019). Effective resource management improves operational efficiencies. The studies have confirmed that better port operational planning contributes directly to energy efficiency (Jeevan & Roso 2019).

Fossil fuel emissions are significantly high compared to electricity consumption emissions used to power port equipment, electrification has become more popular in ports. In recent years, many new equipment types have used electricity as an energy source. The ship to shore (STS) crane is the biggest electricity consumer in the port (Jeevan & Roso 2019). Technological advances strongly influence energy efficiency in power generation, storage, distribution, conversion and consumption. Ports use energy systems that include various components such as batteries, distributors, and converters (Jeevan & Roso 2019). As new methods arise to enhance grid intelligence and new devices are designed to store energy efficiently (e.g., flywheels and supercapacitors), energy efficiency can be further increased. (Jeevan & Roso 2019).

iii. Port Equipment

Cargo is handled by different types of equipment during port operations. Each piece of equipment plays a vital role in handling cargo. On the quayside, STS cranes are commonly used to unload cargo. STS use electricity to operate and modern STS have introduced technologies to improve energy efficiency during operation. There are different technologies to increase energy efficiency. Converting to direct current technology with a proper current factor might be helpful for energy efficiency since direct current can reduce peak demand and average energy consumption. The STS crane can recover tremendous energy in the hoist-down movement, which can be stored for later use. A hybrid powertrain, composed of flywheels and ultracapacitors as an energy storage device and main energy sources, might reduce the peak energy demand to 330 kW. The peak power demand of an STS crane is 1211 kW, so the peak power is reduced by 72.7% (Jeevan & Roso 2019).

A hybridisation generator modernises straddle carriers. The hybrid straddle carriers result in 27.1% fuel efficiency improvements. Sensitivity analyses show hybridisation as a game-changer in straddle carriers performance and component efficiency. Reactive power compensation approaches can be used in many ports, which implies compensating the reactive power consumed by various electrified equipment (Jeevan & Roso 2019).

iv. Renewable/Regeneration Energy

Most port operation's energy supply comes from fossil, electricity grid and green energy sources (Kreith et al. 2016). Renewable energy is generated from natural resources that support sustainable development. These resources include solar lights, winds, tides, waves and geothermal heat. It is important for ports to adopt renewable energy sources to solidify the green port initiative (Kreith et al. 2016). The sustainability goals support the selection of port equipment with fewer emissions (Jeevan & Roso 2019).

2.2 Container Port Sustainable Development Impacts

Sustainable development and energy reduction in container ports requires an examination of past studies on the 17 sustainable development goals (SDGs) set by the United Nations, pointed for the focuses to the five of the 17 sustainable initiative goals.

- *Affordable and clean energy:* Focuses on ensuring access to affordable, reliable, sustainable, and modern energy for all. In the context of container ports, this goal highlights the importance of transitioning from fossil fuels to renewable energy sources, such as wind, solar, and hydrogen. For instance, a study by Wang et al. (2014) found that renewable energy technologies could reduce greenhouse gas emissions in container ports by up to 90%.
- *Decent work and economic growth:* Emphasizes the creation of decent jobs and economic growth that is inclusive and sustainable. In the container port industry, this goal is relevant in terms of promoting fair employment practices and improving the working conditions of port workers. Some study has found that the adoption of sustainable practices in container ports can lead to improved working conditions and job satisfaction for workers.
- *Industry, innovation, and infrastructure:* Highlights the importance of investing in infrastructure, promoting sustainable industrialization, and fostering innovation. In the context of container ports, this goal is relevant in terms of promoting the adoption of new technologies, such as automation and digitalization, to improve efficiency and reduce energy consumption. For instance, a study by Yang et al. (2017) found that the adoption of smart port technologies can lead to energy savings of up to 20% in container ports.
- *Sustainable cities and communities:* Focuses on making cities inclusive, safe, resilient, and sustainable. In the context of container ports, this goal is relevant in terms of promoting sustainable urban development and reducing the environmental impact of port operations. For instance, a study by Zhang et al. (2015) found that the adoption of green port practices can lead to reduced air pollution, noise pollution, and traffic congestion in surrounding communities.

- *Climate action:* Emphasizes the need to take urgent action to combat climate change and its impacts. In the container port industry, this goal is relevant in terms of reducing gas emissions and promoting low-carbon practices. For instance, a study by Wang et al. (2014) found that the adoption of energy-efficient practices in container ports can lead to significant reductions in gas emissions.

Container ports are significant contributors to increased energy consumption and gas emissions due to various sources. Here are some of the primary sources of energy consumption and emissions in and around container ports:

1. *Diesel-powered equipment:* Most of the cargo handling equipment in container ports, such as cranes, straddle carriers, and trucks, run on diesel fuel, which is a significant source of gas emissions.
2. *Electrical power consumption:* The operation of container port facilities, such as lighting, cooling, and heating systems, consumes electricity, which can be generated from fossil fuels or renewable energy sources.
3. *Marine vessels:* Ocean-going vessels that transport containers to and from container ports often use diesel fuel and emit greenhouse gases and other air pollutants.
4. *Road transportation:* Trucks and other vehicles that transport containers between container ports and inland destinations consume fuel and emit greenhouse gases.
5. *Land use:* Container ports often occupy large areas of land, leading to the clearing of natural habitats and contributing to urban heat island effects, which can increase energy consumption and emissions.
6. *Waste generation:* Container ports generate waste from various sources, including cargo handling activities, packaging materials, and food waste, which can contribute to greenhouse gas emissions during disposal and recycling.

Addressing these sources of energy consumption and emissions requires a multi-faceted approach that includes the adoption of energy-efficient technologies, the use of renewable energy sources, the promotion of sustainable transportation practices, and the reduction of waste generation. Implementing these measures can help container ports reduce their carbon footprint and contribute to sustainable development.

Sustainable development goals (SDGs) have been successfully implemented in some container ports around the world, contributing to a more sustainable and equitable future. Here are some examples:

- *Affordable and Clean Energy*: The Port of Rotterdam has implemented a range of measures to reduce energy consumption and promote the use of renewable energy sources, including the installation of wind turbines, solar panels, and heat pumps. These measures have helped the port reduce its carbon footprint and contribute to the goal of affordable and clean energy.
- *Decent Work and Economic Growth*: The Port of Los Angeles has implemented a range of initiatives to promote decent work and economic growth, including training programs for port workers, job creation programs, and efforts to promote economic development in surrounding communities.
- *Industry, Innovation and Infrastructure*: The Port of Singapore has implemented a range of innovative technologies to improve infrastructure and promote sustainable development, including automated guided vehicles, digitalization of port operations, and the use of artificial intelligence for cargo handling.
- *Sustainable Cities and Communities*: The Port of Hamburg has implemented a range of measures to promote sustainable urban development and reduce the environmental impact of port operations, including the implementation of green port initiatives, the promotion of public transportation, and the development of sustainable infrastructure.
- *Climate Action*: The Port of Vancouver has implemented a range of measures to reduce gas emissions and promote climate action, including the development

of a climate action plan, the implementation of energy-efficient technologies, and the promotion of sustainable transportation practices.

These examples demonstrate the potential for container ports to contribute to sustainable development and promote the SDGs. Achieving sustainable development in container ports requires a long-term commitment to sustainable practices, collaboration with stakeholders, and the adoption of innovative technologies and strategies.

2.3 Conclusion

The Port of Durban is a major transit point for containerised cargo, and while the city itself is not located near the port, the links between the port and the municipal region are significant. As a primary point of entry for southern Africa, the port facilitates access to several landlocked countries in the southern region and serves as a crucial gateway for trade. However, the port faces several sustainability challenges due to its physical location, operational characteristics, and connection to the urban area. These challenges include traffic congestion, air pollution, and gas emissions, as well as bottlenecks in the transport network. To address these challenges, the study proposes the implementation of a dry port in the region as a means of diverting cargo from road to rail. The dry port would serve as a customs-controlled logistics facility in the hinterland of Durban, reducing the strain on the city's transport network and allowing for the efficient handling and consolidation of cargo. The study also recommends the implementation of value-added services at the dry port, such as container stripping and stuffing, light repairs, and logistics services, in order to create jobs and promote economic growth.

In addition to the dry port, the study also proposes the electrification of the rail network as a means of reducing the carbon footprint of the port. The electrification of the network would provide a cleaner, more efficient, and more sustainable mode of transport, reducing the reliance on diesel-powered trains and trucks. The electrification of the rail network would also allow for the introduction of regenerative braking technology, which would allow for the recovery of energy during the braking process and improve the overall energy efficiency of the network.

The study also highlights the importance of collaboration and coordination between various stakeholders, including the port authority, the national rail operator, the city of Durban, and the private sector. The implementation of the dry port and the electrification of the rail network would require significant investment and resources, and the involvement of all relevant stakeholders would be essential for the success of the project. The challenge experienced by the Durban Container Terminal is not unique. The threat to sustainable development in the region is high, as indicated by the high level of traffic congestion and the proportion of energy usage. Ports are an essential physical infrastructure component, facilitating the majority of worldwide freight flows (Munim & Schramm 2018). Port operations are energy-intensive activities, which makes it critical to operate responsibly with resilient infrastructure that advocates for economic growth (Munim & Schramm 2018). Global research provides solutions that Durban Container Terminal can adopt to improve its sustainable development position.

CHAPTER 3

METHODOLOGY

The number of studies on sustainable development goals in the container terminal industry has increased in the last decade. The container business has been suffering from tremendous pressure to comply with economic and environmental requirements. The significant energy consumption and the emissions released are the driving forces behind the increased studies conducted worldwide. The energy consumption is significantly high, despite the high energy generation costs. Port stakeholders have recognised the need to address energy efficiency challenges and reduce the emission profiles (Kidere 2017).

Africa has been lagging behind on the sustainable development goals drive in the container terminal industry. South Africa has one of the Africa's biggest container ports. The emission profiles are expanding, and nothing is being done to mitigate this situation. DCT is the most appropriate terminal to determine SA's role in achieving sustainable development goals. The quantitative research method helped to respond and explain the measurable variables, predict and control measures concerning sustainable development goals for the container terminal. Longitudinal studies and field experiments were suitable data collection models to inform this research (Rowan 2013). The associated data collection tools, probability sampling, observation of terminal operating/model document review, and case studies for sustainable development concepts at container terminals were utilised.

This research utilised primary sources data to be stimulate for the desired solution that advocates for and encourages sustainable development goals. The primary sources of data stimulated to find solution that will encourage sustainable development goals at Durban Container Port Terminal. Operational real-time data on port operations, including equipment utilization, energy utilization and gas emissions. The following date was simulated:

1. *Identify Key Performance Indicators (KPIs)*: To simulate the operational data, it's essential to first identify the KPIs that are relevant to sustainable development goals. These may include energy consumption, water usage, gas emissions, waste generation, and cargo handling efficiency.
2. *Gather Historical Data*: Collect as much historical data as possible on the operational performance of the Durban Container Port Terminal. This data may be available from internal databases, industry reports, or regulatory agencies.
3. *Analyze Trends and Patterns*: Use data analysis tools to identify trends and patterns in the historical data. Look for correlations between operational performance and sustainable development goals.
4. *Develop Simulation Models*: Develop simulation models that can predict the impact of various operational changes on sustainable development goals. These models were based on factors such as equipment utilization, cargo handling efficiency, and energy consumption.
5. *Test and Refine the Models*: Test the simulation models using historical data and validate the accuracy of the predictions. Refine the models as needed to improve their accuracy.
6. *Use the Models to Identify Opportunities for Improvement*: Use the simulation models were to identify opportunities for improving operational performance while achieving sustainable development goals. For example, to identify energy-efficient equipment or process improvements can reduce energy consumption while maintaining or even improving cargo handling efficiency.

The study included evaluating the energy consumption across the container business, emissions and energy efficiency measures for DCT. The quantitative approach used case studies, books, technical port videos, technical articles and DCT, including the back of port operation integration. The crucial variables to assess are:

- Goods logistics with different modes of transportation for distributing cargo to inland destinations;
- Observation and documentation of the current DCT operating model;

- Number of trucks leaving and entering the DCT;
- DCT's high energy contribution to the Natal corridor and the impact of port operations on energy-intensive activities (integrated operation); and
- Testing of the impacts of dry ports utilisation in the container handling operation.

Establishing and managing a financially viable container terminal that delivers high-quality service and efficient operations is a complex endeavour. The choice of an operating system plays a crucial role in the terminal's carbon emissions and energy consumption (Böse & Pirhonen 2011). This is particularly relevant in the context of the distinct Z-shape layout of the Durban container terminal, where the appropriate selection and operation of the system can significantly impact its profitability and environmental footprint.

3.1 Data Collection

The research was limited to the eThekweni and Pietermaritzburg municipal areas. This covered 30% of the Natal corridor's rail and road routes. The research objectives focused on road and rail utilisation within the Natal corridor and the DCT's operations. The data required for the study was secured from primary and secondary sources.

The primary sources of raw data for the study were:

- Transnet National Ports Authority (TNPA) Durban traffic study;
- Transnet Port Terminals (TPT) Navis container and truck monitoring system;
- TPT Energy Management System (EMS) for energy consumption;
- Previous studies on DCT's continuous improvement and operation planning;
- Transnet Group Chief Executive Talent Nurturing Programme (GCETNP) research on the impact of operational inefficiencies on Natal-Gauteng Corridor (NatCor) performance; and
- The KwaZulu-Natal Department of Transport's role in road and rail infrastructure.

The primary source was the focal point of the research. The primary source was used to estimate emissions from freight trains (diesel) and freight trucks by checking the fuel use, throttle position, type and distance travelled. Emission reduction was based

on the energy consumption of straddle carriers, rail-mounted gantries, ship-to-shore cranes, and yard trucks.

The continuous improvement report on container design layout outcomes on resource utilisation, effective use of container stack layout and selection of operating technologies. A global study by (Budiyanto et al. 2021) indicated that terminal layouts have influenced energy consumption and CO₂ emissions. The Transnet GCETNP research on the impact of operational inefficiencies on Natal-Gauteng Corridor (NatCor) performance was used to evaluate the relationship of road and rail networks by performing the inland and Port of Durban (Manganyi et al. 2019). Container terminals worldwide are converting to intermodal (road and rail) networks by maximising the import/export operation. This is done by reducing the transshipment and focusing on the import and export operations. This operation can potentially reduce the cargo conveyed by road and improve rail utilisation (Iris & Lam 2019a).

The secondary sources for the study were:

- Port sustainable operation report based on the technical report and operational case studies;
- The Port of Amsterdam's objectives and initiatives on the port's role in achieving sustainable development goals;
- World ports' sustainability report (2020) on world ports' sustainability programmes;
- The dry port integration model report as the catalyst for sustainable cities and communities; and
- Port operation video simulations on terminal layout, dry port integration and logistics networks.

The secondary source assessed the port opportunities to achieve sustainable development goals. The secondary source included reviewing the best port operating models that promote sustainable development goals. The equipment energy consumption was used and multiplied by fuel consumption. The additional calculation involved CO_{2ecc} = CO₂ emission released by the container cranes, CO_{2ech} = CO₂ emission released by container-handling equipment, CO_{2ett} = CO₂ emission released by terminal trucks, CO_{2easc} = CO₂ emission released by the rail-mounted gantry, ship-

to-shore crane, CO_{2esc} = CO_2 emission released by straddle carriers, CO_{2eT} = Container-handling equipment utilisation energy, UT = Equipment Utility per annum operation, FC = container-handling equipment fuel consumption (Budyanto et al. 2021).

The dry port integration and logistics network energy consumption for train and freight trucks using equipment hours multiplied by fuel/energy consumption. The outcome was compared with the secondary source's data.

3.2 Data Analysis

3.2.1 Estimation of Energy Consumption

The fuel and power consumption were used to estimate each container-management machine utilised during port operation (Budyanto et al. 2021). The container handling process at the port is grouped into the following categories:

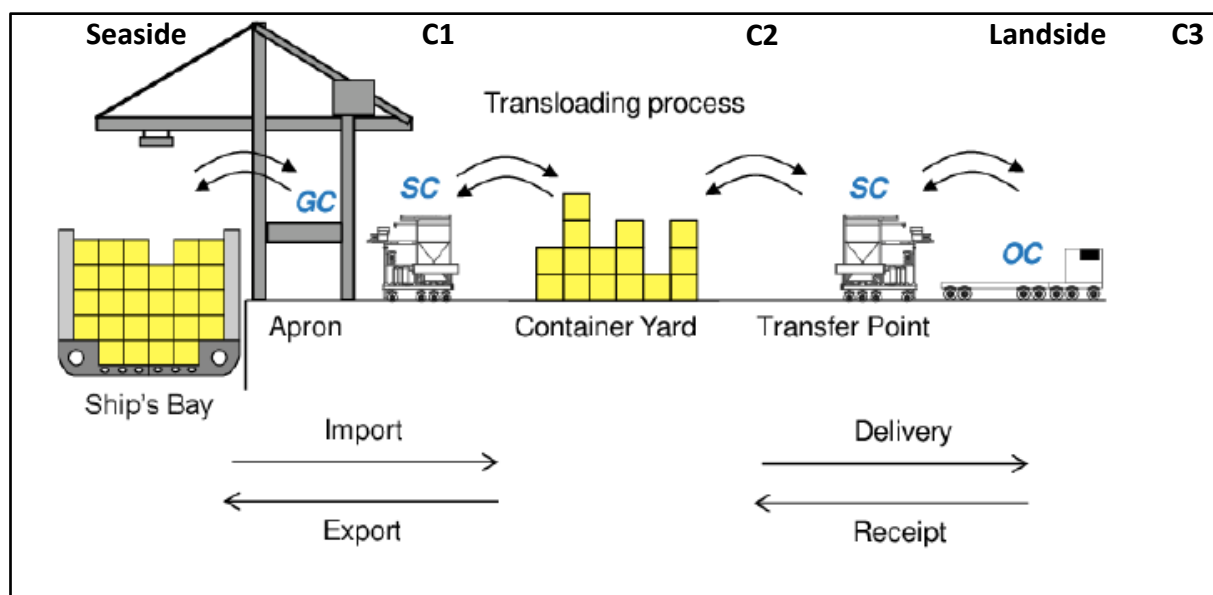


Figure 3.1: Port operational process

Source: TPT Fleet Plan

a) Category 1 (C1)

Category 1 equipment is responsible for the waterside and yard operations. These pieces of equipment are deployed for the loading and offloading of cargo from the

vessel to the stackyard. Category 1 is made up of ship-to-shore cranes and waterside straddle carriers.

b) Category 2 (C2)

Category 2 equipment is responsible for the landside and loading operation. These pieces of equipment are deployed to load and offload containers from the trucks/trains to the yard. Category 2 is made up of landside straddle carriers, hauler/trailers and rail-mounted gantry cranes.

c) Category 3 (C3)

Category 3 equipment is responsible for logistics integration between container terminals and regional warehousing. These pieces of equipment are utilised to move containerised goods between terminals and warehouses. Category 3 is made up of container trucks and trains.

Energy used in container port was obtained from electricity and fuels. Container cranes are the only equipment that uses electricity. Here, data on energy consumption (C1 and C2) was obtained from historical fuel and electricity consumption records at the DCT terminal. The energy consumption (C3) data was obtained from historical records (TNPA), the Durban traffic study and TFR train trips. The data was used to observe the operational performance of the handling equipment in the container terminal and logistics integration operation over the course of a year.

The data collected, storage and energy consumption at the container terminal were estimated using Equations 1 and 2. Equations 1 and 2 were used to sum all the energy used in container cranes, container-handling equipment and trucks (Budiyanto et al. 2021). The energy consumed will be converted to CO₂e.

$$\text{Equation 1: CO}_2 \text{ Emission} = [\textit{litres} \times \textit{fuel CO}_2 \textit{ factor}]/1000$$

or

$$\text{Equation 2: CO}_2 \text{ Emission} = [\textit{kWh} \times \textit{electricity CO}_2 \textit{ factor}]/1000$$

Equations 1 and 2 used the fuel CO₂ factor and electricity CO₂ factor that are essential elements in calculating the overall carbon footprint of an integrated Port Container Terminal operation. These factors represent the amount of CO₂ emitted per unit of energy consumed by the terminal's fuel and electricity sources. The formula to calculate the CO₂ emissions from fuel consumption is as follows: CO₂ emissions (tonnes) = Fuel consumption (tonnes) x Fuel CO₂ factor (tonnes CO₂ per tonne of fuel). Similarly, the formula to calculate the CO₂ emissions from electricity consumption is: CO₂ emissions (tonnes) = Electricity consumption (kWh) x Electricity CO₂ factor (tonnes CO₂ per kWh). To apply these formulas to an integrated Port Container Terminal operation, was required to obtain the relevant data for fuel and electricity consumption, as well as the associated CO₂ factors. These factors vary depending on the specific fuel or electricity source used. For example, the CO₂ factor for diesel fuel may be around 2.67 tonnes CO₂ per tonne of fuel, while the CO₂ factor for electricity generated from coal may be around 0.95 tonnes CO₂ per kWh. By using these formulas and obtaining the necessary data, I was able to calculate the CO₂ emissions associated with the fuel and electricity consumption of the terminal operation. This information was then used to develop scenarios for reducing the terminal's carbon footprint.

$$\text{Equation 3: } CO_{2e_{port}} = CO_{2e_{cc}} + CO_{2e_{ch}} + CO_{2e_{ht}}$$

Equation 3 was used to estimate the CO₂ released during container handling in the terminal area. Equation 4 summed all the energy used by the equipment in loading and offloading at the waterside, yard and landside.

$$\text{Equation 4: } CO_{2e_{ch}} = CO_{2e_{scc1}} + CO_{2e_{scc2}} + CO_{2e_{rmg}} + CO_{2e_{cc}}$$

Equations 3 and 4 used the fuel CO₂ factor as an essential element in calculating the CO₂ emissions released during container handling in the terminal area of an integrated Port Container Terminal operation. The fuel CO₂ factor represents the amount of CO₂ emitted per unit of fuel consumed by the container handling equipment, such as cranes, straddle carriers, and trucks. The formula to calculate the CO₂ emissions from fuel consumption during container handling is as follows: CO₂ emissions (tonnes) = Fuel consumption (litres) x Fuel CO₂ factor (tonnes CO₂ per litre of fuel). To apply this formula to the integrated Port Container Terminal operation, I obtained the relevant

data for fuel consumption by the container handling equipment and the associated CO₂ factor. The CO₂ factor for different types of fuel used in container handling equipment may vary. For example, the CO₂ factor for diesel fuel may be around 2.67 tonnes CO₂ per tonne of fuel. By using this formula and obtaining the necessary data, I calculated the CO₂ emissions associated with the fuel consumption of the container handling equipment. This information was then used to develop scenarios for reducing the CO₂ emissions.

The energy consumption for each piece of equipment was calculated using Equation 5 based on the utility time of the equipment multiplied by fuel consumption, including trucks and trains.

$$\text{Equation 5: } \text{CO}_2\text{eTT} = \text{CO}_2\text{etr} + \text{CO}_2\text{et}$$

Equation 5 used the fuel CO₂ factor and electricity CO₂ factor that are essential elements in calculating the CO₂ emissions released by each piece of equipment in an integrated Port Container Terminal operation. The fuel CO₂ factor represents the amount of CO₂ emitted per unit of fuel consumed, while the electricity CO₂ factor represents the amount of CO₂ emitted per unit of electricity consumed. The formula to calculate the CO₂ emissions from fuel consumption for each piece of equipment is as follows: CO₂ emissions (tonnes) = Fuel consumption (litres) x Fuel CO₂ factor (tonnes CO₂ per litre of fuel). Similarly, the formula to calculate the CO₂ emissions from electricity consumption for each piece of equipment is: CO₂ emissions (tonnes) = Electricity consumption (kWh) x Electricity CO₂ factor (tonnes CO₂ per kWh). To apply these formulas to the integrated Port Container Terminal operation, you would need to obtain the relevant data for fuel and electricity consumption by each piece of equipment, as well as the associated CO₂ factors. This included the distance travelled by the trucks and trains.

3.2.2 Estimating CO₂ Emissions

The emissions estimating method at container ports was calculated in two ways:

- The first way was based on emissions and energy consumption multiplied by the emission factor of equipment type.
- The second way was to estimate emissions based on movement modality.

Since the energy utilisation in transshipment operation results in emissions, the factors affecting the transshipment process include the energy consumed by all the machinery utilised in every sub-method, the energy use patterns of differing container-handling machinery, equipment distribution, and the average distance in each sub-process (Budiyanto et al. 2021). Van Duin introduced the method below, which aims to reduce the recorded data from the container port to enable the estimation of macro emissions (Hu 2008).

1. Total container throughput per annum

In this performance model, the full container utility will record all that is represented by the containers dealt with (Budiyanto et al. 2021).

2. Transportation modality

The movement modality will be monitored concerning the distribution of the total throughput containers based on various modalities (Budiyanto et al. 2021). The process of handling containers and their routes depends on the type of modality used.

3. Terminal layout

The stackyard location determines the ranges as mentioned above. Every terminal has its own particular layout, in which the ranges depend on the different equipment areas in the terminal. Therefore, energy used is measured based on machinery utilising per procedure (Hu 2008). The distances from the stacking area, quay, gate and other points will be determined according to the DCT yard layout and compared with a satellite photo of the port.

The estimation system utilised the results of the bottom-up calculations of the work activities performed in the port and fuel consumption. It does not consider them input variables (Budiyanto et al. 2021). The equipment movement was the activity considered in these calculations. Container movement is the movement by a truck as the transportation method, so that an additional variable is needed, which is the distance calculated using the Manhattan distance metric system. The Manhattan distance metric, also known as taxi-cab geometry or L1 distance, is a measurement of the distance between two points in a grid-like system. It is the sum of the absolute differences of the coordinates along each axis. In the context of a Port Container

Terminal operation, the Manhattan distance metric is applied to the movement of straddle carriers or other container handling equipment. The Manhattan distance metric is used to calculate the distance a straddle carrier must travel between two points in a grid-like terminal area. For example, if a straddle carrier needs to move a container from one stack to another, the Manhattan distance metric is used to calculate the shortest possible path based on the grid-like layout of the terminal area. This can help to optimize the movement of the straddle carrier and reduce operational costs.

The formula to calculate the Manhattan distance between two points (x_1, y_1) and (x_2, y_2) is as follows:

Manhattan distance = $|x_1 - x_2| + |y_1 - y_2|$. In the context of a Port Container Terminal operation, the Manhattan distance metric is used to calculate the shortest possible path for a straddle carrier to move a container from one location to another. The coordinates of the two locations can be inputted into the formula to calculate the Manhattan distance, and the shortest path can then be determined based on the layout of the terminal area. It's important to note that while the Manhattan distance metric can be useful in optimizing the movement of straddle carriers and other container handling equipment, it is just one factor to consider in the overall operation of a Port Container Terminal. Other factors, such as stacking configurations, equipment availability, and operational constraints, may also need to be taken into account to ensure efficient and safe operations. Which was taken in to consideration in the simulation.

On the other hand, a ride is the movement by means of a crane, straddle carrier, or other container-handling equipment. After considering the movement modality, the total CO₂ emissions in a container terminal were predicted based on the number of emissions produced by a combination of various pieces of equipment and the contribution of each piece of equipment to the movement sub-processes (Budiyanto et al. 2021). Table 3.1 shows the emission factors calculated for all types of container-handling machinery using these equations.

Table 3.1: Emission factors

Source: Eskom and IPCC

Energy Source	CO ₂ Emission Factors	Reference
Industrial diesel oil	2.67 kg/L	IPCC 2006
On-grid electricity	0.97 kg/kWh	Eskom

The emission factors table (Table 3.1) is a tool used to calculate the amount of gas emissions associated with various activities. In the context of a Port Container Terminal operation, the emission factors table is used to calculate the emissions associated with fuel consumption, electricity consumption, and other operational activities. To apply the emission factors table to a Port Container Terminal operation, the relevant emission factors is multiplied by the amount of activity to calculate the associated emissions. For example, the amount of CO₂ emissions associated with fuel consumption is calculated by multiplying the amount of fuel consumed by the CO₂ emission factor for that fuel. Similarly, the amount of CO₂ emissions associated with electricity consumption can be calculated by multiplying the amount of electricity consumed by the CO₂ emission factor for the electricity source. The emission factors table is a valuable tool for tracking and reporting emissions from a Port Container Terminal operation.

3.2.3 Characteristics of Container Terminal Layouts

The method of estimating CO₂ emissions and energy consumption was based on the role of the port yard layout and port equipment deployment or utilisation. Numerical simulation assisted in comparing different terminal layout designs in terms of the number of blocks and aisles (Munim & Schramm 2018). Numerical simulation is a powerful tool that can be used to compare different terminal layout designs for container handling in order to achieve sustainable development goals. The design of an Excel-based numerical simulation involves several steps, including defining the model, gathering data, and developing the simulation model.

The first step in designing an Excel-based numerical simulation is to define the model. This involves identifying the key variables and parameters that will be used in the

simulation, such as the number of containers, the size of the terminal, and the equipment used for container handling. Once the model has been defined, data can be gathered to populate the simulation. This may include data on container volumes, equipment specifications, and terminal layouts. After the data has been gathered, the simulation model can be developed using Excel. This may involve creating formulas to calculate the movement of containers, the fuel consumption of equipment, and the emissions associated with different terminal layouts.

The simulation can then be run using different input parameters to compare the performance of different terminal layout designs. The Excel-based numerical simulation can be applied to container handling in a Port Container Terminal operation by comparing different terminal layout designs to achieve sustainable development goals. For example, the simulation can be used to compare the fuel consumption and emissions associated with different stacking configurations, equipment types, and automation levels. By comparing the performance of different terminal layout designs, operators can identify the most efficient and sustainable option. The simulation can also be used to explore different scenarios and evaluate the impact of changes to the terminal layout over time. This can help operators to plan for future growth and ensure that their terminal is able to meet the demands of a changing market. It's important to note that the accuracy of the Excel-based numerical simulation depends on the accuracy of the input data and the assumptions used in the model. Therefore, it's important to use accurate and up-to-date data when developing the simulation model and to carefully consider the assumptions used in the model.

They elaborated on a cost objective function that includes both travel and relocation costs. As external trucks access the blocks in both layouts, travel functions will be customised to account for the differences in travel patterns (Munim & Schramm 2018). Different types of DCT layouts were investigated. In the parallel layout, blocks are arranged side-by-side to the quay wall, and transfer points are situated next to the quayside. In the perpendicular layout, blocks are arranged perpendicularly to the quay wall, and the transfer points are situated at the two edges of each section (Hu 2008). DCT has a combination of both parallel and perpendicular layouts. East Quay has a perpendicular layout, and South and North Quays have a parallel layout. The Z shape of the terminal makes DCT a more complex operating system, making it difficult to smoothly adopt two operating systems at the same terminal. The South and North

Quays use the direct operation (straddle carrier) system and the East Quay uses the indirect operation (hauler and straddle carrier) system. The complexity is further extended by a rail terminal operated with a hauler and rail-mounted gantry crane.



Figure 3.2: DCT Operational layout

Source: Google Earth

The investigation was based on the South, East and North Quays. The following variables were tested:

- Container management in the yard layout,
- Container handling equipment utilisation observed in the yard layout,
- Annual energy utilisation in each yard layout,
- Total port equipment to the energy consumption at the yard layout,
- Container moves per port equipment,
- The distance travelled by equipment from the quayside to the stacking yard, and
- Port equipment contributes to the CO₂ emissions at each yard layout.

3.2.4 Characteristics of Dry Ports and Logistics Integration

The investigation evaluated the operational challenges encountered at Transnet Freight Rail (TFR) to improve the rail operational logistics integration in view of carbon emissions source reduction through the railway network. It also means an environmentally friendly society by reducing the trucks damaging the roads and minimising carbon emissions that pollute the air and damage the roads, causing potholes. This introduces the port-integrated logistics system through comprehensive multi-purpose logistics, which include the use of a dry port.

a) Simulation Model

The simulation was adopted to provide a complete perspective of the full Port/Rail Interface and logistics integration. The Excel general-purpose simulation tool was utilised to assess the container movement, the operating model and logistics.

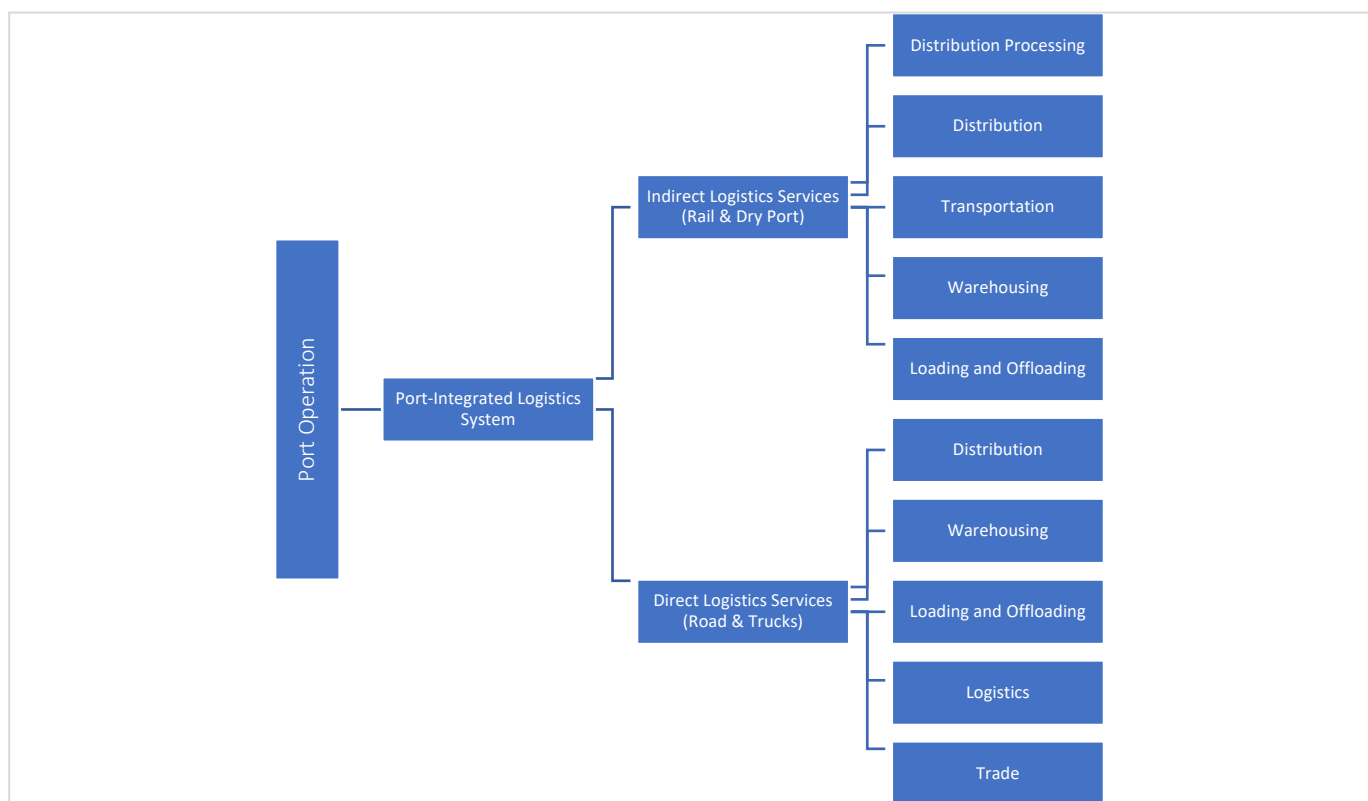


Figure 3.3: Function of port-integrated logistics system

Source: Author

Figure 3.3 illustrate a port container-integrated logistics system that is a comprehensive logistics system that includes all aspects of container handling and

transportation, from the port to the final destination. The function of a port container-integrated logistics system is to ensure the efficient and timely movement of containers from the port to their final destination, while minimizing costs and maximizing sustainability. The Durban Container Terminal is a major port in South Africa that handles a large volume of container traffic.

The port container-integrated logistics system for the Durban Container Terminal includes all aspects of container handling and transportation, from the port to the final destination. This includes the movement of containers within the port, as well as the transportation of containers to and from the port by road, rail, and sea. Simulating the port container-integrated logistics system for the Durban Container Terminal can help operators to identify bottlenecks and inefficiencies in the system, and to develop strategies for improving the efficiency and sustainability of container handling operations. This can be done using a variety of simulation techniques, such as discrete event simulation, agent-based simulation, or system dynamics simulation.

Discrete event simulation is a type of simulation that models the individual events that occur within a system, such as the arrival and departure of containers at the port. This can be useful for analysing the flow of containers through the port and identifying areas for improvement. Agent-based simulation is a type of simulation that models the behaviour of individual agents within a system, such as the drivers of trucks or the operators of container handling equipment. This can be useful for analysing the interactions between different agents and identifying ways to optimize the overall system. System dynamics simulation is a type of simulation that models the feedback loops and causal relationships within a system. This can be useful for analysing the impact of different policies and decisions on the overall system, and for developing strategies for improving the sustainability and efficiency of container handling operations. Regardless of the simulation technique used, it's important to ensure that the simulation accurately reflects the key variables and parameters of the port container-integrated logistics system, and that the results of the simulation are validated using real-world data. By simulating the port container-integrated logistics system for the Durban Container Terminal, operators can identify opportunities for improvement and develop strategies for achieving sustainable development goals.

The simulation tool tested the multimodal logistic efficiency, comprehensive port-integrated logistics services and concerning CO₂e release.

b) Carbon Emissions Sources

Estimating CO₂ emissions and energy consumption was based on the port-integrated logistics system and different kinds of transport utilisation. The port system has four kinds of emission sources: transportation, heavy equipment, materials and energy consumption. Logistics services release significant direct and indirect carbon (Yang et al. 2017).

The following types of information will be collected:

i. Transportation

Trucks and trains are part of transportation contributing to emission sources. This section will focus on the running status to estimate these emissions released in a combined logistics system (Yang et al. 2017).

ii. Energy consumption of electric power

The integrated logistics system also consumes energy by maintaining various services. Power generation is one kind of clean energy, it also produces carbon emissions in the electrical production process. (Yang et al. 2017).

3.3 Simulation Design

a) Defining The Simulation Model Objective

The objective of the simulation model was to test the simulation scenarios designed to improve DCT's sustainable development goals. The simulation design was based on the following assumptions:

- Fuel consumption reduction by 35% (7l/100km–straddle carriers and 10l/100km–haulers),

- Energy consumption reduction by 12% for the ship-to-shore and rail-mounted gantries.
- CO_{2e} emission release impacts sustainable development goals in an integrated operational scenario.

The simulation design took three scenario assumptions as part of the variable input, including distance, consumption, number of trucks, number of trains, number of equipment, operating period, fuel factor CO₂ and electricity factor CO₂. The main objective of the simulation was to find the best integrated operational scenario (full hybrid equipment, indirect operation with hybrid haulers and direct operation with green zone and hybrid haulers) for DCT concerning CO_{2e} emission release. The viable integrated operational scenario is the one with a more significant reduction in CO_{2e} emission release and fewer cost implications during implementation.

b) Developing Simulation Data Model

- **Building Data:** Data model provided the foundation upon which the mechanism I simulated was built. The spreadsheet was developed to import (trains, trucks and electricity variables), aggregates and shaped data, which essentially developed a data model that feeds the simulation model (Peres 2022). The structured source data is appropriately structured for CO_{2e} emission release from inputs for effective data modelling (Alexander 2016).
- **Functions application:** Excel formulas and functions were used to create a mathematical model for simulation design (Peres 2022). The formulas and functions assisted in pulling information from the data layer and creating staging tables that produced charts, tables, and other result components (Alexander 2016).
- **Visualisation:** The best-suited graphical chart view was selected to present the CO_{2e} emission release results per each integrated operational scenario. The chart offered a visual representation of numeric values, and at-a-glance, the views that allowed relationships between data values, point out differences, and observed CO_{2e} emission release trends to be specified (Alexander & Walkenbach 2013).

c) Perform Simulation Model Test

Excel formulas and functions were linked to test if all the mathematically integrated functions pulled the information from the data layer and produced charts and other result components. I repeated the simulation multiple times with different inputs and scenarios to understand how it behaved under different conditions (Peres 2022).

d) Perform Simulation Sensitivity Analysis Test

A sensitivity analysis test was applied to a simulation model to determine how different values of scenario variables affect specific CO₂e emission release variables under a given set of assumptions. By analysing the target and input variables, how the variables moved and affected each other could be checked. Based on this, better ranges for the sensitivity analysis of CO₂e emission release variables and reduced subjectivity were created (Dikov 2020).

e) Run Simulation Model

The simulation was applied to all three integrated operational scenarios using the linked Excel formulas and functions, and the results are presented below.

3.3.1 Data Simulation Application

Simulating data on the model for port operations, several key factors such as trucks and train turnaround time, truck visits to the Distribution Center Terminal (DCT), electrical consumption, and renewable energy generation technologies play a crucial role. Here's how these elements are utilized in developing the simulation data model:

- **Trucks & Train Turnaround Time:** The simulation model incorporates data on the turnaround time for trucks and trains within the port. This data helps in optimizing the flow of vehicles, scheduling arrivals and departures efficiently, and reducing idle times, ultimately streamlining operations and improving productivity.
- **Truck Visits to DCT:** Understanding the frequency of truck visits to the Distribution Center Terminal is essential for the simulation model. By analyzing

this data, the model can determine the optimal number of trucks to handle, plan for resources, and develop strategies to minimize congestion and wait times at the DCT.

- **Electrical Consumption:** Data on electrical consumption within the port is crucial for assessing energy usage patterns, identifying peak demand periods, and exploring ways to reduce energy consumption through efficient operations, load management, and renewable energy integration.
- **Renewable Energy Generation Technology:** Information on renewable energy generation technologies (such as peak shaving method, energy storage systems and wave energy) utilized within the port helps in assessing the potential for green energy production, estimating energy output, and strategizing the integration of renewable sources to offset conventional electricity usage and reduce carbon footprint.

3.4 Validation of Operating Models

The simulation validated the operating model and Port/Rail Interface concerning sustainable development. The results were compared with the current port status core versus the port-integrated logistics system (Prince 2015a). The following variables will be compared:

- Clean energy opportunity,
- Sustainable cities and communities,
- Climate action,
- Decent work and economic growth, and
- Industry, innovation and infrastructure.

The validating process for the operating model and Port/Rail Interface concerning sustainable development at the Port of Durban, followed these step-by-step guidelines:

- *Define Objectives:* Clearly outline the goals and objectives of the simulation, focusing on sustainable development aspects related to the operating model and Port/Rail Interface.

- *Data Collection*: Gather relevant data on the current operating model, Port/Rail Interface, and sustainability metrics at the Port of Durban.
- *Model Development*: Develop a simulation model that incorporates the key elements of the operating model and Port/Rail Interface, considering sustainability factors.
- *Validation Process*: Follow these steps to validate the simulation:
 - *Model Calibration*: Ensure the simulation model accurately represents the real-world system at the port by calibrating it with historical data.
 - *Verification*: Verify that the simulation model is error-free and accurately captures the interactions between the operating model and Port/Rail Interface.
 - *Validation*: Validate the simulation results against real-world data and observations to ensure its reliability.
- *Sustainability Assessment*: Integrate sustainability indicators into the simulation model to assess the impact of different scenarios on sustainable development.
- *Scenario Analysis*: Run different scenarios through the simulation model to analyze the effects of changes in the operating model and Port/Rail Interface on sustainable development goals.
- *Optimization*: Use the simulation results to optimize the operating model and Port/Rail Interface for improved sustainability performance.

3.5 Limitations

The primary sources of raw data were of excellent quality since they were used for performance monitoring within the terminal and logistics integration corridors. While the primary sources were of excellent quality, they may have excluded some of the factors that were applied in the sustainable development initiative. The traffic study by TNPA and Aurecon focused on the trucks driving to the DCT. The report had limitations to this study since it did not take into consideration the trucks leaving in the Gauteng corridor. As a result, the evaluation of the viability of the dry port inland within the Gauteng corridor was limited, and the simulations were based on assumptions. This study excluded the viability of dry port integration.

The engine capacity for the truck was assumed to be the same size to ease the measurement of energy consumption and CO₂ emissions. A report on the impact of operational inefficiencies on NatCor's performance evaluated the relationship of road and rail networks by performing the inland and DCT but did not indicate the type of trains used within the corridor. The study assumed diesel-electric trains were used within the DCT and NatCor. This assisted in collecting data for calculating energy consumption and CO₂ emissions. The traffic operation model conducted by Aurecon presented the estimated distance travelled by equipment and trucks within the terminal. The study excluded some of the factors that were applied in the sustainable development initiative since it focused on the traffic operation model. The assumption was made concerning the application of the sustainable development initiative.

The truck transition sample was based on 2020 data from the Navis container and truck monitoring system. The 2020 data was inaccurate due to the change in truck logistics behaviour after COVID-19 restrictions that affected the container logistics industry. The 2020 data was validated with the 2019 data for accuracy. The change in operating behaviour affected the energy management system after COVID-19 restrictions affected the container logistics industry, leading to some reduction in energy consumption during this period. The same method used in the truck monitoring was adopted to validate the energy consumption used in 2020 with the 2019 data.

The TPT Centre of Excellence benchmarking report was outdated due to the quick changes in technology relating to sustainable development. The secondary sources validated the existing and new port technologies for sustainable development.

3.6 Conclusion

The methodology employed in the research on sustainable development goals in the container terminal industry, particularly focusing on the Durban Container Port Terminal (DCT), was comprehensive and detailed. The study highlighted the significance of addressing energy efficiency challenges and reducing emissions in port operations. The research utilized a quantitative approach, integrating longitudinal studies and field experiments to collect data on energy consumption, emissions, and energy efficiency measures. Key performance indicators were identified to simulate operational data, historical data was analyzed to develop simulation models, and various equations were used to estimate CO₂ emissions associated with fuel and electricity consumption.

The research methodology also delved into the assessment of container handling equipment, energy consumption, CO₂ emissions, and logistics integration at the DCT. The simulation model tested different operational scenarios to improve sustainable development goals, considering variables like fuel consumption reduction, energy consumption reduction, and CO₂ emission impact. Data on trucks and train operations, electrical consumption, and renewable energy technologies were crucial in developing and validating the simulation model.

Moreover, the study evaluated the operating models and Port/Rail Interface to achieve sustainable development goals, comparing clean energy opportunities, urban sustainability, climate action, economic growth, and infrastructure innovation. However, certain limitations were acknowledged, such as data exclusions, assumptions on truck engine sizes, and reliance on outdated reports impacting the accuracy of certain findings.

In essence, the methodology applied in this research provided a detailed examination of energy consumption, emissions estimation, container handling processes, and logistics integration at the Durban Container Port Terminal, contributing valuable insights towards enhancing sustainability in container terminal operations and achieving sustainable development goals.

CHAPTER 4

FINDING AND SIMULATION RESULTS

The future brings increasing societal demands for green ports with sustainable design to handle cargo in port and a better standard of living. The results from this chapter clarify the positioning of DCT's sustainable development in the region and the container port industry. The result creates awareness of DCT's responsibilities and objectives as the terminal operator. This chapter further present the impact analysis of port layout, operating philosophy, green port infrastructure and effective operation (Böse & Pirhonen 2011).

The finding and results presented different approach to the port systems and logistic connection to the container port. The approach covers port performance, storage configurations, effective sustainable outcomes, and reducing emissions and eco-impact from fuel. The chapter showed challenges of balancing port profitability and sustainability targets and the adoption of the literature supporting the theory that states that using dry ports with shorter dwell times for storage results in a positive sustainable outlook (Böse & Pirhonen 2011).

The results presented renewable energy sources as alternatives to reduce the consumption of fossil energy sources. Electricity generated from renewable energy sources (RESs) is the best unconventional solution, as they are environmentally friendly and easily assessable. Wind, solar, hydropower, geothermal and biomass are some readily available RESs used to generate electrical power. However, oceanic wave energy (OWE) is a less utilised renewable energy source. The OWE has a greater potential than any other renewable energy source. OWE is able to generate more than 1 000–10 000 gigawatts (GW) of electrical power, which contributes significantly to the electrical power demands (Farrok et al. 2020).

The dry port planning enhances the logistics development of the traditional ports. The dry port enhances port and logistic capabilities and eliminates congestion in the seaport and its terminals. They also improve the competitiveness within the region and create customer centricity (Hodgkinson 2018). This is achieved by understating the current DCT operating system, planning technique, and its impact on sustainable

design, the efficiency and effectiveness of the integrated intermodal transport system in the region, and the challenges of the east-west route. It reviews the current carbon emission profile compared to world standards and simulates a sustainable development scenario for DCT to install environmentally friendly and cost-effective handling systems.

4.1 Terminal Overview

As with every other terminal, a container terminal is a complex system that functions efficiently only when its layout is designed in such a way that the loading and discharging processes of vessels run smoothly (Böse & Pirhonen 2011). DCT is not immune to the complex container operating system. The Z shape of the terminal makes DCT a more complex operating system, making it difficult to smoothly adopt two operating systems at the same terminal. The South and North Quays use the direct operation (straddle carrier) system and the East Quay uses the indirect operation (hauler and straddle carrier) system. The complexity is further extended by a rail terminal operated with a hauler and rail-mounted gantry crane.

DCT consists of three operational areas:

- Operational area (quayside or waterside) between the quay wall and container yard (apron or the area just behind the berthing front);
- Container yard (terminal storage = stacking area); and
- Terminal area (landside) operations (including the gate, rail terminal, parking, office buildings, customs facilities, container freight station with an area for stuffing and stripping, empty container storage, container maintenance and repair area, etc.)

DCT combination of terminal equipment (see Figure 4.1) used:

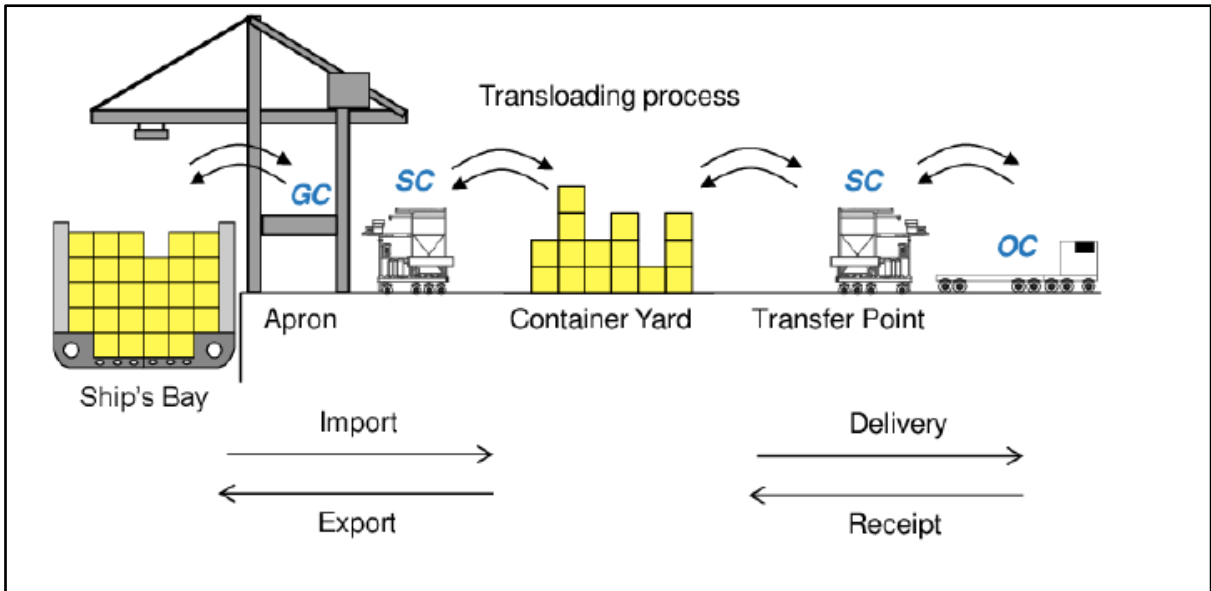


Figure 4.1: Port operational process
 Source: TPT Fleet Plan

4.1.1 Operations Systems

Designing and operating a profitable container terminal is a difficult task, while ensuring quality service and effective operations. The operating system has a more significant impact on the terminal carbon emission and energy consumption profiles. Therefore, correctly selecting the operations system is critical to a successful terminal (Bose & Pirhonen 2011). DCT is a straddle carrier (SC) operating system, and the figure below illustrates the DCT operating system.

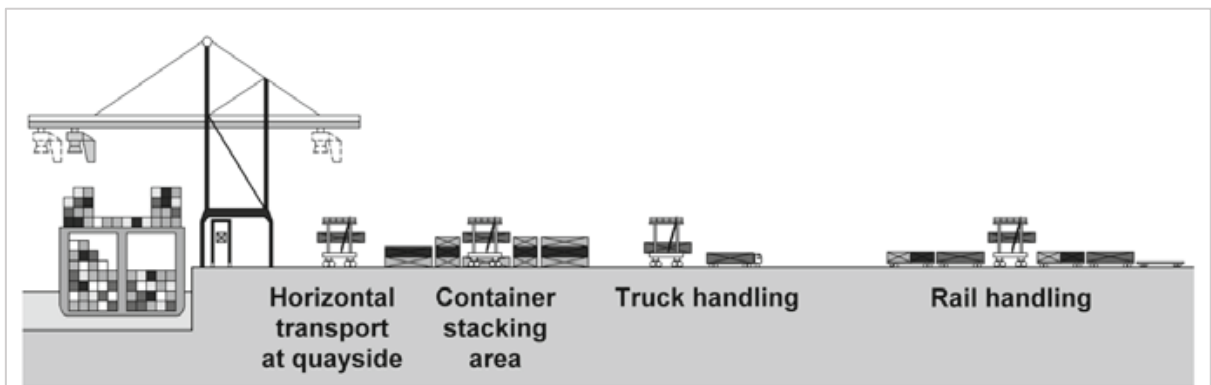


Figure 4.2: Straddle carrier operating system
 Source: Handbook of Terminal Planning (2011: 33)

The ship-to-shore (STS) crane offloads containers from the vessel and places them in the slot, from where the SCs move the container box to the yard for storage (see Figure 4. 2). The SCs are one of the core equipment, since they can perform all the different handling operations: transport, stacking and the loading and unloading of the trucks (Böse & Pirhonen 2011).

DCT selected the SC operation because it can cover all kinds of port movements. This includes quayside and landside operations. The SC operation is flexible enough to accommodate operational changes (Böse & Pirhonen 2011). This operation is perfect for the DCT Z-shape layout.

4.1.2 Fuel Contribution to CO₂ Emission

The DCT operation is based on 116 SC and 71 hauler trailer combinations. Supported by ten (10) empty container handlers, three (3) reach stackers for housekeeping and non-revenue vehicles for transporting the staff within the terminal. The table below presents the current terminal emission release based on fuel usage.

Table 4.1: Terminal equipment emission release based on fuel

Source: OEMs

No.	Equipment Type	Fuel Type	Estimated Travelled Distance (km)	Average L/100km	Equip/Vehic Quantity	Duration	Fuel CO ₂ Factor	Estimated tCO ₂ e pa
1	Straddle Carriers	Diesel	255	11	116	363	2,67	315 362
2	Haulers	Diesel	150	16	71	363	2,67	165 153
3	NRE's vehicle	Diesel	60	9	25	363	2,67	13 084
Total								493 599

The tCO₂e is based on calculation equation.

$$[(L/100km) \times fuel\ CO_2\ factor]/1000.$$

The terminal consumed 10 047 176 litres per annum, based on the 3-year fuel consumption DCT report. The figure below presents the percentage split of fuel

consumption during operation. Figure 4.3 illustrate that straddle carriers contribute 80% (21 460.7 tCO₂e), Haulers 12% (3 219.1 tCO₂e), non-revenue vehicles 5% (1 341.3 tCO₂e) and others 3% (804,8 tCO₂e) to emission release in the last 3 years.

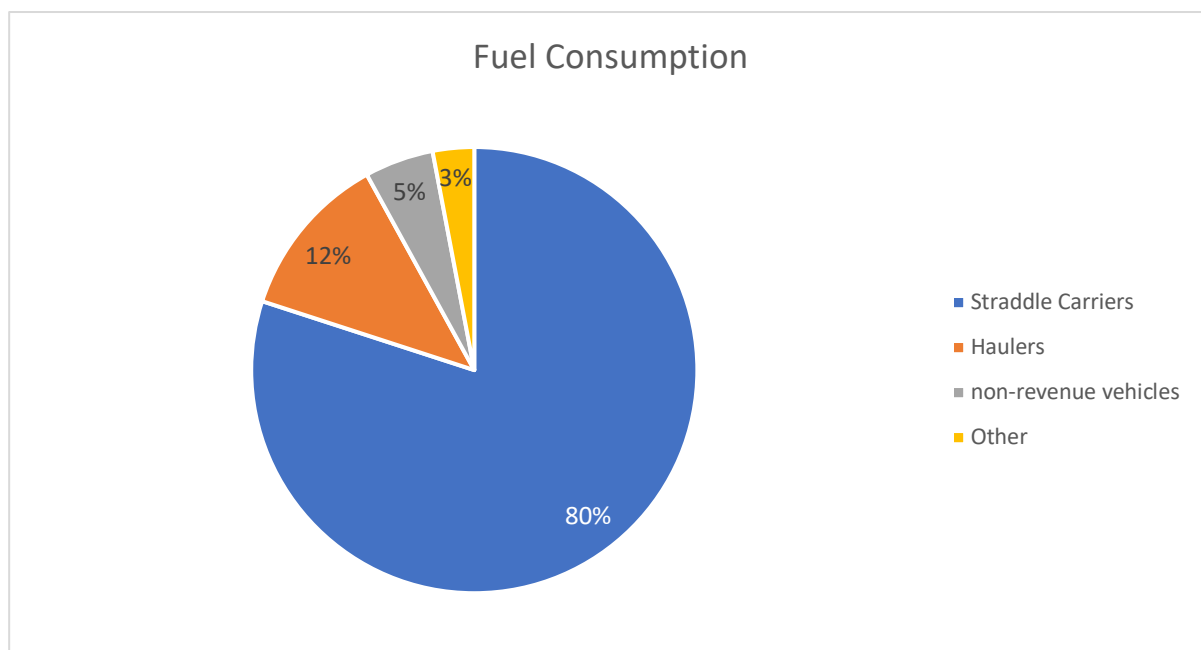


Figure 4.3: Port equipment fuel consumption

Source: 3-year fuel consumption DCT report

The DCT annual CO₂e contribution is based on the 3-year fuel consumption DCT report.

$$\text{CO}_2 \text{ Emission} = [\textit{litres} \times \textit{fuel CO}_2 \textit{ factor}]/1000$$

$$\text{CO}_2 \text{ Emission} = (10\,047\,176 \times 2,67)/1000$$

$$\text{CO}_2 \text{ Emission} = \underline{26\,825.9\text{tCO}_2\text{e annum}}$$

The observation conducted in the DCT terminal layout did not indicate a correlation to excessive CO₂ release or significant differences in CO₂ emission contribution between parallel and perpendicular layouts. The case study published by www.nature.com supported this observation. The case study results clarified the green port initiative because they proved that both layouts are viable for implementing green ports. Furthermore, this study constructed a baseline to reduce CO₂ emissions for green port terminals further to achieve the United Nations Sustainable Development Goals (Budyanto et al. 2021). However, effective operational planning has come under the spotlight with SC travelling more than 70km as a set target. Long-distance SC travel

creates excessive CO₂ release and reduces the lifespan of the equipment since it is designed for short-distance operation.

4.1.3 Electricity Contribution to CO₂ Emission

STS and rail-mounted gantry's (RMG) electrical power equipment complement the SC operating system. The DCT operates with 16 STS cranes for the waterside operation and two (2) RMGs for the rail terminal. Both pieces of equipment use a significant amount of electricity during operation, and the consumption increases during peak hours. Peak consumption contributes significantly to DCT's monthly electricity bill (Iris & Lam 2019b). The DCT does not have peak shaving technology that aims to reduce the energy peak consumption during operation.

The DCT is missing the opportunities offered by various methods for peak shaving. Figure 4.4 illustrates a number of different methods using the following load profile curves (Iris & Lam 2019b):

- (1) Power-sharing: Using any stored energy in the case of peak energy demand periods,
- (2) Load shifting (i.e., load levelling): Shifting the energy demand from peak periods to non-peak periods,
- (3) Load shedding (sometimes called peak shaving): Turning off non-critical loads during peak periods.

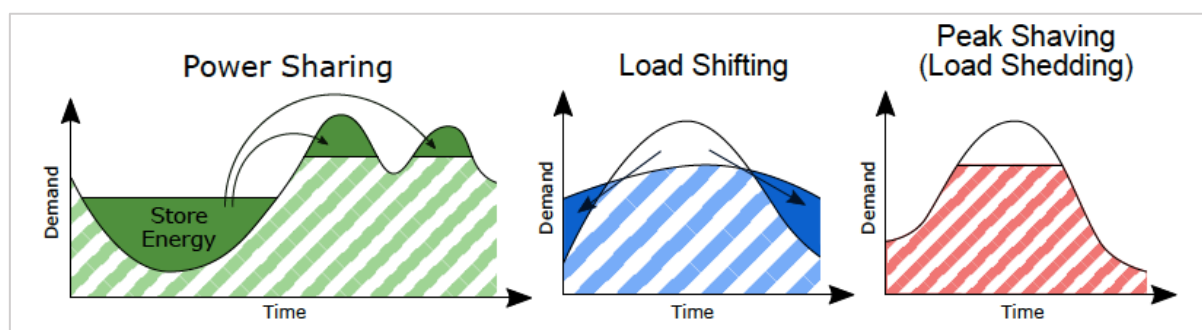


Figure 4.4: Peak shaving method

Source: Iris, C and Lam, J (2019:5)

The Figure 4.4 illustrate the electrical consumption peak shaving method for port container equipment as a strategy to reduce the peak demand for electricity in a port where container equipment is used. This method is designed to help manage and optimize the use of electricity efficiently. Here are some key components of this method:

- **Load Management:** Implementing load management techniques to distribute the energy demand evenly throughout the day. This can involve scheduling the operation of container equipment during off-peak hours to avoid high electricity rates during peak times.
- **Energy Storage:** Using energy storage systems such as batteries to store excess energy during low-demand periods and then utilize it during peak times to reduce the overall electricity demand from the grid.
- **Renewable Energy Integration:** Incorporating renewable energy sources like solar panels or wind turbines to generate electricity onsite, reducing dependency on the grid and lowering peak demand.
- **Energy Efficiency Measures:** Implementing energy-efficient practices and technologies, such as using energy-efficient equipment and lighting, to reduce overall energy consumption and peak demand.
- **Demand Response Programs:** Participating in demand response programs where the port can reduce electricity consumption during peak times in exchange for financial incentives or lower electricity rates.
- **Smart Grid Technologies:** Utilizing smart grid technologies to monitor and control energy usage in real-time, enabling better management of electricity consumption and peak shaving.

If, DCT combine these various strategies in a coordinated manner, ports can effectively reduce their peak electricity demand, leading to cost savings, improved energy efficiency, and a more sustainable operation of container equipment. The ZPMC 7 tandem STS cranes are the only ones with regeneration technology out of the 16 STS cranes at DCT. The absence of regeneration technology on other STS cranes makes it impossible to adopt any of the various methods for peak shaving. The report published by the University of Gavle in Sweden supports the argument for implementing energy recovery and storage systems in port cranes. The study results

indicated that energy recovery and storage systems (ESS) can reduce the energy consumption of port cranes by 9–15%. The ESS modification can be implemented on the existing port crane, meaning the balance of the DCT crane can benefit from the technology. Energy storage systems are still under research, even if they are already used in many applications. The ESS has considerable potential to reduce energy consumption and increase operation profitability (Decori 2020).

DCT has a single energy source, which is an original fossil energy source. The terminal's location presents an opportunity for one of the reliable energy technologies that are not utilised. Wave energy is one of the most promising renewable technologies and it's also more dependable than most renewable energy resources. Wave power at a given site is available up to 90% of the time, while solar and wind power availability tends to be available just 20–30% of the time. There are more than 1 000 different patented proposals for wave energy devices, and several have demonstrated the potential for commercially viable electricity generation. Worldwide, wave energy could potentially provide up to 2 TW of electricity, according to the World Energy Council, approximately 1/5 of the current global energy demand (Nik et al. 2009). Wave energy is the new recommended source of electricity production in areas next to the sea, since other energy sources are declining. The world has produced equivalent to 1TW of wave power in recent years, with the capabilities of approximately 2000TWh of energy generation annually, equating to hydropower or nuclear power generated in 2006 (Farrok et al. 2020).

DCT does not have renewable energy generation technology at the terminal at present to create relief for traditional grid usage. The terminal is currently consuming 33 135 954 kWh per annum, based on the 3-year electricity consumption DCT report. The chart below presents the percentage split of fuel consumption during operation. Figure 4.5 illustrate that STS cranes contribute 65% (20 892.2 tCO₂e), RMG cranes 15% (4 821.2 tCO₂e), stack layout light 10% (3 214.2 tCO₂e), workshop 5% (1 607,1 tCO₂e) and general building 5% (1 607,1 tCO₂e) to emission release in the last 3 years.

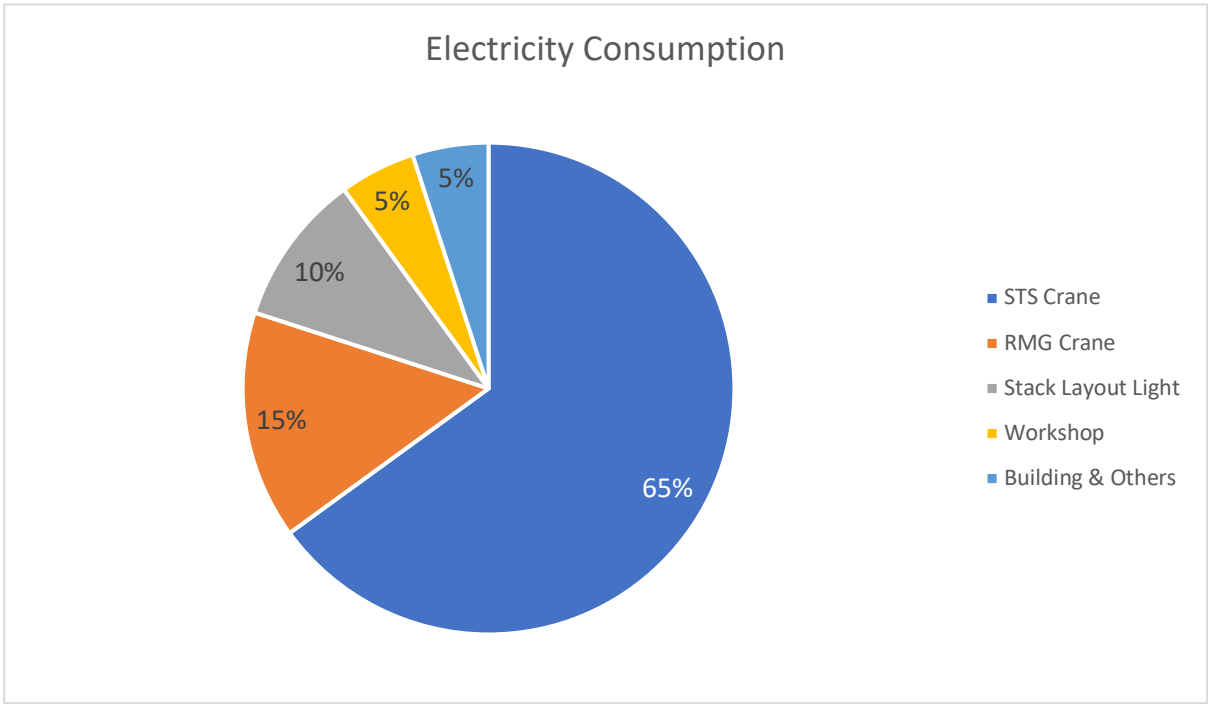


Figure 4.5: Port equipment and operation electricity consumption

Source: Author

The DCT annual CO₂e contribution is based on the three-year electricity consumption DCT report.

$$\text{CO}_2 \text{ Emission} = [\text{kWh} \times \text{electricity CO}_2 \text{ factor}] / 1000$$

$$\text{CO}_2 \text{ Emission} = (33\,135\,954 \times 0.97) / 1000$$

$$\text{CO}_2 \text{ Emission} = \underline{32\,141.9\text{tCO}_2\text{e annum}}$$

4.2 Road & Rail Integration Overview (including dry port)

Transnet’s strategic objective on road and rail, as prescribed by the Department of Public Enterprise’s Statement of Strategic Intent, is to accelerate the modal shift from road to rail. The rail network does not have a dedicated entity mandated to fund, improve, manage and maintain the national rail network. The road network will always be ahead of the rail network due to the developmental support from the South African Roads Agency. The number of trucks will continue to increase on our roads. This responsibility has been left to the rail operators, TFR and PRASA. The transport

Freight Report highlighted that road is currently the primary mode of transport for freight for various reasons, with rail taking the backseat due to the sector's being characterised by significant constraints such as operational inefficiencies. These results indicate a greater number of freight vehicles on the road, which contributes to overloading and subsequently significant deterioration of the road network (which increases the government cost of road infrastructure), traffic congestion, noise pollution, carbon emissions and an increased number of road accidents (Manganyi et al. 2019).

Mutambara report indicated that South Africa has an extensive railway network, which assists road networks in moving millions of tons of freight all over the country. However, railway network conditions have deteriorated for many years as track maintenance has been deferred because of a lack of funding. The poor railway condition and unavailability of the correct wagons have declined the performance standards of rail. Consignment companies started to choose road transport to move their freight instead of rail transport (Manganyi et al. 2019). The rail network serves inland consumer needs through the Natcor corridor, with new intermodal hubs near Cato Ridge/Camperdown dry port. Improving efficiencies, capacities, and new rolling stock will result in more freight being handled on rail, with reduced road congestion, carbon emissions and transportation costs (Transnet 2010).

4.2.1 Train Operation

According to the Transnet rail development plan, the current demand of Natcor shows a theoretical 33 trains per day and an eventual end-state requirement of 184 trains by 2044, which is impossible. Due to the increased demand for container, break-bulk and agriculture trains, various operation philosophies can be adopted, including increasing the train running speeds from 50km/hr to 80km/hr; however, there are too many areas where the curve and gradient maximums make this impossible. Introducing the dry port is one of the ways to ease the operational demand to create a local distribution. Transnet does not have an effective dry port in the NatCor, and it only has more effective siding. The City Deep is one of the effective dry ports in Gauteng. The distance between the port and the City Deep is long enough to create an effective local distribution, reducing people's migration to the developed cities and promoting

economic growth through the development of inland regions by developing new cities next to the dry port (Hodgkinson 2018).

The Durban-Gauteng freight corridor vision 2050 proposed the theoretical location of dry ports and the conversion of the siding. This study focuses on developing the Cato Ridge/Camperdown dry port. The introduction of new corridors with intermodal hubs in the vicinity of Cato Ridge/Camperdown. The current operation uses two locomotives with diesel-electric engines pulling 50-wagon container trains, and this can be reconfigured to increase the container train wagons to 75. The 150-wagon container trains are feasible. However, the condition of the rail network, including the train axle, requires upgrades. The longer trains will make the proposed Cato Ridge/Camperdown dry port effective in the region and logistics distribution network (see Figure 4.6).

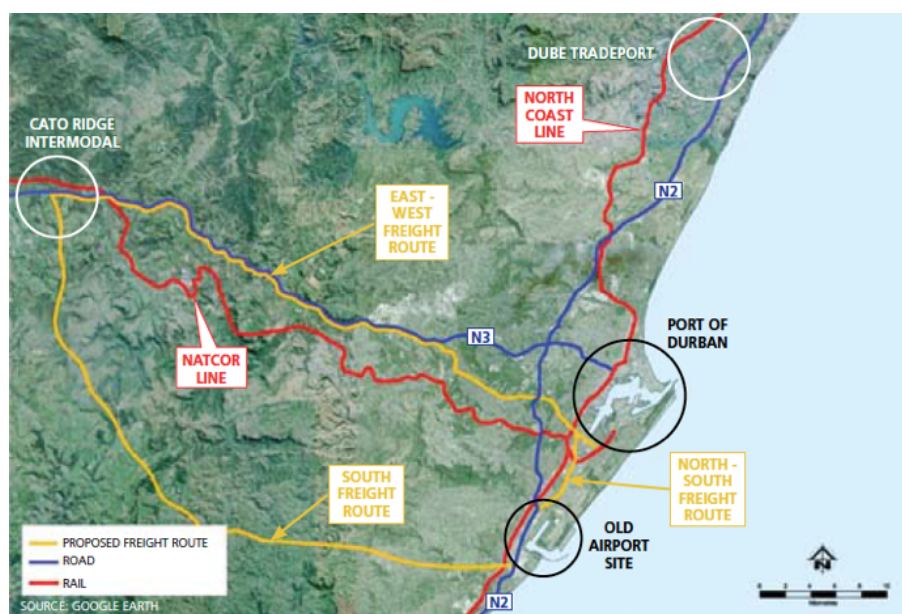


Figure 4.6: eThekweni Metro transportation and logistics routes

Source: Transnet Group Planning (2010:3)

The current NatCor container operating system is compromising the DCT. The increase in vessel sizes further strains the DCT operation as containers physically dwell for a longer period in the terminal as the vessel is discharged and loaded. This longer dwell time increases the CO₂ emissions released by the vessels. The intervention of longer trains can reduce the dwell time, reducing CO₂ emission release. The figure below presents the current utilisation status.



Figure 4.7: DCT Port capacity utilisation and Rail handling capacity utilisation

Source: Durban to Gauteng freight corridor vision 2050 report

a) Operational Challenges

The actual average of a general freight train's running time from Newcastle to Kingsrest is 16 hours and 30 minutes, against the service design of 10:58 hours. The results show inefficiencies in the system as it requires the rostering of two train drivers for a single train to relieve the previous train crew to ensure adherence to the Transnet Variation Agreement that stipulates train crew time on duty of 12 hours per shift inclusive of the sign-on and sign-off duty (Manganyi et al. 2019).

Key Rail Challenges:

- NatCor's infrastructure was built in the 1950s; therefore, the railway lines were challenged due to the changes in topography, bordered by numerous cuttings and heavy rainfalls that exposed the poor drainage system throughout the track.
- The flooding experienced due to heavy rainfalls in 2017 and April 2019 led to recurring mud holes, slacks and even formation failure.
- The above rail conditions increased temporary speed restrictions (TSRs), which impacted the train service turn-around time that had increased and reduced throughput.
- Infrastructure conditions have deteriorated over the past five (5) years, and this is evident as there is an increased Track Quality Index (TQI) and defects per km.
- Increased cable theft, vandalism, budget constraints and procurement challenges for spares have further aggravated it.

4.2.2 Train Fuel Contribution to CO₂ Emission

Rail operations are admittable comparatively efficient user of energy and fuel with less emission compared to other means of transport (such as planes and cars/trucks) (Wang 2014).

In Britain, according to the RSSB report called 'Meeting Rail's Carbon Ambition', rail can reduce emissions by 38% per container wagon train per km and save 400 000 tons per annum in five years. From a carbon and cost-saving perspective, it is recommended that the industry implement available technologies that reduce emissions (Wang 2014).

This sample of DCT operations is based on the 120km range (Durban to Cato Ridge/Camperdown and return to Durban). Each trip uses two (2) locomotives to pull the container wagon train. DCT receives an average of 2 964 container wagon trains annually, with 50 containers per trip, which adds up to 148 200 containers annually. Table 4.2 below presents the current container wagon train emission release based on fuel usage.

Table 4.2: Container train wagon emission release based on fuel

Source: OEMs

No.	Equipment Type	Fuel Type	Estimated Travelled Distance (km)	Average L/100km	Train Quantity	Duration	Fuel CO ₂ Factor	Estimated tCO ₂ e pa
1	2x locomotives (GE ES40ACi)	Diesel	120	12	2	363	2,67	5 583
2	2x locomotives (GE C30ACi)	Diesel	120	11	2	363	2,67	5 117
Total								10 700

The current diesel locomotive utilised by TFR is averaging at 7.92l/km for a range of 120km with two (2) locomotives to pull the container wagon train. The average diesel consumed by train totals 5 633 971,2 litres per annum.

$$\text{CO}_2 \text{ Emission} = [\textit{litres} \times \textit{fuel CO}_2 \textit{ factor}]/1000$$

$$\text{CO}_2 \text{ Emission} = (5\,633\,971,2 \times 2,67)/1000$$

$$\text{CO}_2 \text{ Emission} = \underline{15\,042.7\text{tCO}_2\text{e annum}}$$

With the introduction of diesel-electric engine locomotives on the horizon, CO₂ emissions can be further reduced. This comes with energy-efficient system technology. Recent regeneration technology developments have introduced railway systems with viable alternative energy storage. The energy generated from the brake system gets stored in the energy storage system (ESS) to optimize the operation. (Fayad et al. 2021)

4.2.3 Trucks Operation

The Durban to Gauteng freight corridor vision 2050 shows that road freight has a better infrastructure network compared to rail. That is one of the reasons road freights dominate the market. Road freight transports 80% of containerised goods and 20% is transported by rail. Road freight has fewer challenges compared to rail. The operational difficulties encountered at Transnet Freight Rail were mitigated to improve the rail's operational challenges and customer centricity via the railway network. It is

also meant to help society and the environment by decreasing the number of road trucks damaging the roads and reducing carbon emissions on the road, polluting the air and damaging the roads by causing potholes.

4.2.4 Trucks Fuel Contribution to CO₂ Emission

Recent studies conducted on port logistics development strategies indicate that trucks are the biggest contributor to CO₂ emissions within port-integrated logistics. This supports the International Transport Forum report that the transportation sector accounts for 25% of global carbon dioxide (CO₂) emissions, with road transport being the dominant source. Furthermore, it is responsible for 60% of the world's oil consumption and 70% of carbon monoxide emissions (Prince 2015). The transport sector carries much of the burden of climate change adaptation.

This sample of DCT's operation is based on the 120km range (Durban to Cato Ridge/Camperdown). DCT receives an average of 12 000 container trucks a week and 624 000 annually. Table 4.3 below presents the current container truck emission release based on fuel usage.

Table 4.3: Container truck emission release-based fuel
Source: OEM's

No.	Equipment Type	Fuel Type	Estimated Travelled Distance (km)	Average L/100km	Trucks Quantity	Duration	Fuel CO ₂ Factor	Estimated tCO ₂ e pa
01	Mercedes Benz Actros	Diesel	120	19,44	124 800	363	2,67	282 169 441
02	Volvo FH	Diesel	120	26,8	124 800	363	2,67	388 999 024
03	Man TGS	Diesel	120	26,4	124 800	363	2,67	383 193 069
04	Scania	Diesel	120	24,92	124 800	363	2,67	361 711 033
05	FAW	Diesel	120	20,6	124 800	363	2,67	299 006 713
Total								1 715 079 280

The truck sample is based on the truck manufacturer's specification of CO₂ emissions released. The current diesel truck's container utilisation is based on the manufacturer's technical specification, averaging 23.634l/km for a range of 120km. The average diesel consumed by tracks totals 34 032 960 litres per week.

$$\text{CO}_2 \text{ Emission} = [\textit{litres} \times \textit{fuel CO}_2 \textit{ factor}]/1000$$

$$\text{CO}_2 \text{ Emission} = (34\ 032\ 960 \times 2,67)/1000$$

$$\text{CO}_2 \text{ Emission} = 90\ 868.0\text{tCO}_2\text{e week}$$

$$\text{CO}_2 \text{ Emission} = \underline{4\ 725\ 136\text{tCO}_2\text{e annum}}$$

The road and rail networks serve different purposes and have different strengths. Road networks are generally more flexible and can reach more destinations, but it more energy-intensive and produce more emissions per unit of goods transported. Rail networks, on the other hand, is more energy-efficient and produce fewer emissions, but they it less flexible and can't reach as many destinations. For Durban container terminal, the imbalance between road and rail networks is evident, the fact that most goods are transported to and from the terminal by truck, rather than by train. This is partly due to historical factors, such as the fact that the road network was developed earlier and more extensively than the rail network. However, it's also due to the fact that the road network is better able to handle the variability and unpredictability of container traffic. Energy consumption and emissions, the dominance of road transport has significant implications. Trucks are generally less fuel-efficient than trains, and they produce more emissions per unit of goods transported. Meaning that the current reliance on road transport for container traffic is contributing to higher energy consumption and emissions than would be the case if more goods were transported by rail. Maintenance costs are also a factor, roads require more frequent and more expensive maintenance than railways, due to the higher loads and more variable traffic that they have to handle. Meaning that the current reliance on road transport for container traffic is also contributing to higher maintenance costs than would be the case if more goods were transported by rail.

The imbalance between road and rail networks is contributing to higher energy consumption, emissions, and maintenance costs than would be the case if more goods were transported by rail.

4.3 Current Carbon Emission Profile

The International Transport Forum (ITF) estimates that international trade-related freight transport currently accounts for around 30% of all transport-related CO₂ emissions from fuel combustion and more than 7% of global emissions (International Transport Forum 2016).

Road freight's share of total international trade-related emissions will grow from 53% in 2010 to 56% by 2050. The largest increases in CO₂ emissions in absolute terms will be registered in Asia and the North Pacific corridor, while relative growth is strongest in Africa (+689%) (International Transport Forum 2016). DCT is one African terminal that is contributing to the largest increases in CO₂ emissions. DCT CO₂ emissions can be categorised into two:

- Terminal Operation Systems
- Road and Rail Port Integration

DCT integrated operation CO₂ emissions profile is currently averaging at 4 799 146 tCO₂e, which is very high compared to other terminals. Figure 4.8 below presents the current DCT CO₂ emissions profile:

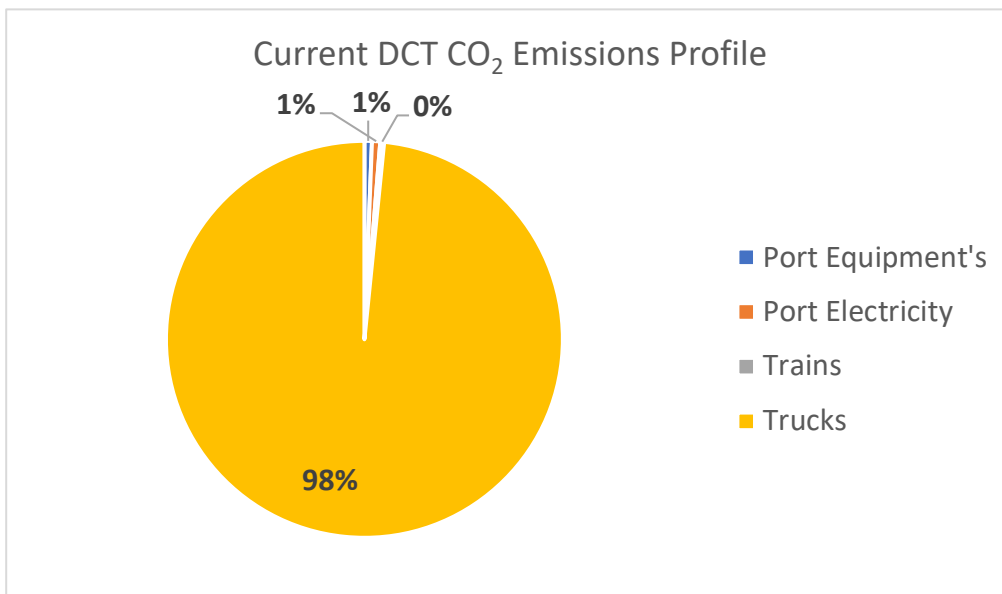


Figure 4.8: DCT Integrated operation CO₂ emissions profile

Source: Author

Figure 4.8 excoriated container port as the significant contributor to integrated freight container operation. This strength the section 4.2.4 narrative, which indicated the trucks are the highest contributors to CO₂ emissions release. Figure 4.8 shows that truck 98% of CO₂ emissions release in the integrated freight container operation. Based on the IFT road freight CO₂e emission growth projections. This means the current DCT integrated operation CO₂ emission will increase by 56% in 2050. This will take the CO₂e profile to 7 486 668tCO₂e.

4.4 Sustainable Development Scenario Simulation

The simulation scenarios are designed to evaluate and help DCT to identify gaps in understanding why DCT is failing to achieve sustainable development goals.

The case study by Kalmar Global presented that hybrid equipment can reduce fuel consumption by 30% to 40%, as detailed in Table 4.4. The simulation adopted 35% as the hybrid impact.

Table 4.4: Hybrid equipment consumption impact

Source: Author

No.	Equipment Type	Fuel Type	Average L/100km	
			Diesel Electric	Hybrid
1	Straddle Carriers	Diesel	11	7
2	Haulers	Diesel	16	10

Table 4.4 is a Hybrid port equipment impact, Straddle carriers and haulers, combine traditional fuel engines with electric power. The primary benefit of this setup is reduced fuel consumption and emissions, providing a more sustainable solution for port operations. Straddle carriers are designed to straddle and transport containers in the yard. Hybrid straddle carriers consume less fuel than traditional models by using electric power for low-speed operations and assisted movements, such as lifting and lowering containers. This not only reduces fuel costs but also lowers emissions, contributing to improved air quality in and around the port. Haulers, transport containers between the quay and the storage areas. Similar to straddle carriers, hybrid haulers use electric power for slow-speed operations and assisted movements. This reduces fuel consumption, leading to lower operational costs and fewer emissions. Additionally, hybrid haulers can offer a smoother and quieter riding experience, enhancing overall efficiency and reducing noise pollution. Hybrid port equipment, specifically straddle carriers and haulers, contribute to reduced fuel consumption and lower emissions (36% straddle and 38% haulers), making port operations more sustainable, cost-effective, and environmentally friendly.

According to the case study presented by Iris and Lam (2019), energy shaving technology can reduce energy consumption between 9 and 15%, as detailed in Table 4.5. The simulation adopted 12% as the energy-shaving technology impact.

Table 4.5: Electricity consumption adjustment

Source: Author

No.	Equipment Type	Electricity Consumption pa.		Electricity Consumption Adjustment pa.
		Main Electricity (kWh)	With Energy Shaving Technology (kWh)	Energy Innovations (kWh)
1	Ship-to-Shore	21 558 520	18 971 498	12 331 473
2	Rail Mounted Gantry	4 975 043	4 378 038	2 845 725

4.4.1 Full Hybrid Equipment

This scenario assumed the following:

- Direct SC operation;
- Introduction of Cato Ridge/Camperdown dry port and road to rail strategy; and
- Introduction of ocean wave energy and energy shaving technology.

Figure 4.9 illustrates the terminal scenario process flow:

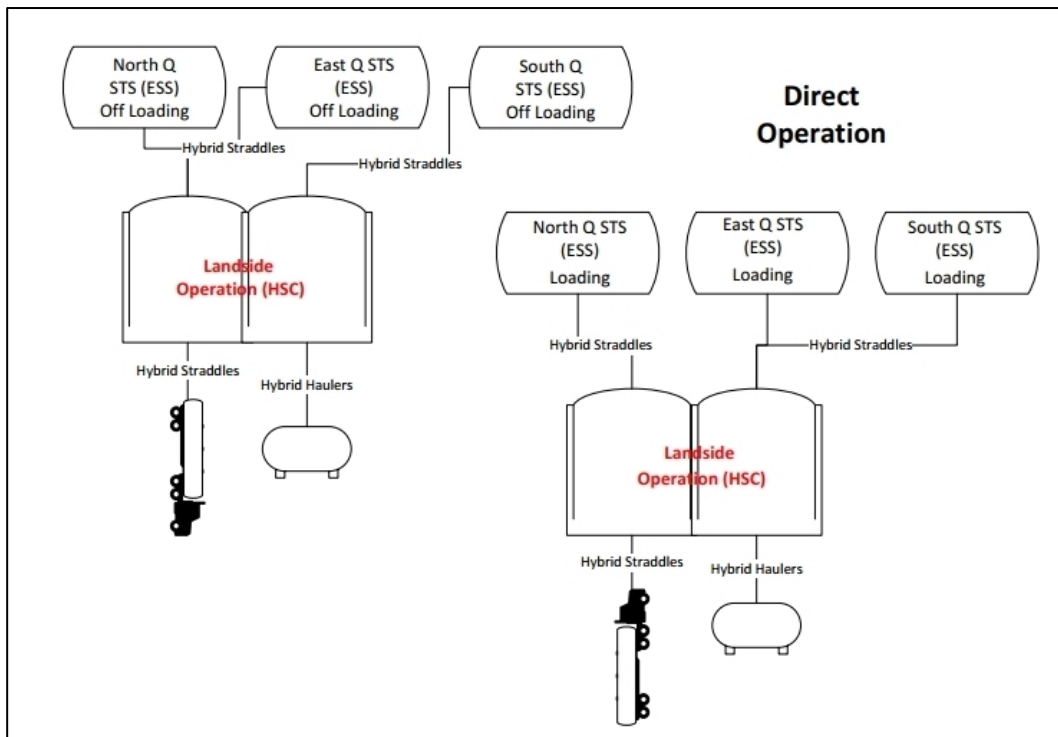


Figure 4.9: Direct operation layout

Source: Author

Advantages

- Well-known DCT traditional operation with the terminal and preferred operation due to its flexibility.
- The hybrid equipment will not change anything about the current operation;
- The hybrid equipment will reduce fuel consumption.
- The dry port will increase the number of wagon trains and reduce the number of trucks entering the terminal.
- Reduction in grid power consumption after the introduction of ocean wave energy and energy shaving technology.
- Diesel-electric engine trains will also reduce cable theft since grid power will not be required.

Disadvantages

- Some of the hybrid equipment has less power and torque.
- Technical training will be required for the new hybrid technology.
- The SC will still travel a long distance (> 750m), which greatly impacts the equipment's maintenance, as a longer distance travelled means more stresses are present on the machines for longer periods of time. Suspensions, drive motors and tyres, among other parts, will require more maintenance and attention than before.
- NatCor's infrastructure has deteriorated, and the current infrastructure has a lot of restrictions.
- Capital investment will be required for the refurbishment of ocean wave energy, energy shaving technology, and the NatCor rail network infrastructure.

4.4.2 Indirect Operation with Hybrid Haulers

This scenario assumed the following:

- Indirect operation with diesel-electric SC;
- Introduction of Cato Ridge/Camperdown dry port and road to rail strategy; and
- Introduction of ocean wave energy and energy shaving technology.

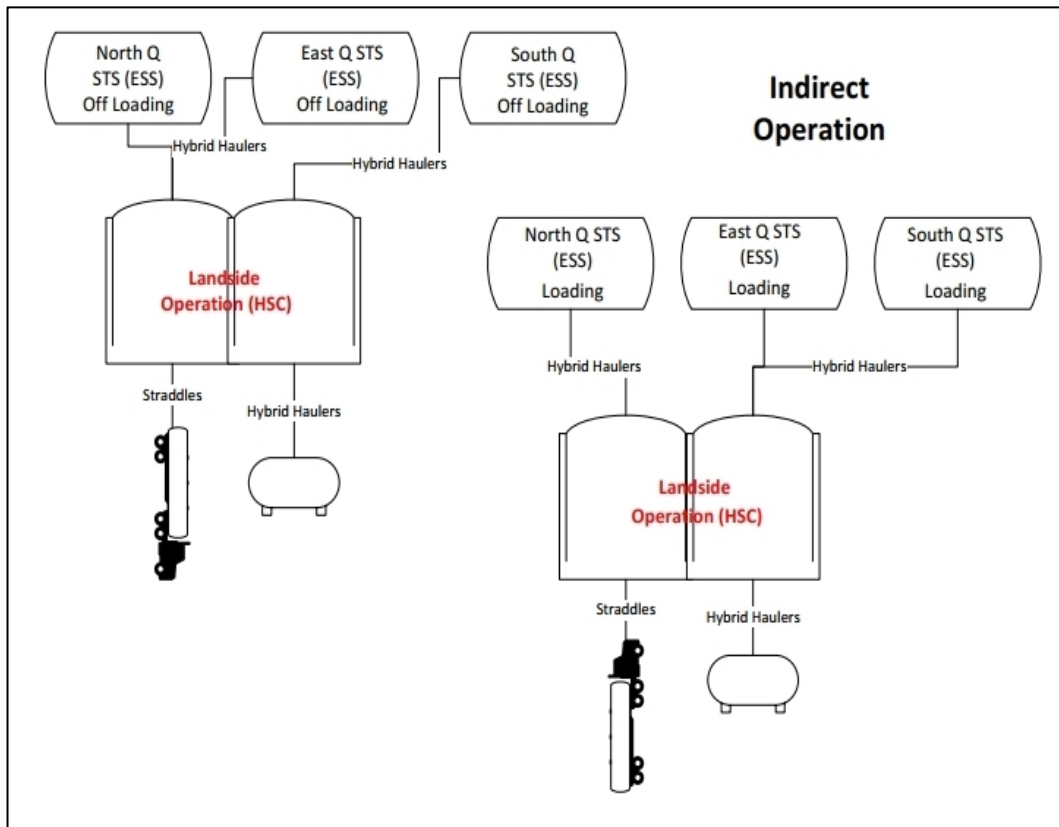


Figure 4.10: Indirect operation layout

Source: Author

Advantages

- The DCT traditional operation with the terminal is well-known, however, it is not a preferred operation due to flexibility restrictions.
- The SC will travel a shorter distance, reducing the equipment's maintenance.
- The hybrid equipment will reduce fuel consumption.
- The dry port will increase the number of wagon trains and reduce the number of trucks entering the terminal.
- Reduction in grid power consumption after the introduction of ocean wave energy and energy shaving technology.
- Diesel-electric engine trains will also reduce cable theft since grid power will not be required.
- A reduction in SC acquisition and an increase in hybrid haulers are cheaper than SC.

Disadvantages

- Some of the hybrid equipment has less power and torque.
- Technical training will be required for the new hybrid technology.
- NatCor's infrastructure has deteriorated, and the current infrastructure has a lot of restrictions.
- Capital investment will be required for the refurbishment of ocean wave energy, energy shaving technology, and the NatCor rail network infrastructure.

4.4.3 Direct Operation with Green Zone and Hybrid Haulers

This scenario assumed the following:

- Direct operation with diesel-electric SC with the introduction of the green zone to reduce the distance travelled;
- Includes the introduction of hybrid haulers between the green zone stacking yard;
- Introduction of Cato Ridge/Camperdown dry port and road-to-rail strategy; and
- Introduction of ocean wave energy and energy shaving technology.

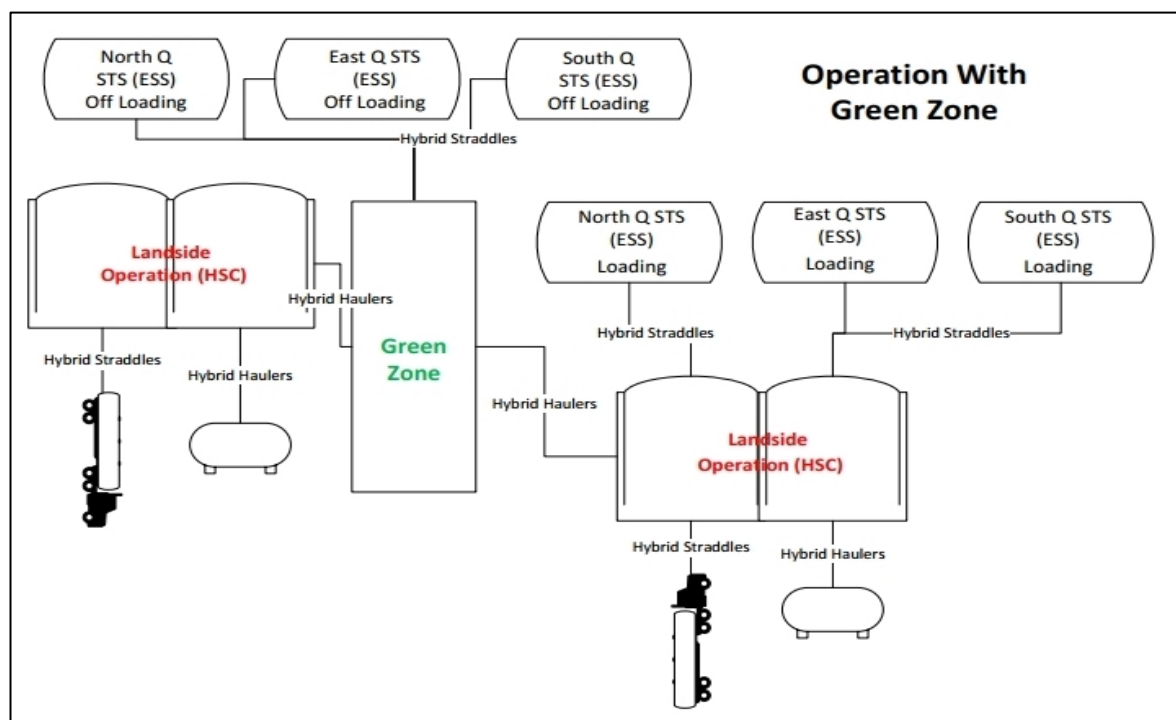


Figure 4.11: Direct operation, with green zone layout

Source: Author

Advantages

- The SC will travel a shorter distance, reducing the equipment's maintenance.
- The hybrid equipment will reduce fuel consumption.
- The dry port will increase the number of wagon trains and reduce the number of trucks entering the terminal.
- A reduction in grid power consumption after the introduction of ocean wave energy and energy shaving technology.
- Diesel-electric engine trains will also reduce cable theft since grid power will not be required.
- A reduction in SC acquisition and an increase in hybrid haulers are cheaper than SC.

Disadvantage

- This is a new operational method, which may introduce operational interference.
- Some of the hybrid equipment has less power and torque.
- Technical training will be required for the new hybrid technology.
- NatCor's infrastructure has deteriorated, and the current infrastructure has a lot of restrictions.
- Capital investment will be required for the refurbishment of ocean wave energy, energy shaving technology, and the NatCor rail network infrastructure.

4.5 Operating Simulation Model

The results from the observation and data collected concluded that port equipment, road, rail and the absence of dry ports are the main contributors to CO₂ emission release during the full Port/Rail Interface and integrated logistics system. The inefficiencies in the current multimodal transport system contribute to the high release of CO₂. The DCT terminal layout has been excluded from the list of contributors to excessive CO₂ release. However, effective operational planning has come under the spotlight to SC travelling more than 70km as a set target. Long-distance SC travel creates excessive CO₂ release and reduces the lifespan of the equipment since it is designed for short-distance operation. A shorter distance is recommended.

Port equipment (STS and RMGs) use a significant amount of electricity during operation and consumption increases during peak periods. Peak-hour electricity consumption contribute significantly to DCT monthly electricity bill. DCT does not have peak shaving technology, that aims to flatten the energy peak demand curve during operation. Wave energy is an alternative and reliable renewable technology. The wave energy renewable resources power at a given site is available up to 90% of the time, while solar and wind availability tends to be available just 20–30% of the time. DCT does not have renewable energy generation technology present at the terminal. Renewable energy is recommended to provide relief for traditional grid usage. The poor rail condition and absence of a dry port have led to road freight dominating the market share; road freight transports 80% of containerised goods, and 20% is transported by rail. The operating simulation scenario design is based on introducing the dry port model to test sustainable development goals. The figure below illustrates the DCT integrated operation scenario.

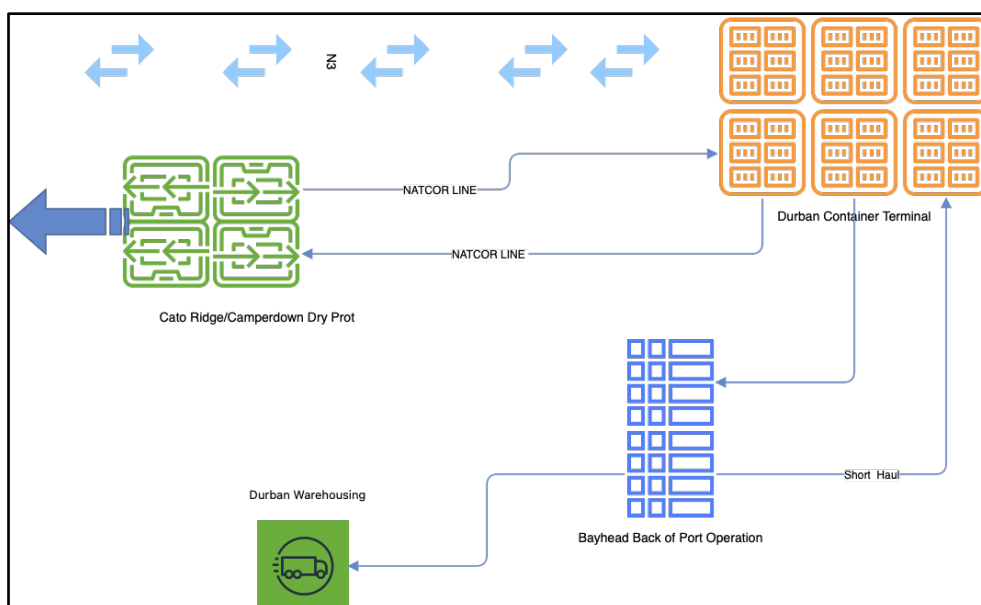


Figure 4.12: DCT integrated operation proposed model

Source: Author

The DCT integrated operation simulation scenarios are based on introducing dry ports and adopting mass evacuation to dry ports, which will promote decent work, economic growth, and sustainable cities and communities. The aim is to reduce road freight dominance in the market share and increase rail freight. Climate action contribution will improve.

The three operating sustainable development scenarios for DCT were adopted to find possible recommendations for DCT to make positive steps in achieving the NDP's and the UN's sustainable development goals.

4.5.1 Simulation Result

The simulation model was developed to test sustainable development goals and analyse operational findings. The simulation confirmed that the dominant cause of CO₂ release contributed to DCT's failure to achieve sustainable development goals. The figure below illustrates an overview of the relationship between rail, trucks and port equipment, including a scenario representation of CO₂ contribution.

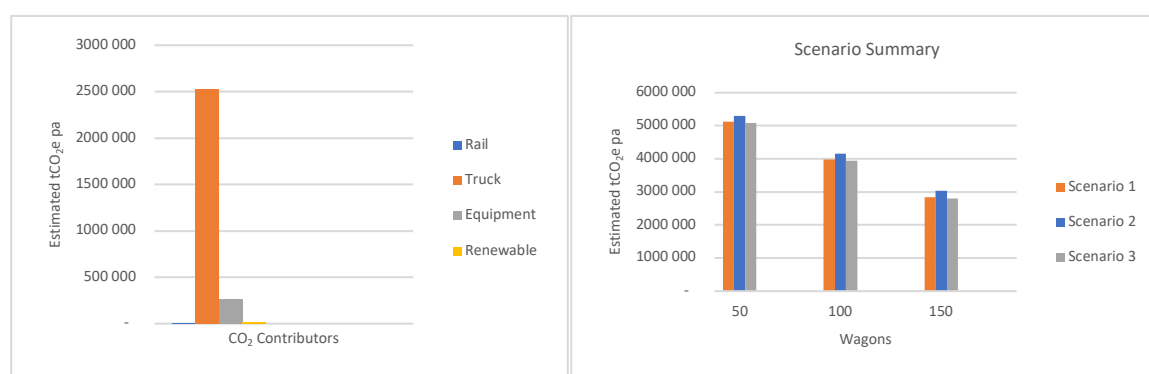


Figure 4.13: CO₂ contribution summary and Scenario summary results

Source: Simulator Results

The simulating model in Figure 4.13 confirms the dominance of trucks and is followed by port equipment concerning CO₂ release. The simulator scenario summary in Figure 4.13 illustrates the impact of ineffective rail freight. It indicates that if you increase the number of wagons, the number of trucks on the road is reduced, resulting in a reduction in CO₂ release. The impact of poor rail condition is evidenced in the simulator scenario summary in Figure 4.13. The current condition forces integrated operation to 50 wagons instead of 75, 100, and 150 wagons, leading to high CO₂ release. The best-simulated scenario reduces the CO₂ release by 42% (2 003 526tCO₂e per annum). However, it has made big operational changes and capital investments. The rail infrastructure is the current stumbling block to unlocking decent work, economic growth and sustainable cities and communities within the Midlands region. All simulated scenarios have a direct correlation to poor rail

conditions. The DCT terminal operation has a 10% (274 276tCO₂e pa) CO₂ release contribution to the DCT integrated operation.

4.5.2 Scenario One

Scenario one assumed the current direct SC operation with the introduction of hybrid port equipment and energy-saving technology for cranes (STS and RMGs). Introducing hybrid port equipment will reduce the CO₂ release contribution to the DCT operation by 37% (diesel). The energy-saving technology for the cranes (STS and RMGs) will further reduce the CO₂ release contribution to the DCT operation by 43% (electricity). All port equipment combined initiatives will reduce the DCT operation CO₂ release contribution by 37%. The increase in wagons (150) in the rail network and the introduction of dry ports maintain its current CO₂ release profile, while the road (trucks) CO₂ release profile reduces by 47%. Scenario one promotes the reduction of container trucks, calling for a DCT terminal. Scenario one reduces the CO₂ release contribution to the DCT integrated operation by 41%. The figure below illustrates an overview of the relationship between rail, trucks and port equipment, including scenario one's representation of CO₂ contribution.

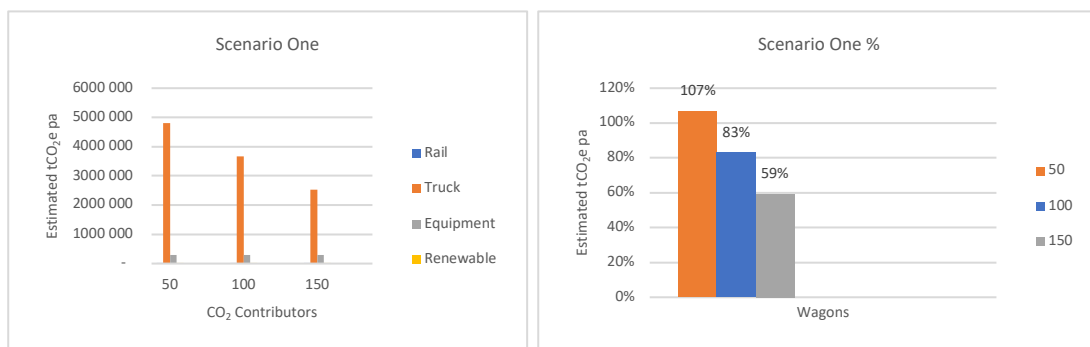


Figure 4.14: Scenario one CO₂ summary and Scenario one CO₂ reduction results
Source: Simulator Results

The simulating model in Figure 4.14 confirms the reduction of trucks concerning the increase of wagons to 150. The simulator scenario in Figure 4.14 illustrates the impact of improving and upgrading rail freight infrastructure. It indicates that if you increase the number of wagons, the number of trucks on the road is reduced, resulting in a reduction in CO₂ release. The impact of poor rail condition is evidenced in the simulator scenario in Figure 4. 14. The current condition forces the integrated

operation to 50 wagons instead of 150 wagons, leading to high CO₂ release. Scenario one reduces the CO₂ release by 41% (1 959 174tCO₂e pa). However, it has not any big operational changes or capital investment.

a) Operational Changes

This scenario has no significant operational changes within the DCT terminal operation. Hybrid equipment and energy-saving technology can be introduced gradually during the port equipment end-of-life replacement period. A significant change will be in the DCT integrated operation, introducing a dry port and upgrading the rail infrastructure to accommodate the train's 150 wagons.

b) Capital Impact

The rail upgrade and dry port infrastructure will attract significant capital investment. The estimated cost is based on the market cost. The rail infrastructure is estimated at R 23m per kilometre, and the dry port infrastructure is estimated at R 30 000 per m². Table 4.6 illustrates the estimated capital investment required to achieve scenario one's objectives.

Table 4.6: Scenario one estimated capital investment summary

Source: Author

No.	Activities	Quantity	Rate	Total
1	Rail infrastructure	120km	R 23 000 000	R 2 760 000 000.00
2	Dry Port Infrastructure	20 000m ²	R 30 000	R 600 000 000.00
3	Port Equipment's	15	R 15 000 000	R 225 000 000.00
Sub Total				R 3 585 000 000.00
4	6% Escalation			R 215 100 000.00
Total				R 3 800 100 000.00

The rail infrastructure is the biggest contributor to the success and the failure of the sustainable development goals, and the associated cost required to upgrade the infrastructure. This is evident in scenario one's simulation result.

4.5.3 Scenario Two

Scenario two assumed the indirect diesel-electric SC operation by introducing hybrid haulers and energy-saving technology for cranes (STS and RMGs). The port equipment combination will increase the CO₂ release contribution to the DCT operation by 1% (diesel) due to the hauler travelling a longer distance and SC being diesel. The energy-saving technology for the cranes (STS and RMGs) will further reduce the CO₂ release contribution to the DCT operation by 43% (electricity). All port equipment's initiative has no significant reduction in CO₂ release (1%) during DCT operation. The increase in wagons (150) in the rail network and the introduction of dry ports have the same result as in scenario one's simulation. Scenario two reduces the CO₂ release contribution to the DCT integrated operation by 37%. The figure below illustrates an overview of the relationship between rail and trucks, including representing scenario two's CO₂ contribution.

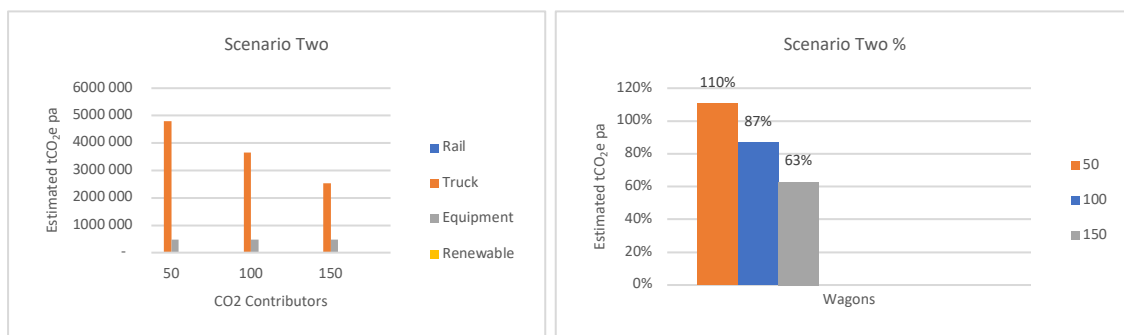


Figure 4.15: Scenario two CO₂ summary and Scenario two CO₂ reduction results

Source: Simulator Results

The simulating model has confirmed the direct correlation between road and rail freight, as indicated in scenario one. Scenario two reduces the CO₂ release by 37% (1 776 779tCO₂e pa). However, it has big operational changes and capital investments.

a) Operational Changes

This scenario has a significant operational change within the DCT terminal operation. The hybrid haulers and energy-saving technology can be introduced gradually during the port equipment end-of-life replacement period. The significant change will be in indirect operation and the DCT integrated operation as per scenario one.

b) Capital Impact

Scenario two has the same financial requirements as scenario one. However, scenario two has less CO₂ reduction compared to scenario one. The rail infrastructure is still the biggest contributor to the success or failure of sustainable development goals.

4.5.4 Scenario Three

Scenario three assumed the current direct SC operation with a green zone and the introduction of hybrid port equipment and energy-saving technology for cranes (STS and RMGs). Introducing hybrid port equipment will reduce the CO₂ release contribution to the DCT operation by 46% (diesel). All port equipment combined initiative will reduce the DCT operation CO₂ release contribution by 46%. Scenario three reduces the CO₂ release contribution to the DCT integrated operation by 42%. The figure below illustrates an overview of the relationship between rail and trucks, including scenario one's representation of CO₂ contribution.

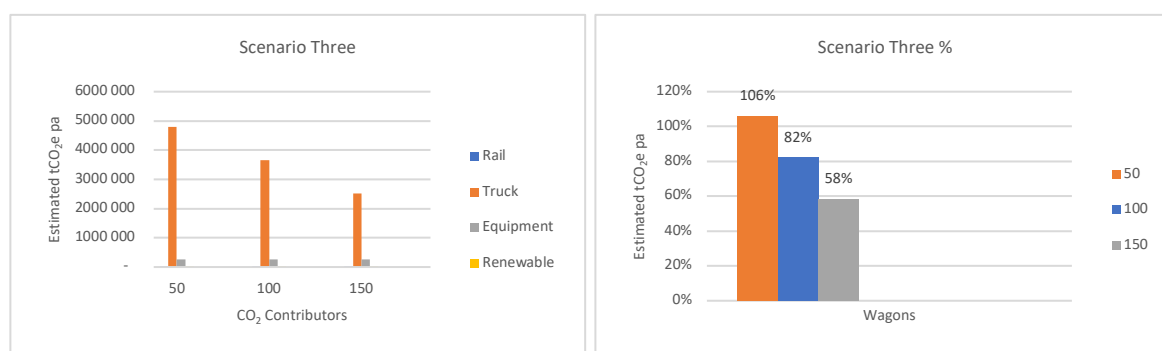


Figure 4.16: Scenario two CO₂ summary and Scenario two CO₂ reduction results

Source: Simulator Results

Scenario three also confirms the direct correlation between road and rail freight, as indicated in scenarios one and two. Scenario three reduces the CO₂ release by 42% (2 003 526tCO₂e pa) and has the biggest CO₂ release reduction, more than the other two scenarios. However, it has the biggest operational changes and capital investment than any other scenario.

a) Operational Changes

This scenario has a significant operational change within the DCT terminal operation. The hybrid and energy-saving technologies can be introduced gradually during the port equipment end-of-life replacement period. The significant change will introduce a green zone and the DCT integrated operation as per scenarios one and two.

b) Capital Impact

Scenario three has the biggest financial requirement, more so than scenarios one and two. However, scenario three has a larger CO₂ reduction compared to scenarios one and two. The rail infrastructure is still the biggest contributor to the success or failure of sustainable development goals. Table 4.7 below illustrates the estimated capital investment required to achieve scenario three objectives.

Table 4.7: Scenario three estimated capital investment summary

Source: Author

No.	Activities	Quantity	Rate	Total
1	Rail infrastructure	120km	R 23 000 000	R 2 760 000 000.00
2	Dry Port Infrastructure	20 000m2	R 30 000	R 600 000 000.00
3	Green Zone	2 000m2	R 2 000	R 4 000 000.00
4	Port Equipment's	15	R 15 000 000	R 225 000 000.00
Sub Total				R 3 589 000 000.00
5	6% Escalation			R 215 340 000.00
Total				R 3 804 340 000.00

4.6 Conclusion

This chapter has presented challenges and a threat to DCT if the current position is not addressed in relation to how to balance operational requirements, to port sustainability. The literature study and engineering reports illustrate the available technologies. The theory supports the critical role played by the dry port, layout, and operating system. The engineering and DCT electricity consumption annual reports confirm the high consumption of energy during operation. Based on its three-year electricity consumption report, the DCT currently consumes 33 135 954kWh per annum.

Based on the simulation results, the DCT terminal operation has an insignificant contribution to CO₂ release. Ineffective operational planning is in the spotlight. However, improving operational planning will not significantly change the contribution of CO₂ release. The DCT terminal operation contributes only 10% to the DCT integrated operation's CO₂ release. Road and rail freight are the main contributors to the DCT integrated operation's CO₂ release. Combined road and rail freight releases 90% CO₂ during the DCT integrated operation.

The simulating model confirmed trucks dominated CO₂ emissions, followed by port equipment. The results illustrate the impact of the ineffective role of rail freight. It indicates that if the number of wagons is increased, the number of trucks on the road will reduce, resulting in a reduction in CO₂ release. The impact of poor rail conditions is the main reason DCT integrated terminal operation is not achieving sustainable development goals. The DCT terminal sustainable development initiatives will not significantly change the CO₂ release profile. However, it is DCT's terminal obligation to play its role in achieving sustainable development goals. Road and rail freight will be forced to follow suit.

4.6.1 Overview Results

Layout and Operation

The observation conducted in the DCT terminal layout did not indicate a correlation with excessive CO₂ release or significant differences in CO₂ emission contribution between parallel and perpendicular layouts. The case study published by www.nature.com supported this observation. The case study results clarified that both layouts are suitable for future development. However, effective operational planning has come under the spotlight with SC travelling more than 70km as a set target. SC long-distance travel creates excessive CO₂ release and reduces lifespan of the equipment since it is designed for short-distance operation.

Equipment and Infrastructure

DCT is a straddle carrier-based operation system. Straddle operation is flexible enough to accommodate any operational changes. Terminal layouts can be simply altered, as SCs can be easily moved within the terminal since no pre-set routes or tracks are needed (Böse & Pirhonen 2011). This operation is perfect for the DCT Z-shape layout. The system can easily migrate to hybrid equipment without changing the current operation.

The DCT electricity consumption annual report confirms the high consumption of energy during operation. The studies indicated that Peak-hour electricity consumption contribute significantly to DCT monthly electricity bill. Natural resources will be badly

affected if high peak energy consumption is not well balanced (Iris & Lam 2019a). The study results indicated that a saving of 9–15% in energy consumption with the implementation of energy recovery and storage systems (ESS) in port cranes can reduce their energy consumption. DCT is in need of the operational strategy that aims to reduce energy consumption during peak hours. The observation indicated problems with relaying to one energy supply source, which originates from a fossil energy source. Wave energy technology is the best alternative to DCT as a renewable technology. Wave energy is dependable and always available compared to other green energy sources.

Combined equipment and electrical infrastructure contribute 58 967tCO₂e of 4 799 146tCO₂e for DCT integrated logistics. By adopting the available technologies, DCT can reduce CO₂ emissions by approximately +/- 55%.

Road and Rail

Rail operations are admittable comparatively efficient user of energy and fuel with less emission than other transport means (Wang 2014). DCT rail integration network conditions have deteriorated as track maintenance was deferred because of a lack of funding. This has resulted in poor railway lines. The rail conditions have led to an increase in temporary speed restrictions (TSRs), which impacts the train service turn-around time that has increased, and reduced throughput. The poor rail condition limits the rail operation opportunities for achieving the Transnet Road to Rail strategy, which requires significant capital investment to implement. Low carbon dioxide emissions benefit can only be realised on a functional rail network; hence, the road network dominates the market share. Road transport is the main CO₂ emitter in international trade-related transport due to its high emission intensity per ton-kilometre compared with other modes, producing over half of all trade-related freight emissions. Road freight's share of total international trade-related emissions will grow from 53% in 2010 to 56% by 2050. The current road CO₂ emission contribution is 4 725 136tCO₂e of 4 799 146 tCO₂e for DCT integrated logistics. With the 98% DCT integrated operation CO₂ emissions profile, climate action, and sustainable cities and communities will not be achieved without good rail network infrastructure.

Dry Ports

The dry port is the link of different modes of transport for handling and storage. The introduction of the Cato Ridge/Camperdown dry port as one of the NatCor inland terminals will create intermodal hubs within the region and promote economic growth through the development of inland regions by developing new cities next to the dry port (Hodgkinson 2018). This will increase efficiencies and capacities, and new rolling stock will result in more freight being handled on the rail, with reduced road congestion, carbon emissions and transportation costs (Transnet 2010).

The poor rail conditions have led to an increase in temporary speed restrictions (TSRs). These restrictions will make the proposed Cato Ridge/Camperdown dry port unviable. The rail network is the main dependence on the proposed Cato Ridge/Camperdown dry port. The potential for economic growth through the development of inland regions and the estimated reduction of 148 200 containers (annually) travelling by road if container wagons increase from 50 to 100 wagons. The proposed 150-container wagon designed by the Transnet development plan can double the reduction of containers travelling by road to 296 400 containers (annual). This will reduce carbon emissions by 30 085.4tCO₂e. Introducing the Cato Ridge/Camperdown dry port is impossible without a good rail network infrastructure that promotes climate action and sustainable cities and communities.

The results from the port equipment, infrastructure, road and rail integration and dry port explain why DCT fails to achieve the sustainable development goals set by the NDP and the UN. These reasons can be categorised into the following focus areas of sustainable development goals:

a) **Affordable and Clean Energy, Industry, Innovation and Infrastructure:**

DCT does not have port equipment, renewable technology, or alternative energy supplies. DCT depends on the main grid energy supply originating from fossil energy sources. This has led to a total of 58 967tCO₂e for DCT operation from equipment and electrical infrastructure. By adopting the available technologies, DCT can reduce CO₂ emissions by approximately +/- 55%.

- b) **Decent Work and Economic Growth, Sustainable Cities and Communities:** The poor rail conditions have increased temporary speed restrictions (TSRs). These restrictions will make the proposed Cato Ridge/Camperdown dry port unviable. The lack of investment in the rail infrastructure and TSR take away the opportunity that comes from having the dry port promote decent work, economic growth and sustainable cities and communities.
- c) **Climate Action:** The poor rail conditions have led to an increase in temporary speed restrictions (TSRs), and the lack of investment in the rail infrastructure takes away the opportunity to reduce the number of containers travelling by road. The DCT integrated logistics is missing a possible CO₂ emission release reduction of carbon emissions by 30 085.4tCO₂e if 296 400 containers (annual) were to travel by rail. With all the missing renewable technologies, renewable energy initiatives and rail, the CO₂ emission release reduction is estimated at 59 149.4tCO₂e.

The next chapter's analysis will assist in providing the best operating and sustainable development scenario for DCT. The sustainable development scenario simulation outcome will offer possible recommendations to DCT to make positive steps in achieving sustainable development goals by the NDP and the UN.

4.6.2 Simulation Results

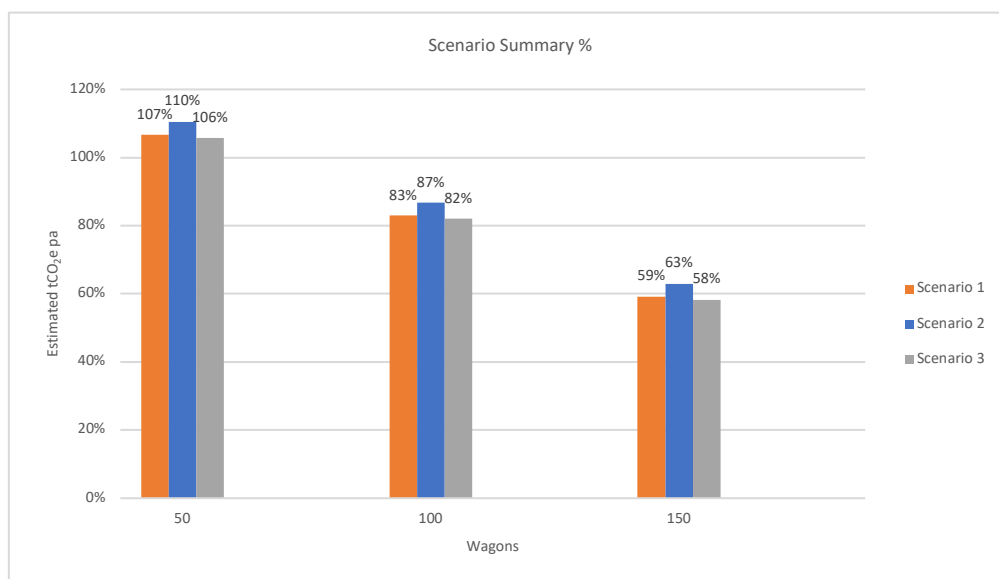


Figure 4.17: Scenario CO₂ summary comparison

Source: Simulator Results

The Figure 4.17 indicate the best-simulated scenario reduces the CO₂ release by 42% (2 003 526tCO₂e pa). However, it requires significant operational changes and capital investment. The rail infrastructure is the current stumbling block in unlocking decent work, economic growth, sustainable cities, and communities within the Midlands region. All simulated scenarios have a direct correlation to the poor rail condition. The DCT terminal operation has a 10% (274 276tCO₂e pa) CO₂ release contribution to the DCT integrated operation.

Scenario one is the recommended integrated operating model since it has no significant operational changes within the DCT terminal. The hybrid equipment and energy-saving technology can be introduced gradually during the port equipment end-of-life replacement period. The significant change will be in the DCT integrated operation, introducing a dry port and upgrading the rail infrastructure to accommodate the train's 150 wagons. This integrated operating model will reduce DCT's operations CO₂ release contribution by 37%. The increase in wagons by 150 in the rail network and the introduction of dry ports maintain its current CO₂ release profile, while the road (trucks) CO₂ release profile reduces by 47%. This promotes the reduction of container trucks, calling for a DCT terminal, unlocks decent work and economic growth, and creates sustainable cities and communities within the Midlands region. This integrated operating model will unlock the selected sustainable development goals that follow:

- Affordable and clean energy: The introduction of energy shaving and renewable wave energy technology will reduce energy consumption and operational costs.
- Sustainable cities, decent work and economic growth: Converting the Cato Ridge/Camperdown siding to dry port and improving the poor condition of the NatCor rail.
- Climate action: Reducing Road freight, increasing rail freight and introducing hybrid port equipment will lead to a reduction in CO₂ release.
- Industry, innovation and infrastructure: This will be part of energy shaving and renewable wave energy technology, including upgrading port crane infrastructure by implementing energy recovery and storage systems (ESS), leading to energy consumption reduction.

CHAPTER 5

RECOMMENDATION

The result and findings of this study have confirmed that the DCT terminal integrated operation is a threat to sustainable development in the region. The results and findings on the port equipment, infrastructure, road and rail integration and dry port explain the extent of sustainable development's impact on the region.

Scenario one is the recommended integrated operating model since it has no significant operational changes within the DCT terminal. Hybrid equipment and energy-saving technology can be introduced gradually during the port equipment end-of-life replacement period. The significant change will be in the DCT integrated operation, including introducing a dry port and upgrading the rail infrastructure to accommodate the train's 150 wagons. This integrated operating model will reduce the DCT operation's CO₂ release contribution by 37%. The increase in wagons (150) in the rail network and the introduction of dry ports maintain its current CO₂ release profile, while the road (trucks) CO₂ release profile reduces by 47%. The proposed solution promotes the reduction of container trucks, calls for a DCT terminal, unlocking decent work and economic growth and sustainable cities and communities within the Midlands region.

This study's results and findings have confirmed that road and rail freight are the main contributors to the DCT's integrated CO₂ release. The combined road and rail freight releases 90% CO₂ during the DCT integrated operation. However, shifting from road freight to rail freight will be one step in the right direction. Poor rail conditions and the absence of a dry port and capital funding make it impossible for the concept to be viable.

The DCT terminal operation contributes only 10% to the DCT integrated intermodal operation's CO₂ release. However, it still contributes to CO₂ release, which can also be reduced. This study has confirmed that investing in renewable energy technologies will reduce CO₂ emissions by approximately +/- 55%. Scenario one, which recommended an integrated operating model, has demonstrated that the DCT

terminal obligation to play its role in achieving sustainable development goals is achievable. For this to be achieved, the following recommendation must be adopted.

5.1 Dry Port Private Partnership

Sustainable Cities and Communities and Decent work and economic growth

TPT and TFR invite private investors to build and operate a dry port terminal in Cato Ridge/Camperdown. The involvement of the private sector is one of the best practices adopted around the world, leading to increased quality of service, improved efficiency of operations and improved allocation of public spending (Zhu 2015). The Cato Ridge/Camperdown dry port will connect of one or more modes of transport for the handling, storage and regulatory inspection of goods moving in regional trade and the execution of applicable customs control and formalities. The Cato Ridge/Camperdown dry port will discourage people from migrating to Durban and promote economic growth through the development of the Midlands regions by developing Cato Ridge/Camperdown as a new city next to the dry port. The Cato Ridge/Camperdown dry port will support the road-to-rail transition and reduce the number of trucks on the road, resulting in an approximately +/- 30% CO₂ release reduction if integrated into DCT's integrated intermodal operation. Ensure people have jobs that pay enough to support themselves and their families.

5.2 Rail Upgrade Private Partnership

Climate Action, Decent Work and Economic Growth

TFR invites private investors to invest and share profits on the Durban and Cato Ridge/Camperdown NatCor routes. The investment will also include network maintenance, which brings wider dissemination of best practices, leading to increased quality of service, improved efficiency of operations and improved allocation of public spending. The rail upgrade will remove or reduce the temporary speed restrictions (TSRs), and fewer restrictions will make the Cato Ridge/Camperdown dry port viable. The rail network is the main dependence on the proposed Cato Ridge/Camperdown dry port. The upgraded rail network will accommodate 150 container wagons designed by the Transnet development plan, which can double the reduction of containers

travelling by road to 296 400 containers (annually). This will reduce carbon emissions by 30 085.4tCO₂e and promote climate action, decent work, and economic growth within the DCT integrated intermodal operation.

5.3 Investing in Renewable Energy Technologies

Industry, Innovation and Infrastructure

TPT should focus on the operational energy saving strategy to reduce energy consumption during operation and peak electricity consumption, which accounts for reducing monthly electricity bills by 25–30%. TPT should invest in ESS technology to peak-shave energy demand during peak energy consumption in the port. TPT should focus on updating the port equipment's technical and functional specifications to align with the proposed hybrid equipment. The introduction of port hybrid equipment should be rolled out during the port equipment end-of-life replacement programme. This will ensure renewable energy technologies will reduce CO₂ emissions by approximately +/- 55% after implementation.

TNPA should invite private investors to build and operate wave energy technology. This technology will create relief for traditional DCT grid usage and present renewable energy generation technology for the port. Further work will be required to select the best option between oceanic wave energy and breakwater turbines.

5.4 Rail Network Agency

Establishment of Rail Network Agency

National Department of Transport to reconsider the establishment of a rail network agency similar to SANRAL. Establishing a rail network agency will assist in financing, managing and maintaining the national road network. The rail infrastructure may eliminate the temporary speed restrictions (TSRs). This will improve rail availability and promote a road-to-rail strategy.

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List of Appendices

Appendix 1: Transported containerised cargo

2007/08							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	19064	82615	25712	127391	15,0	64,9	20,2
May	17949	80053	23315	121317	14,8	66,0	19,2
Jun	17389	81772	21601	120762	14,4	67,7	17,9
Jul	16202	82197	22054	120453	13,5	68,2	18,3
Aug	19213	81006	21463	121682	15,8	66,6	17,6
Sep	19505	85917	23002	128424	15,2	66,9	17,9
Oct	17576	80885	24714	123175	14,3	65,7	20,1
Nov	18948	83067	27554	129569	14,6	64,1	21,3
Dec	14925	76669	32257	123851	12,1	61,9	26,0
Jan	13798	64515	25897	104210	13,2	61,9	24,9
Feb	17056	78019	31197	126272	13,5	61,8	24,7
Mar	14709	66192	26592	107493	13,7	61,6	24,7
Total	206334	942907	305358	1454599	14,2	64,8	21,0

2008/09							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	17544	68510	30773	116827	15,0	58,6	26,3
May	16229	68098	27878	112205	14,5	60,7	24,8
Jun	15217	72727	30146	118090	12,9	61,6	25,5
Jul	14803	69869	28429	113101	13,1	61,8	25,1
Aug	17616	72589	27573	117778	15,0	61,6	23,4
Sep	15521	68844	30471	114836	13,5	59,9	26,5
Oct	16844	73203	28859	118906	14,2	61,6	24,3
Nov	17633	77268	42939	137840	12,8	56,1	31,2
Dec	12780	57844	47080	117704	10,9	49,1	40,0
Jan	12458	50168	35438	98064	12,7	51,2	36,1
Feb	11131	53745	33510	98386	11,3	54,6	34,1
Mar	13910	54691	31384	99985	13,9	54,7	31,4
Total	181686	787556	394480	1363722	13,3	57,8	28,9

2009/10							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	15735	63338	32189	111262	14,1	56,9	28,9
May	18111	61760	26792	106663	17,0	57,9	25,1
Jun	15107	65500	32882	113489	13,3	57,7	29,0
Jul	14004	58301	22057	94362	14,8	61,8	23,4
Aug	18649	60158	30014	108821	17,1	55,3	27,6
Sep	16568	66660	31661	114889	14,4	58,0	27,6
Oct	16175	58494	34689	109358	14,8	53,5	31,7
Nov	15787	66168	40811	122766	12,9	53,9	33,2
Dec	14650	57281	32703	104634	14,0	54,7	31,3
Jan	15791	56204	36015	108010	14,6	52,0	33,3
Feb	17260	63640	35704	116604	14,8	54,6	30,6
Mar	16825	60099	27654	104578	16,1	57,5	26,4
Total	194662	737603	383171	1315436	14,8	56,1	29,1

2010/11							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	18965	63843	28684	111492	17,0	57,3	25,7
May	8588	30789	16351	55728	15,4	55,2	29,3
Jun	18567	77976	29730	126273	14,7	61,8	23,5
Jul	19492	74572	29172	123236	15,8	60,5	23,7
Aug	20718	81787	21194	123699	16,7	66,1	17,1
Sep	21124	79961	25675	126760	16,7	63,1	20,3
Oct	18728	66796	24591	110115	17,0	60,7	22,3
Nov	18786	75905	31245	125936	14,9	60,3	24,8
Dec	15398	62766	28389	106553	14,5	58,9	26,6
Jan	17486	56300	28208	101994	17,1	55,2	27,7
Feb	19995	65022	29968	114985	17,4	56,5	26,1
Mar	14681	55307	25982	95970	15,3	57,6	27,1
Total	212528	791024	319189	1322741	16,1	59,8	24,1

2011/12							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	12486	53670	14137	80293	15,6	66,8	17,6
May	16938	67526	26473	110937	15,3	60,9	23,9
Jun	17096	74174	23350	114620	14,9	64,7	20,4
Jul	17924	64052	22476	104452	17,2	61,3	21,5
Aug	16603	66806	23193	106602	15,6	62,7	21,8
Sep	18519	73193	18035	109747	16,9	66,7	16,4
Oct	18933	75324	19929	114186	16,6	66,0	17,5
Nov	16550	76470	19223	112243	14,7	68,1	17,1
Dec	15713	68100	21179	104992	15,0	64,9	20,2
Jan	13378	59988	27564	100930	13,3	59,4	27,3
Feb	15967	65249	18595	99811	16,0	65,4	18,6
Mar	15623	58219	18059	91901	17,0	63,3	19,7
Total	195730	802771	252213	1250714	15,6	64,2	20,2

2012/13							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	16939	69900	21699	108538	15,6	64,4	20,0
May	15406	67968	23039	106413	14,5	63,9	21,7
Jun	16014	73658	20732	110404	14,5	66,7	18,8
Jul	12671	57415	19321	89407	14,2	64,2	21,6
Aug	15242	74352	12951	102545	14,9	72,5	12,6
Sep	15673	63971	10466	90110	17,4	71,0	11,6
Oct	15887	78287	9510	103684	15,3	75,5	9,2
Nov	13134	67988	10321	91443	14,4	74,4	11,3
Dec	12905	55868	9160	77933	16,6	71,7	11,8
Jan	14922	67826	7948	90696	16,5	74,8	8,8
Feb	15802	61092	11813	88707	17,8	68,9	13,3
Mar	14503	56748	11724	82975	17,5	68,4	14,1
Total	179098	795073	168684	1142855	15,7	69,6	14,8

2013/14							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	14628	64650	13849	93127	15,7	69,4	14,9
May	17909	63422	9373	90704	19,7	69,9	10,3
Jun	19340	75135	17606	112081	17,3	67,0	15,7
Jul	16189	70501	22653	109343	14,8	64,5	20,7
Aug	15826	73004	19130	107960	14,7	67,6	17,7
Sep	15959	69150	19630	104739	15,2	66,0	18,7
Oct	16470	63391	20243	100104	16,5	63,3	20,2
Nov	20086	73226	16399	109711	18,3	66,7	14,9
Dec	17402	67244	17172	101818	17,1	66,0	16,9
Jan	18789	60213	15744	94746	19,8	63,6	16,6
Feb	19634	61059	16388	97081	20,2	62,9	16,9
Mar	14909	44649	19618	79176	18,8	56,4	24,8
Total	207141	785644	207805	1200590	17,3	65,4	17,3

2014/15							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	19137	57851	16197	93185	20,5	62,1	17,4
May	15379	59452	13785	88616	17,4	67,1	15,6
Jun	17468	63067	17802	98337	17,8	64,1	18,1
Jul	14906	66516	24251	105673	14,1	62,9	22,9
Aug	14510	70187	22054	106751	13,6	65,7	20,7
Sep	15898	72308	21657	109863	14,5	65,8	19,7
Oct	15385	70234	24246	109865	14,0	63,9	22,1
Nov	14889	71558	20217	106664	14,0	67,1	19,0
Dec	14380	66153	22741	103274	13,9	64,1	22,0
Jan	13275	61150	25617	100042	13,3	61,1	25,6
Feb	14183	67155	37190	118528	12,0	56,7	31,4
Mar	14516	62226	21954	98696	14,7	63,0	22,2
Total	183926	787857	267711	1239494	14,8	63,6	21,6

2015/16							
Month	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)	Total (TEU's)	Rail (TEU's)	Road (TEU's)	Tranships (TEU's)
Apr	16378	65445	28180	110003	14,9	59,5	25,6
May	13732	67112	17452	98296	14,0	68,3	17,8
Jun	15749	68425	29890	114064	13,8	60,0	26,2
Jul	12600	71766	20772	105138	12,0	68,3	19,8
Aug	17585	79248	18764	115597	15,2	68,6	16,2
Sep	16422	75319	15640	107381	15,3	70,1	14,6
Oct	14424	75391	16681	106496	13,5	70,8	15,7
Nov	15307	69901	16912	102120	15,0	68,4	16,6
Dec	12077	63915	21131	97123	12,4	65,8	21,8
Jan	11679	55718	23894	91291	12,8	61,0	26,2
Feb	12909	65311	23565	101785	12,7	64,2	23,2
Mar	13460	57806	21912	93178	14,4	62,0	23,5
Total	172322	815357	254793	1242472	13,9	65,6	20,5

Appendix 4: Summary Truck Visit for 2020/21 Financial Year

24hr		Years	
Duration	Monthly		
Months	Time of Day (No.)	Terminal (No.)	Sum of Trucks (No.)
2020	733	733	454 982
Apr	82	82	36 429
May	77	77	53 277
Jun	84	84	53 591
Jul	81	81	41 433
Aug	83	83	54 529
Sep	84	84	52 296
Oct	80	80	51 764
Nov	85	85	59 347
Dec	77	77	52 316
2021	239	239	160 227
Jan	79	79	48 606
Feb	85	85	60 975
Mar	75	75	50 646
Grand Total	972	972	615 209

Appendix 5: Truck Visit for 2020/21 Financial Year

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/06/29	Y	1 Morning	8	B	348	44	391	11	28	39
Mon	2020/07/20	Y	1 Morning	8	B	302	38	338	14	29	43
Fri	2020/11/06	Y	1 Morning	8	B	696	87	903	15	28	43
Mon	2020/12/14	Y	1 Morning	8	B	531	66	731	12	31	43
Mon	2020/10/26	Y	1 Morning	8	C	632	79	866	12	33	45
Mon	2020/10/12	Y	1 Morning	8	B	615	77	799	11	35	46
Wed	2020/08/19	Y	1 Morning	8	A	712	89	939	16	31	47
Mon	2020/10/19	Y	1 Morning	8	A	655	82	887	13	34	47
Thu	2020/05/14	Y	1 Morning	8	C	575	72	771	13	36	49
Wed	2020/07/01	Y	1 Morning	8	B	491	61	556	12	38	50
Tue	2020/07/21	Y	1 Morning	8	B	380	48	464	13	37	50
Fri	2021/03/19	Y	1 Morning	8	A	807	101	1158	15	36	51
Mon	2020/05/11	Y	1 Morning	8	C	499	62	696	12	42	54
Tue	2020/10/13	Y	1 Morning	8	B	630	79	890	14	40	54
Thu	2020/12/03	Y	1 Morning	8	A	618	77	870	13	41	54
Wed	2021/03/24	Y	1 Morning	8	C	707	88	867	17	37	54
Tue	2020/04/07	Y	1 Morning	8	B	444	56	519	13	42	55
Fri	2020/12/04	Y	1 Morning	8	A	552	69	716	18	37	55
Tue	2020/10/20	Y	1 Morning	8	A	457	57	646	19	37	56
Wed	2021/03/17	Y	1 Morning	8	A	436	55	548	12	44	56
Fri	2020/04/10	Y	4 12 Hr Day	12	A	574	48	698	11	28	39
Sat	2020/04/11	Y	4 12 Hr Day	12	A	659	55	776	15	38	53
Sun	2020/04/12	Y	4 12 Hr Day	12	A	629	52	749	11	37	48
Mon	2020/04/13	Y	4 12 Hr Day	12	A	544	45	646	13	46	59

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Sat	2020/04/04	Y	4 12 Hr Day	12	B	720	60	905	19	44	63
Sun	2020/04/05	Y	4 12 Hr Day	12	B	502	42	577	25	35	60
Sat	2020/04/25	Y	4 12 Hr Day	12	B	681	57	857	14	59	73
Sat	2020/03/28	Y	4 12 Hr Day	12	C	321	27	390	11	48	59
Sun	2020/03/29	Y	4 12 Hr Day	12	C	231	19	271	14	63	77
Sat	2020/04/18	Y	4 12 Hr Day	12	C	837	70	1088	29	79	108
Sun	2020/04/19	Y	4 12 Hr Day	12	C	1027	86	1249	11	71	82
Mon	2020/04/06	Y	2 Afternoon	8	A	426	53	488	59	72	131
Tue	2020/04/07	Y	2 Afternoon	8	A	466	58	545	42	77	119
Wed	2020/04/08	Y	2 Afternoon	8	A	588	74	721	70	88	158
Thu	2020/04/09	Y	2 Afternoon	8	A	641	80	754	26	63	89
Mon	2020/03/30	Y	2 Afternoon	8	B	480	60	594	71	117	188
Tue	2020/03/31	Y	2 Afternoon	8	B	313	39	383	17	71	88
Wed	2020/04/01	Y	2 Afternoon	8	B	233	29	253	24	86	110
Thu	2020/04/02	Y	2 Afternoon	8	B	158	20	182	16	45	61
Fri	2020/04/03	Y	2 Afternoon	8	B	515	64	651	45	64	109
Mon	2020/04/20	Y	2 Afternoon	8	B	611	76	776	41	90	131
Tue	2020/04/21	Y	2 Afternoon	8	B	654	82	846	99	88	187
Wed	2020/04/22	Y	2 Afternoon	8	B	773	97	1121	77	71	148
Thu	2020/04/23	Y	2 Afternoon	8	B	668	84	1054	82	71	153
Fri	2020/04/24	Y	2 Afternoon	8	B	632	79	883	29	70	99
Thu	2020/03/26	Y	2 Afternoon	8	C	514	64	635	406	184	590
Fri	2020/03/27	Y	2 Afternoon	8	C	184	23	288	36	32	68
Tue	2020/04/14	Y	2 Afternoon	8	C	406	51	491	14	132	146
Wed	2020/04/15	Y	2 Afternoon	8	C	508	64	595	24	102	126
Thu	2020/04/16	Y	2 Afternoon	8	C	644	81	724	30	105	135
Fri	2020/04/17	Y	2 Afternoon	8	C	675	84	828	70	97	167
Sat	2020/04/04	Y	5 12 Hr Night	12	A	372	31	467	14	29	43

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Sun	2020/04/05	Y	5 12 Hr Night	12	A	156	13	179	9	34	43
Sat	2020/04/25	Y	5 12 Hr Night	12	A	530	44	667	43	70	113
Sat	2020/03/28	Y	5 12 Hr Night	12	B	90	8	110	63	42	105
Sun	2020/03/29	Y	5 12 Hr Night	12	B	60	5	70	26	36	62
Sat	2020/04/18	Y	5 12 Hr Night	12	B	624	52	810	69	110	179
Sun	2020/04/19	Y	5 12 Hr Night	12	B	767	64	933	14	52	66
Fri	2020/04/10	Y	5 12 Hr Night	12	C	486	41	590	13	36	49
Sat	2020/04/11	Y	5 12 Hr Night	12	C	325	27	383	12	34	46
Sun	2020/04/12	Y	5 12 Hr Night	12	C	180	15	215	14	33	47
Mon	2020/04/13	Y	5 12 Hr Night	12	C	225	19	268	13	35	48
Mon	2020/03/30	Y	3 Night	8	A	186	23	230	30	104	134
Tue	2020/03/31	Y	3 Night	8	A	168	21	206	59	144	203
Wed	2020/04/01	Y	3 Night	8	A	16	2	17	17	31	48
Thu	2020/04/02	Y	3 Night	8	A	188	24	217	31	25	56
Fri	2020/04/03	Y	3 Night	8	A	339	42	428	61	43	104
Mon	2020/04/20	Y	3 Night	8	A	227	28	289	81	123	204
Tue	2020/04/21	Y	3 Night	8	A	562	70	727	129	80	209
Wed	2020/04/22	Y	3 Night	8	A	648	81	939	96	74	170
Thu	2020/04/23	Y	3 Night	8	A	577	72	910	118	77	195
Fri	2020/04/24	Y	3 Night	8	A	491	61	686	42	71	113
Thu	2020/03/26	Y	3 Night	8	B	376	47	464	283	156	439
Fri	2020/03/27	Y	3 Night	8	B	107	13	167	31	36	67
Tue	2020/04/14	Y	3 Night	8	B	458	57	554	35	120	155
Wed	2020/04/15	Y	3 Night	8	B	526	66	615	51	124	175
Thu	2020/04/16	Y	3 Night	8	B	547	68	615	43	106	149
Fri	2020/04/17	Y	3 Night	8	B	600	75	735	56	87	143
Mon	2020/04/06	Y	3 Night	8	C	214	27	245	16	96	112
Tue	2020/04/07	Y	3 Night	8	C	363	45	424	39	95	134

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Wed	2020/04/08	Y	3 Night	8	C	463	58	568	48	106	154
Thu	2020/04/09	Y	3 Night	8	C	301	38	354	15	48	63
Fri	2020/03/27	Y	1 Morning	8	A	276	35	433	20	37	57
Mon	2020/04/06	Y	1 Morning	8	B	410	51	470	21	36	57
Wed	2020/10/14	Y	1 Morning	8	B	911	114	1322	19	38	57
Wed	2020/11/25	Y	1 Morning	8	B	732	92	982	17	41	58
Thu	2020/09/10	Y	1 Morning	8	A	864	108	1266	16	43	59
Mon	2020/09/21	Y	1 Morning	8	B	276	35	385	16	43	59
Fri	2020/12/11	Y	1 Morning	8	C	868	109	1214	14	45	59
Fri	2020/04/03	Y	1 Morning	8	C	281	35	355	11	49	60
Mon	2020/12/21	Y	1 Morning	8	A	669	84	884	14	46	60
Tue	2020/04/14	Y	1 Morning	8	A	401	50	485	13	49	62
Mon	2020/11/09	Y	1 Morning	8	A	589	74	797	11	51	62
Mon	2020/05/25	Y	1 Morning	8	A	614	77	792	24	39	63
Mon	2020/09/28	Y	1 Morning	8	A	624	78	824	20	43	63
Thu	2020/12/17	Y	1 Morning	8	B	832	104	1226	16	47	63
Tue	2020/06/30	Y	1 Morning	8	B	484	61	580	17	47	64
Tue	2021/03/16	Y	1 Morning	8	A	540	68	681	13	51	64
Tue	2021/03/23	Y	1 Morning	8	C	596	75	715	12	52	64
Fri	2020/12/18	Y	1 Morning	8	B	741	93	1007	13	52	65
Thu	2020/07/30	Y	1 Morning	8	A	644	81	851	33	33	66
Fri	2020/05/01	N	4 12 Hr Day	12	A	0	0	0	0	0	0
Sat	2020/05/02	Y	4 12 Hr Day	12	A	601	50	826	108	108	216
Sun	2020/05/03	Y	4 12 Hr Day	12	A	712	59	1003	129	104	233
Sat	2020/05/23	Y	4 12 Hr Day	12	A	1133	94	1680	55	55	110
Sun	2020/05/24	Y	4 12 Hr Day	12	A	1101	92	1569	90	85	175
Sun	2020/04/26	Y	4 12 Hr Day	12	B	555	46	765	10	52	62
Mon	2020/04/27	Y	4 12 Hr Day	12	B	851	71	1311	13	48	61

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Sat	2020/05/16	Y	4 12 Hr Day	12	B	1157	96	1667	19	53	72
Sun	2020/05/17	Y	4 12 Hr Day	12	B	1043	87	1311	15	52	67
Sat	2020/05/09	Y	4 12 Hr Day	12	C	803	67	1095	26	84	110
Sun	2020/05/10	Y	4 12 Hr Day	12	C	827	69	1219	44	79	123
Tue	2020/04/28	Y	2 Afternoon	8	A	575	72	900	140	87	227
Wed	2020/04/29	Y	2 Afternoon	8	A	626	78	902	124	80	204
Thu	2020/04/30	Y	2 Afternoon	8	A	617	77	841	159	104	263
Mon	2020/05/18	Y	2 Afternoon	8	A	599	75	824	69	84	153
Tue	2020/05/19	Y	2 Afternoon	8	A	544	68	803	190	118	308
Wed	2020/05/20	Y	2 Afternoon	8	A	446	56	652	275	122	397
Thu	2020/05/21	Y	2 Afternoon	8	A	565	71	769	101	102	203
Fri	2020/05/22	Y	2 Afternoon	8	A	831	104	1060	33	55	88
Mon	2020/05/11	Y	2 Afternoon	8	B	654	82	912	30	109	139
Tue	2020/05/12	Y	2 Afternoon	8	B	923	115	1248	120	82	202
Wed	2020/05/13	Y	2 Afternoon	8	B	706	88	939	27	54	81
Thu	2020/05/14	Y	2 Afternoon	8	B	679	85	910	17	44	61
Fri	2020/05/15	Y	2 Afternoon	8	B	869	109	1177	21	49	70
Mon	2020/05/04	Y	2 Afternoon	8	C	623	78	877	141	106	247
Tue	2020/05/05	Y	2 Afternoon	8	C	727	91	1123	72	96	168
Wed	2020/05/06	Y	2 Afternoon	8	C	635	79	1038	23	80	103
Thu	2020/05/07	Y	2 Afternoon	8	C	746	93	1200	65	83	148
Fri	2020/05/08	Y	2 Afternoon	8	C	504	63	724	27	80	107
Mon	2020/05/25	Y	2 Afternoon	8	C	778	97	1005	24	50	74
Sun	2020/04/26	Y	5 12 Hr Night	12	A	647	54	892	13	38	51
Mon	2020/04/27	Y	5 12 Hr Night	12	A	776	65	1195	16	46	62
Sat	2020/05/16	Y	5 12 Hr Night	12	A	756	63	1090	19	44	63
Sun	2020/05/17	Y	5 12 Hr Night	12	A	610	51	766	19	40	59
Sat	2020/05/09	Y	5 12 Hr Night	12	B	856	71	1166	54	86	140

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Sun	2020/05/10	Y	5 12 Hr Night	12	B	939	78	1383	85	86	171
Fri	2020/05/01	N	5 12 Hr Night	12	C	0	0	0	0	0	0
Sat	2020/05/02	Y	5 12 Hr Night	12	C	894	75	1229	136	108	244
Sun	2020/05/03	Y	5 12 Hr Night	12	C	765	64	1078	142	137	279
Sat	2020/05/23	Y	5 12 Hr Night	12	C	1007	84	1493	109	96	205
Sun	2020/05/24	Y	5 12 Hr Night	12	C	957	80	1365	106	74	180
Mon	2020/05/11	Y	3 Night	8	A	720	90	1003	67	87	154
Tue	2020/05/12	Y	3 Night	8	A	842	105	1139	142	91	233
Wed	2020/05/13	Y	3 Night	8	A	569	71	757	26	43	69
Thu	2020/05/14	Y	3 Night	8	A	563	70	754	28	56	84
Fri	2020/05/15	Y	3 Night	8	A	677	85	917	25	61	86
Mon	2020/05/04	Y	3 Night	8	B	728	91	1026	229	81	310
Tue	2020/05/05	Y	3 Night	8	B	683	85	1055	115	104	219
Wed	2020/05/06	Y	3 Night	8	B	779	97	1272	82	88	170
Thu	2020/05/07	Y	3 Night	8	B	619	77	996	34	67	101
Fri	2020/05/08	Y	3 Night	8	B	633	79	910	82	85	167
Mon	2020/05/25	Y	3 Night	8	B	662	83	854	34	57	91
Tue	2020/04/28	Y	3 Night	8	C	752	94	1178	151	80	231
Wed	2020/04/29	Y	3 Night	8	C	471	59	677	162	108	270
Thu	2020/04/30	Y	3 Night	8	C	458	57	624	161	119	280
Mon	2020/05/18	Y	3 Night	8	C	587	73	808	173	110	283
Tue	2020/05/19	Y	3 Night	8	C	558	70	822	317	138	455
Wed	2020/05/20	Y	3 Night	8	C	514	64	750	173	134	307
Thu	2020/05/21	Y	3 Night	8	C	581	73	791	181	114	295
Fri	2020/05/22	Y	3 Night	8	C	924	116	1179	35	55	90
Tue	2020/12/22	Y	1 Morning	8	A	677	85	915	20	46	66
Tue	2020/12/01	Y	1 Morning	8	A	538	67	747	18	49	67
Fri	2020/05/08	Y	1 Morning	8	A	703	88	1011	29	39	68

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/07/06	Y	1 Morning	8	A	562	70	735	16	52	68
Mon	2020/08/17	Y	1 Morning	8	A	514	64	683	14	54	68
Fri	2020/09/18	Y	1 Morning	8	C	571	71	826	15	53	68
Tue	2020/11/24	Y	1 Morning	8	B	683	85	878	15	53	68
Wed	2021/03/03	Y	1 Morning	8	C	644	81	800	15	53	68
Fri	2020/05/15	Y	1 Morning	8	C	496	62	672	21	48	69
Mon	2020/11/23	Y	1 Morning	8	B	229	29	312	13	56	69
Fri	2020/07/24	Y	1 Morning	8	B	629	79	704	17	53	70
Thu	2020/04/02	Y	1 Morning	8	C	110	14	127	11	60	71
Mon	2020/08/31	Y	1 Morning	8	B	648	81	890	17	54	71
Wed	2020/04/15	Y	1 Morning	8	A	555	69	649	17	55	72
Thu	2020/11/19	Y	1 Morning	8	C	745	93	1020	13	59	72
Wed	2020/04/01	Y	1 Morning	8	C	157	20	171	9	64	73
Thu	2020/07/23	Y	1 Morning	8	B	638	80	720	18	55	73
Tue	2020/10/27	Y	1 Morning	8	C	819	102	1186	23	50	73
Mon	2020/11/16	Y	1 Morning	8	C	531	66	703	24	49	73
Thu	2021/01/14	Y	1 Morning	8	A	580	73	889	16	57	73
Mon	2021/03/01	Y	1 Morning	8	C	493	62	677	16	57	73
Wed	2020/04/08	Y	1 Morning	8	B	428	54	525	15	59	74
Sat	2020/06/13	Y	4 12 Hr Day	12	A	953	79	1390	45	64	109
Sun	2020/06/14	Y	4 12 Hr Day	12	A	832	69	1132	55	80	135
Tue	2020/06/16	Y	4 12 Hr Day	12	A	948	79	1220	55	60	115
Sat	2020/06/06	Y	4 12 Hr Day	12	B	1143	95	1607	56	68	124
Sun	2020/06/07	Y	4 12 Hr Day	12	B	899	75	1221	28	73	101
Sat	2020/05/30	Y	4 12 Hr Day	12	C	973	81	1340	27	78	105
Sun	2020/05/31	Y	4 12 Hr Day	12	C	819	68	1134	39	73	112
Sat	2020/06/20	Y	4 12 Hr Day	12	C	1082	90	1423	193	65	258
Sun	2020/06/21	Y	4 12 Hr Day	12	C	988	82	1593	17	51	68

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/06/08	Y	2 Afternoon	8	A	480	60	673	23	49	72
Tue	2020/06/09	Y	2 Afternoon	8	A	561	70	776	154	111	265
Wed	2020/06/10	Y	2 Afternoon	8	A	626	78	922	164	82	246
Thu	2020/06/11	Y	2 Afternoon	8	A	675	84	998	219	99	318
Fri	2020/06/12	Y	2 Afternoon	8	A	806	101	1110	160	71	231
Mon	2020/06/01	Y	2 Afternoon	8	B	648	81	867	29	74	103
Tue	2020/06/02	Y	2 Afternoon	8	B	671	84	876	29	101	130
Wed	2020/06/03	Y	2 Afternoon	8	B	612	77	756	20	70	90
Thu	2020/06/04	Y	2 Afternoon	8	B	590	74	700	109	123	232
Fri	2020/06/05	Y	2 Afternoon	8	B	850	106	1104	84	76	160
Mon	2020/06/22	Y	2 Afternoon	8	B	647	81	914	96	73	169
Tue	2020/06/23	Y	2 Afternoon	8	B	633	79	830	156	99	255
Wed	2020/06/24	Y	2 Afternoon	8	B	529	66	723	155	106	261
Thu	2020/06/25	Y	2 Afternoon	8	B	700	88	835	38	88	126
Tue	2020/05/26	Y	2 Afternoon	8	C	627	78	866	156	90	246
Wed	2020/05/27	Y	2 Afternoon	8	C	546	68	722	196	115	311
Thu	2020/05/28	Y	2 Afternoon	8	C	630	79	842	128	108	236
Fri	2020/05/29	Y	2 Afternoon	8	C	589	74	776	102	121	223
Mon	2020/06/15	Y	2 Afternoon	8	C	736	92	864	54	88	142
Wed	2020/06/17	Y	2 Afternoon	8	C	635	79	809	84	105	189
Thu	2020/06/18	Y	2 Afternoon	8	C	616	77	825	165	93	258
Fri	2020/06/19	Y	2 Afternoon	8	C	692	87	974	231	96	327
Sat	2020/06/06	Y	5 12 Hr Night	12	A	944	79	1326	55	80	135
Sun	2020/06/07	Y	5 12 Hr Night	12	A	430	36	585	18	61	79
Sat	2020/05/30	Y	5 12 Hr Night	12	B	880	73	1213	109	100	209
Sun	2020/05/31	Y	5 12 Hr Night	12	B	654	55	905	35	60	95
Tue	2020/06/16	Y	5 12 Hr Night	12	B	539	45	694	59	78	137
Sat	2020/06/20	Y	5 12 Hr Night	12	B	990	83	1301	52	60	112

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Sun	2020/06/21	Y	5 12 Hr Night	12	B	655	55	1057	15	38	53
Sat	2020/06/13	Y	5 12 Hr Night	12	C	770	64	1124	36	84	120
Sun	2020/06/14	Y	5 12 Hr Night	12	C	720	60	979	108	100	208
Mon	2020/06/01	Y	3 Night	8	A	513	64	686	66	88	154
Tue	2020/06/02	Y	3 Night	8	A	391	49	511	43	55	98
Wed	2020/06/03	Y	3 Night	8	A	416	52	514	52	101	153
Thu	2020/06/04	Y	3 Night	8	A	514	64	610	222	75	297
Fri	2020/06/05	Y	3 Night	8	A	576	72	748	108	92	200
Mon	2020/06/22	Y	3 Night	8	A	551	69	779	123	96	219
Tue	2020/06/23	Y	3 Night	8	A	612	77	802	197	102	299
Wed	2020/06/24	Y	3 Night	8	A	481	60	657	155	117	272
Thu	2020/06/25	Y	3 Night	8	A	242	30	289	17	55	72
Tue	2020/05/26	Y	3 Night	8	B	739	92	1020	164	107	271
Wed	2020/05/27	Y	3 Night	8	B	714	89	945	148	110	258
Thu	2020/05/28	Y	3 Night	8	B	550	69	734	171	131	302
Fri	2020/05/29	Y	3 Night	8	B	629	79	829	144	125	269
Mon	2020/06/15	Y	3 Night	8	B	698	87	819	44	88	132
Wed	2020/06/17	Y	3 Night	8	B	549	69	700	118	90	208
Thu	2020/06/18	Y	3 Night	8	B	540	68	723	344	120	464
Fri	2020/06/19	Y	3 Night	8	B	676	85	952	254	91	345
Mon	2020/06/08	Y	3 Night	8	C	393	49	550	28	77	105
Tue	2020/06/09	Y	3 Night	8	C	437	55	603	277	186	463
Wed	2020/06/10	Y	3 Night	8	C	662	83	976	195	106	301
Thu	2020/06/11	Y	3 Night	8	C	662	83	980	277	108	385
Fri	2020/06/12	Y	3 Night	8	C	644	81	887	84	92	176
Thu	2020/07/16	Y	1 Morning	8	C	476	60	615	13	61	74
Fri	2020/08/07	Y	1 Morning	8	C	588	74	782	17	58	75
Thu	2020/04/09	Y	1 Morning	8	B	505	63	594	14	62	76

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/06/08	Y	1 Morning	8	B	279	35	391	14	62	76
Tue	2020/12/08	Y	1 Morning	8	C	160	20	251	15	61	76
Thu	2021/03/25	Y	1 Morning	8	C	689	86	964	25	51	76
Wed	2020/07/22	Y	1 Morning	8	B	476	60	595	15	62	77
Thu	2020/08/20	Y	1 Morning	8	A	667	83	873	28	49	77
Wed	2020/09/02	Y	1 Morning	8	B	172	22	207	20	57	77
Thu	2020/08/27	Y	1 Morning	8	C	385	48	499	14	63	77
Mon	2020/09/14	Y	1 Morning	8	C	470	59	648	11	67	78
Fri	2020/10/02	Y	1 Morning	8	A	636	80	856	23	55	78
Thu	2020/11/05	Y	1 Morning	8	B	682	85	914	36	42	78
Wed	2020/06/03	Y	1 Morning	8	C	472	59	582	20	59	79
Fri	2020/09/11	Y	1 Morning	8	A	569	71	794	23	57	80
Fri	2021/03/05	Y	1 Morning	8	C	525	66	804	20	60	80
Tue	2020/03/31	Y	1 Morning	8	C	216	27	264	17	64	81
Mon	2020/06/15	Y	1 Morning	8	A	580	73	681	17	64	81
Mon	2020/09/07	Y	1 Morning	8	A	522	65	694	28	53	81
Thu	2020/10/15	Y	1 Morning	8	B	610	76	815	20	61	81
Tue	2020/12/15	Y	1 Morning	8	B	699	87	985	19	62	81
Sat	2020/07/04	Y	4 12 Hr Day	12	A	939	78	1147	37	112	149
Sun	2020/07/05	Y	4 12 Hr Day	12	A	1031	86	1253	40	80	120
Sat	2020/07/25	Y	4 12 Hr Day	12	A	304	25	363	14	22	36
Sat	2020/06/27	Y	4 12 Hr Day	12	B	779	65	1534	24	69	93
Sun	2020/06/28	Y	4 12 Hr Day	12	B	615	51	738	14	35	49
Sat	2020/07/18	Y	4 12 Hr Day	12	B	962	80	1119	14	43	57
Sun	2020/07/19	Y	4 12 Hr Day	12	B	693	58	843	13	39	52
Sat	2020/07/11	Y	4 12 Hr Day	12	C	758	63	928	24	100	124
Sun	2020/07/12	Y	4 12 Hr Day	12	C	818	68	965	41	71	112
Mon	2020/06/29	Y	2 Afternoon	8	A	425	53	477	19	27	46

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Tue	2020/06/30	Y	2 Afternoon	8	A	633	79	758	107	100	207
Wed	2020/07/01	Y	2 Afternoon	8	A	522	65	591	25	66	91
Thu	2020/07/02	Y	2 Afternoon	8	A	657	82	819	71	102	173
Fri	2020/07/03	Y	2 Afternoon	8	A	599	75	733	205	100	305
Mon	2020/07/20	Y	2 Afternoon	8	A	354	44	397	19	30	49
Tue	2020/07/21	Y	2 Afternoon	8	A	551	69	672	45	73	118
Wed	2020/07/22	Y	2 Afternoon	8	A	686	86	857	58	59	117
Thu	2020/07/23	Y	2 Afternoon	8	A	798	100	900	35	36	71
Fri	2020/07/24	Y	2 Afternoon	8	A	654	82	731	40	52	92
Fri	2020/06/26	Y	2 Afternoon	8	B	807	101	1087	25	73	98
Mon	2020/07/13	Y	2 Afternoon	8	B	575	72	716	117	103	220
Tue	2020/07/14	Y	2 Afternoon	8	B	651	81	791	122	100	222
Wed	2020/07/15	Y	2 Afternoon	8	B	621	78	742	82	78	160
Thu	2020/07/16	Y	2 Afternoon	8	B	617	77	797	111	91	202
Fri	2020/07/17	Y	2 Afternoon	8	B	706	88	870	44	93	137
Mon	2020/07/06	Y	2 Afternoon	8	C	464	58	606	62	138	200
Tue	2020/07/07	Y	2 Afternoon	8	C	89	11	108	19	287	306
Wed	2020/07/08	Y	2 Afternoon	8	C	309	39	390	122	120	242
Thu	2020/07/09	Y	2 Afternoon	8	C	413	52	536	218	128	346
Fri	2020/07/10	Y	2 Afternoon	8	C	665	83	817	48	93	141
Sat	2020/06/27	Y	5 12 Hr Night	12	A	365	30	718	27	51	78
Sun	2020/06/28	Y	5 12 Hr Night	12	A	88	7	105	17	24	41
Sat	2020/07/18	Y	5 12 Hr Night	12	A	573	48	666	16	38	54
Sun	2020/07/19	Y	5 12 Hr Night	12	A	309	26	376	24	28	52
Sat	2020/07/11	Y	5 12 Hr Night	12	B	622	52	761	51	65	116
Sun	2020/07/12	Y	5 12 Hr Night	12	B	335	28	396	31	79	110
Sat	2020/07/04	Y	5 12 Hr Night	12	C	784	65	958	16	122	138
Sun	2020/07/05	Y	5 12 Hr Night	12	C	532	44	647	34	107	141

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Sat	2020/07/25	Y	5 12 Hr Night	12	C	235	20	281	13	28	41
Fri	2020/06/26	Y	3 Night	8	A	644	81	867	64	90	154
Mon	2020/07/13	Y	3 Night	8	A	493	62	614	123	97	220
Tue	2020/07/14	Y	3 Night	8	A	403	50	490	146	88	234
Wed	2020/07/15	Y	3 Night	8	A	407	51	487	64	49	113
Thu	2020/07/16	Y	3 Night	8	A	596	75	769	124	88	212
Fri	2020/07/17	Y	3 Night	8	A	462	58	569	50	68	118
Mon	2020/07/06	Y	3 Night	8	B	609	76	797	163	134	297
Tue	2020/07/07	Y	3 Night	8	B	52	7	64	85	252	337
Wed	2020/07/08	Y	3 Night	8	B	140	18	176	271	402	673
Thu	2020/07/09	Y	3 Night	8	B	523	65	678	278	128	406
Fri	2020/07/10	Y	3 Night	8	B	358	45	440	14	53	67
Mon	2020/06/29	Y	3 Night	8	C	338	42	379	16	30	46
Tue	2020/06/30	Y	3 Night	8	C	494	62	591	42	99	141
Wed	2020/07/01	Y	3 Night	8	C	278	35	315	15	141	156
Thu	2020/07/02	Y	3 Night	8	C	486	61	606	169	165	334
Fri	2020/07/03	Y	3 Night	8	C	499	62	610	145	169	314
Mon	2020/07/20	Y	3 Night	8	C	161	20	180	14	66	80
Tue	2020/07/21	Y	3 Night	8	C	542	68	662	20	69	89
Wed	2020/07/22	Y	3 Night	8	C	540	68	675	21	106	127
Thu	2020/07/23	Y	3 Night	8	C	706	88	796	80	62	142
Fri	2020/07/24	Y	3 Night	8	C	210	26	235	13	45	58
Mon	2021/01/04	Y	1 Morning	8	B	514	64	753	11	70	81
Fri	2020/09/04	Y	1 Morning	8	B	464	58	578	15	67	82
Fri	2020/09/25	Y	1 Morning	8	B	695	87	951	21	62	83
Mon	2020/10/05	Y	1 Morning	8	C	473	59	614	10	73	83
Tue	2020/10/06	Y	1 Morning	8	C	618	77	803	19	64	83
Fri	2020/10/09	Y	1 Morning	8	C	488	61	769	41	42	83

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Fri	2020/11/20	Y	1 Morning	8	C	599	75	827	16	67	83
Mon	2021/02/22	Y	1 Morning	8	A	693	87	1062	17	66	83
Mon	2020/06/22	Y	1 Morning	8	C	477	60	674	15	69	84
Thu	2020/10/22	Y	1 Morning	8	A	683	85	846	29	55	84
Fri	2021/01/15	Y	1 Morning	8	A	612	77	763	19	65	84
Mon	2021/03/15	Y	1 Morning	8	A	494	62	650	13	71	84
Thu	2021/03/18	Y	1 Morning	8	A	703	88	894	34	50	84
Wed	2020/06/17	Y	1 Morning	8	A	579	72	737	25	61	86
Fri	2020/07/17	Y	1 Morning	8	C	539	67	664	20	66	86
Thu	2021/03/04	Y	1 Morning	8	C	465	58	569	14	72	86
Wed	2021/01/13	Y	1 Morning	8	A	496	62	775	22	65	87
Mon	2021/03/08	Y	1 Morning	8	B	710	89	1075	14	73	87
Mon	2020/11/02	Y	1 Morning	8	B	480	60	624	17	71	88
Mon	2020/08/24	Y	1 Morning	8	C	543	68	758	17	72	89
Wed	2020/06/24	Y	1 Morning	8	C	555	69	759	20	70	90
Sun	2020/07/26	Y	4 12 Hr Day	12	A	792	66	977	11	45	56
Sat	2020/08/15	Y	4 12 Hr Day	12	A	882	74	1297	156	90	246
Sun	2020/08/16	Y	4 12 Hr Day	12	A	1154	96	1537	77	72	149
Sat	2020/08/08	Y	4 12 Hr Day	12	B	698	58	864	15	30	45
Sun	2020/08/09	Y	4 12 Hr Day	12	B	402	34	430	10	31	41
Mon	2020/08/10	Y	4 12 Hr Day	12	B	663	55	863	19	53	72
Sat	2020/08/01	Y	4 12 Hr Day	12	C	1088	91	1421	16	58	74
Sun	2020/08/02	Y	4 12 Hr Day	12	C	947	79	1297	37	79	116
Sat	2020/08/22	Y	4 12 Hr Day	12	C	1213	101	1676	110	88	198
Sun	2020/08/23	Y	4 12 Hr Day	12	C	1005	84	1276	45	74	119
Tue	2020/08/11	Y	2 Afternoon	8	A	560	70	697	166	99	265
Wed	2020/08/12	Y	2 Afternoon	8	A	727	91	958	234	88	322
Thu	2020/08/13	Y	2 Afternoon	8	A	797	100	1097	148	75	223

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Fri	2020/08/14	Y	2 Afternoon	8	A	616	77	869	215	83	298
Mon	2020/08/03	Y	2 Afternoon	8	B	803	100	1100	173	76	249
Tue	2020/08/04	Y	2 Afternoon	8	B	760	95	1015	133	92	225
Wed	2020/08/05	Y	2 Afternoon	8	B	771	96	1041	32	89	121
Thu	2020/08/06	Y	2 Afternoon	8	B	254	32	348	202	305	507
Fri	2020/08/07	Y	2 Afternoon	8	B	797	100	1060	46	77	123
Mon	2020/08/24	Y	2 Afternoon	8	B	909	114	1270	105	63	168
Tue	2020/08/25	Y	2 Afternoon	8	B	748	94	1060	65	79	144
Mon	2020/07/27	Y	2 Afternoon	8	C	560	70	727	210	132	342
Tue	2020/07/28	Y	2 Afternoon	8	C	630	79	886	200	116	316
Wed	2020/07/29	Y	2 Afternoon	8	C	717	90	897	53	83	136
Thu	2020/07/30	Y	2 Afternoon	8	C	689	86	912	133	133	266
Fri	2020/07/31	Y	2 Afternoon	8	C	732	92	977	94	75	169
Mon	2020/08/17	Y	2 Afternoon	8	C	45	6	60	26	82	108
Tue	2020/08/18	Y	2 Afternoon	8	C	589	74	752	41	106	147
Wed	2020/08/19	Y	2 Afternoon	8	C	579	72	762	82	75	157
Thu	2020/08/20	Y	2 Afternoon	8	C	724	91	947	102	75	177
Fri	2020/08/21	Y	2 Afternoon	8	C	657	82	841	104	107	211
Sat	2020/08/08	Y	5 12 Hr Night	12	A	367	31	455	16	38	54
Sun	2020/08/09	Y	5 12 Hr Night	12	A	284	24	304	47	74	121
Mon	2020/08/10	Y	5 12 Hr Night	12	A	507	42	660	25	113	138
Sat	2020/08/01	Y	5 12 Hr Night	12	B	649	54	847	18	82	100
Sun	2020/08/02	Y	5 12 Hr Night	12	B	743	62	1018	144	111	255
Sat	2020/08/22	Y	5 12 Hr Night	12	B	908	76	1255	90	80	170
Sun	2020/08/23	Y	5 12 Hr Night	12	B	688	57	873	48	62	110
Sun	2020/07/26	Y	5 12 Hr Night	12	C	370	31	457	18	60	78
Sat	2020/08/15	Y	5 12 Hr Night	12	C	847	71	1246	278	151	429
Sun	2020/08/16	Y	5 12 Hr Night	12	C	733	61	977	32	92	124

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/08/03	Y	3 Night	8	A	740	93	1013	218	98	316
Tue	2020/08/04	Y	3 Night	8	A	662	83	884	116	85	201
Wed	2020/08/05	Y	3 Night	8	A	638	80	862	110	84	194
Thu	2020/08/06	Y	3 Night	8	A	551	69	754	291	93	384
Fri	2020/08/07	Y	3 Night	8	A	523	65	695	21	45	66
Mon	2020/08/24	Y	3 Night	8	A	739	92	1033	94	73	167
Tue	2020/08/25	Y	3 Night	8	A	313	39	443	90	88	178
Mon	2020/07/27	Y	3 Night	8	B	543	68	705	370	130	500
Tue	2020/07/28	Y	3 Night	8	B	587	73	824	243	129	372
Wed	2020/07/29	Y	3 Night	8	B	621	78	778	60	80	140
Thu	2020/07/30	Y	3 Night	8	B	684	86	904	146	146	292
Fri	2020/07/31	Y	3 Night	8	B	624	78	834	34	70	104
Mon	2020/08/17	Y	3 Night	8	B	640	80	851	369	174	543
Tue	2020/08/18	Y	3 Night	8	B	596	75	761	40	84	124
Wed	2020/08/19	Y	3 Night	8	B	797	100	1051	78	44	122
Thu	2020/08/20	Y	3 Night	8	B	633	79	828	154	93	247
Fri	2020/08/21	Y	3 Night	8	B	659	82	844	177	100	277
Tue	2020/08/11	Y	3 Night	8	C	522	65	650	305	136	441
Wed	2020/08/12	Y	3 Night	8	C	478	60	631	285	123	408
Thu	2020/08/13	Y	3 Night	8	C	693	87	953	135	100	235
Fri	2020/08/14	Y	3 Night	8	C	833	104	1175	267	73	340
Tue	2020/07/07	Y	1 Morning	8	A	346	43	422	29	61	90
Tue	2020/11/10	Y	1 Morning	8	A	599	75	852	34	56	90
Thu	2020/09/17	Y	1 Morning	8	C	607	76	793	20	71	91
Tue	2020/11/03	Y	1 Morning	8	B	746	93	1119	24	67	91
Fri	2021/02/26	Y	1 Morning	8	A	565	71	909	22	69	91
Thu	2021/02/04	Y	1 Morning	8	A	779	97	1046	39	53	92
Mon	2020/12/07	Y	1 Morning	8	C	528	66	718	21	72	93

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2021/01/11	Y	1 Morning	8	A	531	66	790	27	66	93
Fri	2021/02/05	Y	1 Morning	8	A	776	97	1009	32	61	93
Tue	2021/03/02	Y	1 Morning	8	C	799	100	1105	35	58	93
Mon	2020/06/01	Y	1 Morning	8	C	356	45	476	19	75	94
Wed	2020/07/08	Y	1 Morning	8	A	360	45	454	13	81	94
Thu	2020/07/02	Y	1 Morning	8	B	501	63	625	32	62	94
Wed	2020/08/05	Y	1 Morning	8	C	628	79	848	21	74	95
Fri	2021/02/19	Y	1 Morning	8	B	945	118	1326	20	75	95
Fri	2020/06/26	Y	1 Morning	8	C	418	52	564	18	78	96
Tue	2020/06/09	Y	1 Morning	8	B	524	66	725	23	75	98
Fri	2020/11/13	Y	1 Morning	8	A	820	103	1162	45	54	99
Mon	2020/04/20	Y	1 Morning	8	C	507	63	644	13	87	100
Thu	2020/06/25	Y	1 Morning	8	C	464	58	553	18	82	100
Mon	2020/11/30	Y	1 Morning	8	A	686	86	875	39	61	100
Mon	2020/07/13	Y	1 Morning	8	C	419	52	521	16	85	101
Sat	2020/09/05	Y	4 12 Hr Day	12	A	1006	84	1263	56	52	108
Sun	2020/09/06	Y	4 12 Hr Day	12	A	1063	89	1323	33	56	89
Sat	2020/08/29	Y	4 12 Hr Day	12	B	872	73	1149	105	109	214
Sun	2020/08/30	Y	4 12 Hr Day	12	B	844	70	1134	55	72	127
Sat	2020/09/19	Y	4 12 Hr Day	12	B	998	83	1533	22	65	87
Sun	2020/09/20	Y	4 12 Hr Day	12	B	1045	87	1431	71	75	146
Thu	2020/09/24	Y	4 12 Hr Day	12	B	1017	85	1449	40	71	111
Sat	2020/09/12	Y	4 12 Hr Day	12	C	858	72	1135	26	73	99
Sun	2020/09/13	Y	4 12 Hr Day	12	C	787	66	991	10	53	63
Mon	2020/08/31	Y	2 Afternoon	8	A	727	91	998	87	81	168
Tue	2020/09/01	Y	2 Afternoon	8	A	741	93	1002	131	87	218
Thu	2020/08/27	Y	2 Afternoon	8	B	0	0	0	0	0	0
Thu	2020/09/03	Y	2 Afternoon	8	A	564	71	673	107	113	220

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Fri	2020/09/04	Y	2 Afternoon	8	A	430	54	535	84	84	168
Mon	2020/09/21	Y	2 Afternoon	8	A	533	67	744	314	118	432
Tue	2020/09/22	Y	2 Afternoon	8	A	711	89	1026	133	89	222
Wed	2020/09/23	Y	2 Afternoon	8	A	642	80	884	71	88	159
Fri	2020/09/25	Y	2 Afternoon	8	A	349	44	477	104	134	238
Wed	2020/08/26	Y	2 Afternoon	8	B	647	81	896	402	224	626
Wed	2020/09/02	Y	2 Afternoon	8	A	0	0	0	0	0	0
Fri	2020/08/28	Y	2 Afternoon	8	B	639	80	826	184	86	270
Mon	2020/09/14	Y	2 Afternoon	8	B	628	79	866	20	84	104
Tue	2020/09/15	Y	2 Afternoon	8	B	876	110	1154	116	79	195
Wed	2020/09/16	Y	2 Afternoon	8	B	730	91	1089	37	73	110
Thu	2020/09/17	Y	2 Afternoon	8	B	736	92	960	81	76	157
Fri	2020/09/18	Y	2 Afternoon	8	B	617	77	894	16	53	69
Mon	2020/09/07	Y	2 Afternoon	8	C	553	69	735	149	92	241
Tue	2020/09/08	Y	2 Afternoon	8	C	669	84	964	122	78	200
Wed	2020/09/09	Y	2 Afternoon	8	C	713	89	1019	205	92	297
Thu	2020/09/10	Y	2 Afternoon	8	C	613	77	898	53	75	128
Fri	2020/09/11	Y	2 Afternoon	8	C	720	90	1004	46	87	133
Sat	2020/08/29	Y	5 12 Hr Night	12	A	925	77	1219	91	85	176
Sun	2020/08/30	Y	5 12 Hr Night	12	A	725	60	974	111	72	183
Sat	2020/09/19	Y	5 12 Hr Night	12	A	760	63	1167	43	49	92
Sun	2020/09/20	Y	5 12 Hr Night	12	A	998	83	1366	166	81	247
Sat	2020/09/12	Y	5 12 Hr Night	12	B	295	25	391	93	60	153
Sun	2020/09/13	Y	5 12 Hr Night	12	B	156	13	197	49	78	127
Sat	2020/09/05	Y	5 12 Hr Night	12	C	874	73	1097	63	92	155
Sun	2020/09/06	Y	5 12 Hr Night	12	C	932	78	1160	26	65	91
Thu	2020/09/24	Y	5 12 Hr Night	12	C	756	63	1076	150	108	258
Wed	2020/08/26	Y	3 Night	8	A	632	79	874	101	85	186

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Thu	2020/08/27	Y	3 Night	8	A	616	77	799	440	178	618
Fri	2020/08/28	Y	3 Night	8	A	570	71	737	168	105	273
Mon	2020/09/14	Y	3 Night	8	A	470	59	648	64	86	150
Tue	2020/09/15	Y	3 Night	8	A	632	79	832	159	79	238
Wed	2020/09/16	Y	3 Night	8	A	458	57	683	20	50	70
Thu	2020/09/17	Y	3 Night	8	A	559	70	729	33	66	99
Fri	2020/09/18	Y	3 Night	8	A	547	68	793	27	50	77
Mon	2020/09/07	Y	3 Night	8	B	646	81	858	286	91	377
Tue	2020/09/08	Y	3 Night	8	B	672	84	968	247	88	335
Wed	2020/09/09	Y	3 Night	8	B	787	98	1124	199	75	274
Thu	2020/09/10	Y	3 Night	8	B	760	95	1113	69	79	148
Fri	2020/09/11	Y	3 Night	8	B	612	77	853	94	92	186
Mon	2020/08/31	Y	3 Night	8	C	496	62	681	157	117	274
Tue	2020/09/01	Y	3 Night	8	C	489	61	662	69	105	174
Wed	2020/09/02	Y	3 Night	8	C	282	35	340	750	195	945
Thu	2020/09/03	Y	3 Night	8	C	399	50	476	86	124	210
Fri	2020/09/04	Y	3 Night	8	C	476	60	592	68	89	157
Mon	2020/09/21	Y	3 Night	8	C	680	85	950	134	79	213
Tue	2020/09/22	Y	3 Night	8	C	743	93	1071	209	108	317
Wed	2020/09/23	Y	3 Night	8	C	562	70	773	57	90	147
Fri	2020/09/25	Y	3 Night	8	C	340	43	465	502	134	636
Thu	2021/02/11	Y	1 Morning	8	C	531	66	646	22	79	101
Wed	2020/05/06	Y	1 Morning	8	A	790	99	1290	44	59	103
Thu	2020/05/21	Y	1 Morning	8	B	716	90	974	34	69	103
Tue	2020/07/14	Y	1 Morning	8	C	396	50	482	17	86	103
Mon	2021/01/18	Y	1 Morning	8	C	486	61	662	27	76	103
Wed	2020/05/13	Y	1 Morning	8	C	682	85	908	38	66	104
Mon	2021/02/08	Y	1 Morning	8	C	522	65	847	44	60	104

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Thu	2020/04/23	Y	1 Morning	8	C	670	84	1056	20	85	105
Thu	2020/08/06	Y	1 Morning	8	C	500	63	683	29	76	105
Tue	2020/11/17	Y	1 Morning	8	C	575	72	808	37	68	105
Fri	2021/03/12	Y	1 Morning	8	B	715	89	987	34	72	106
Wed	2020/12/23	Y	1 Morning	8	A	504	63	709	38	70	108
Mon	2021/02/15	Y	1 Morning	8	B	476	60	667	15	93	108
Thu	2020/04/16	Y	1 Morning	8	A	677	85	762	37	72	109
Wed	2020/11/04	Y	1 Morning	8	B	755	94	1077	44	65	109
Tue	2020/05/26	Y	1 Morning	8	A	532	67	735	48	62	110
Mon	2020/07/27	Y	1 Morning	8	A	472	59	612	26	84	110
Tue	2020/05/12	Y	1 Morning	8	C	650	81	879	32	79	111
Wed	2020/10/07	Y	1 Morning	8	C	654	82	858	38	73	111
Fri	2020/04/17	Y	1 Morning	8	A	536	67	657	47	65	112
Sat	2020/09/26	Y	4 12 Hr Day	12	A	1376	115	1979	249	85	334
Sun	2020/09/27	Y	4 12 Hr Day	12	A	992	83	1377	30	60	90
Sat	2020/10/17	Y	4 12 Hr Day	12	A	1066	89	1286	44	64	108
Sun	2020/10/18	Y	4 12 Hr Day	12	A	1024	85	1305	19	44	63
Sat	2020/10/10	Y	4 12 Hr Day	12	B	644	54	860	17	29	46
Sun	2020/10/11	Y	4 12 Hr Day	12	B	942	79	1168	52	56	108
Sat	2020/10/03	Y	4 12 Hr Day	12	C	1003	84	1325	70	94	164
Sun	2020/10/04	Y	4 12 Hr Day	12	C	915	76	1295	29	88	117
Sat	2020/10/24	Y	4 12 Hr Day	12	C	1253	104	1557	67	61	128
Sun	2020/10/25	Y	4 12 Hr Day	12	C	879	73	1169	17	56	73
Mon	2020/10/12	Y	2 Afternoon	8	A	640	80	832	18	27	45
Tue	2020/10/13	Y	2 Afternoon	8	A	163	20	231	179	301	480
Wed	2020/10/14	Y	2 Afternoon	8	A	957	120	1388	47	41	88
Thu	2020/10/15	Y	2 Afternoon	8	A	733	92	979	78	73	151
Fri	2020/10/16	Y	2 Afternoon	8	A	436	55	869	106	65	171

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/10/05	Y	2 Afternoon	8	B	72	9	94	36	82	118
Tue	2020/10/06	Y	2 Afternoon	8	B	768	96	1000	99	83	182
Wed	2020/10/07	Y	2 Afternoon	8	B	178	22	234	70	104	174
Thu	2020/10/08	Y	2 Afternoon	8	B	732	92	965	130	81	211
Fri	2020/10/09	Y	2 Afternoon	8	B	435	54	687	17	43	60
Mon	2020/09/28	Y	2 Afternoon	8	C	593	74	782	58	81	139
Tue	2020/09/29	Y	2 Afternoon	8	C	686	86	879	70	111	181
Wed	2020/09/30	Y	2 Afternoon	8	C	333	42	446	79	76	155
Thu	2020/10/01	Y	2 Afternoon	8	C	474	59	606	244	191	435
Fri	2020/10/02	Y	2 Afternoon	8	C	893	112	1202	83	56	139
Mon	2020/10/19	Y	2 Afternoon	8	C	802	100	1086	29	52	81
Tue	2020/10/20	Y	2 Afternoon	8	C	278	35	393	328	250	578
Wed	2020/10/21	Y	2 Afternoon	8	C	971	121	1286	122	58	180
Thu	2020/10/22	Y	2 Afternoon	8	C	621	78	769	68	67	135
Fri	2020/10/23	Y	2 Afternoon	8	C	777	97	1003	38	38	76
Sat	2020/10/10	Y	5 12 Hr Night	12	A	464	39	619	312	58	370
Sun	2020/10/11	Y	5 12 Hr Night	12	A	436	36	540	19	33	52
Sat	2020/10/03	Y	5 12 Hr Night	12	B	698	58	923	90	74	164
Sun	2020/10/04	Y	5 12 Hr Night	12	B	467	39	662	13	65	78
Sat	2020/10/24	Y	5 12 Hr Night	12	B	955	80	1186	51	47	98
Sun	2020/10/25	Y	5 12 Hr Night	12	B	531	44	707	97	59	156
Sat	2020/09/26	Y	5 12 Hr Night	12	C	938	78	1350	128	106	234
Sun	2020/09/27	Y	5 12 Hr Night	12	C	685	57	951	131	109	240
Sat	2020/10/17	Y	5 12 Hr Night	12	C	542	45	653	41	49	90
Sun	2020/10/18	Y	5 12 Hr Night	12	C	718	60	915	12	41	53
Mon	2020/10/05	Y	3 Night	8	A	549	69	713	260	146	406
Tue	2020/10/06	Y	3 Night	8	A	559	70	728	160	94	254
Wed	2020/10/07	Y	3 Night	8	A	384	48	504	322	254	576

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Thu	2020/10/08	Y	3 Night	8	A	637	80	839	116	87	203
Fri	2020/10/09	Y	3 Night	8	A	348	44	550	19	36	55
Mon	2020/09/28	Y	3 Night	8	B	387	48	511	169	117	286
Tue	2020/09/29	Y	3 Night	8	B	556	70	712	179	123	302
Wed	2020/09/30	Y	3 Night	8	B	495	62	664	419	179	598
Thu	2020/10/01	Y	3 Night	8	B	569	71	728	108	50	158
Fri	2020/10/02	Y	3 Night	8	B	712	89	959	120	78	198
Mon	2020/10/19	Y	3 Night	8	B	810	101	1096	46	50	96
Tue	2020/10/20	Y	3 Night	8	B	638	80	902	279	67	346
Wed	2020/10/21	Y	3 Night	8	B	673	84	891	111	79	190
Thu	2020/10/22	Y	3 Night	8	B	597	75	739	181	83	264
Fri	2020/10/23	Y	3 Night	8	B	764	96	987	98	45	143
Mon	2020/10/12	Y	3 Night	8	C	564	71	732	13	36	49
Tue	2020/10/13	Y	3 Night	8	C	637	80	900	265	46	311
Wed	2020/10/14	Y	3 Night	8	C	509	64	738	29	44	73
Thu	2020/10/15	Y	3 Night	8	C	612	77	816	174	74	248
Fri	2020/10/16	Y	3 Night	8	C	421	53	840	21	73	94
Thu	2020/06/18	Y	1 Morning	8	A	633	79	847	45	67	112
Tue	2021/01/12	Y	1 Morning	8	A	548	69	703	44	68	112
Thu	2020/06/04	Y	1 Morning	8	C	518	65	616	30	83	113
Mon	2020/03/30	Y	1 Morning	8	C	226	28	281	18	96	114
Tue	2020/08/11	Y	1 Morning	8	B	464	58	578	42	73	115
Mon	2020/05/18	Y	1 Morning	8	B	386	48	531	30	86	116
Wed	2020/07/15	Y	1 Morning	8	C	445	56	532	36	80	116
Fri	2021/02/12	Y	1 Morning	8	C	572	72	780	47	69	116
Thu	2020/12/10	Y	1 Morning	8	C	918	115	1394	59	60	119
Thu	2020/12/31	Y	1 Morning	8	C	632	79	854	41	78	119
Wed	2020/04/29	Y	1 Morning	8	B	692	87	997	35	85	120

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2021/01/25	Y	1 Morning	8	B	555	69	882	39	81	120
Fri	2020/04/24	Y	1 Morning	8	C	624	78	870	40	82	122
Fri	2020/07/31	Y	1 Morning	8	A	675	84	902	49	76	125
Fri	2020/10/30	Y	1 Morning	8	C	742	93	922	62	65	127
Thu	2020/05/28	Y	1 Morning	8	A	619	77	827	46	82	128
Wed	2020/09/16	Y	1 Morning	8	C	730	91	1089	41	91	132
Tue	2020/06/02	Y	1 Morning	8	C	530	66	692	43	90	133
Fri	2020/11/27	Y	1 Morning	8	B	706	88	994	72	62	134
Thu	2021/01/07	Y	1 Morning	8	B	738	92	1010	42	94	136
Wed	2021/02/17	Y	1 Morning	8	B	707	88	1074	56	84	140
Wed	2020/10/21	Y	1 Morning	8	A	647	81	857	57	84	141
Tue	2021/02/02	Y	1 Morning	8	A	647	81	1012	69	74	143
Sat	2020/11/07	Y	4 12 Hr Day	12	A	1187	99	1704	42	42	84
Sun	2020/11/08	Y	4 12 Hr Day	12	A	1226	102	1681	40	45	85
Sat	2020/10/31	Y	4 12 Hr Day	12	B	957	80	1229	28	57	85
Sun	2020/11/01	Y	4 12 Hr Day	12	B	922	77	1229	37	58	95
Sat	2020/11/21	Y	4 12 Hr Day	12	B	1114	93	1575	44	65	109
Sun	2020/11/22	Y	4 12 Hr Day	12	B	983	82	1271	15	52	67
Sat	2020/11/14	Y	4 12 Hr Day	12	C	1480	123	2142	48	44	92
Sun	2020/11/15	Y	4 12 Hr Day	12	C	1223	102	1802	27	48	75
Mon	2020/11/02	Y	2 Afternoon	8	A	682	85	886	74	73	147
Tue	2020/11/03	Y	2 Afternoon	8	A	848	106	1272	58	64	122
Wed	2020/11/04	Y	2 Afternoon	8	A	712	89	1016	56	67	123
Thu	2020/11/05	Y	2 Afternoon	8	A	702	88	940	21	43	64
Fri	2020/11/06	Y	2 Afternoon	8	A	914	114	1186	27	29	56
Mon	2020/11/23	Y	2 Afternoon	8	A	509	64	693	19	37	56
Tue	2020/11/24	Y	2 Afternoon	8	A	818	102	1052	58	46	104
Wed	2020/11/25	Y	2 Afternoon	8	A	793	99	1065	62	64	126

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/10/26	Y	2 Afternoon	8	B	778	97	1066	21	64	85
Tue	2020/10/27	Y	2 Afternoon	8	B	887	111	1284	56	59	115
Wed	2020/10/28	Y	2 Afternoon	8	B	716	90	1054	100	77	177
Thu	2020/10/29	Y	2 Afternoon	8	B	375	47	551	124	158	282
Fri	2020/10/30	Y	2 Afternoon	8	B	680	85	844	34	49	83
Mon	2020/11/16	Y	2 Afternoon	8	B	680	85	899	48	54	102
Tue	2020/11/17	Y	2 Afternoon	8	B	688	86	966	76	69	145
Wed	2020/11/18	Y	2 Afternoon	8	B	505	63	688	89	100	189
Thu	2020/11/19	Y	2 Afternoon	8	B	546	68	748	107	103	210
Fri	2020/11/20	Y	2 Afternoon	8	B	703	88	970	48	71	119
Mon	2020/11/09	Y	2 Afternoon	8	C	713	89	965	30	56	86
Tue	2020/11/10	Y	2 Afternoon	8	C	615	77	875	124	83	207
Wed	2020/11/11	Y	2 Afternoon	8	C	758	95	1078	97	72	169
Thu	2020/11/12	Y	2 Afternoon	8	C	977	122	1389	98	65	163
Fri	2020/11/13	Y	2 Afternoon	8	C	882	110	1250	64	63	127
Sat	2020/10/31	Y	5 12 Hr Night	12	A	612	51	785	36	70	106
Sun	2020/11/01	Y	5 12 Hr Night	12	A	420	35	559	82	61	143
Sat	2020/11/21	Y	5 12 Hr Night	12	A	637	53	900	39	64	103
Sun	2020/11/22	Y	5 12 Hr Night	12	A	519	43	672	12	37	49
Sat	2020/11/14	Y	5 12 Hr Night	12	B	719	60	1040	24	47	71
Sun	2020/11/15	Y	5 12 Hr Night	12	B	589	49	868	16	51	67
Sat	2020/11/07	Y	5 12 Hr Night	12	C	949	79	1363	33	37	70
Sun	2020/11/08	Y	5 12 Hr Night	12	C	557	46	763	16	39	55
Mon	2020/10/26	Y	3 Night	8	A	810	101	1109	73	63	136
Tue	2020/10/27	Y	3 Night	8	A	647	81	937	111	88	199
Wed	2020/10/28	Y	3 Night	8	A	598	75	881	121	89	210
Thu	2020/10/29	Y	3 Night	8	A	595	74	873	242	83	325
Fri	2020/10/30	Y	3 Night	8	A	466	58	578	19	45	64

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2020/11/16	Y	3 Night	8	A	623	78	824	89	60	149
Tue	2020/11/17	Y	3 Night	8	A	505	63	710	139	99	238
Wed	2020/11/18	Y	3 Night	8	A	618	77	842	91	71	162
Thu	2020/11/19	Y	3 Night	8	A	528	66	723	40	46	86
Fri	2020/11/20	Y	3 Night	8	A	734	92	1014	104	70	174
Mon	2020/11/09	Y	3 Night	8	B	560	70	757	32	57	89
Tue	2020/11/10	Y	3 Night	8	B	537	67	763	179	118	297
Wed	2020/11/11	Y	3 Night	8	B	690	86	981	85	92	177
Thu	2020/11/12	Y	3 Night	8	B	686	86	975	104	88	192
Fri	2020/11/13	Y	3 Night	8	B	785	98	1112	78	76	154
Mon	2020/11/02	Y	3 Night	8	C	656	82	851	56	59	115
Tue	2020/11/03	Y	3 Night	8	C	689	86	1034	106	68	174
Wed	2020/11/04	Y	3 Night	8	C	529	66	755	86	105	191
Thu	2020/11/05	Y	3 Night	8	C	564	71	756	26	49	75
Fri	2020/11/06	Y	3 Night	8	C	661	83	858	30	38	68
Mon	2020/11/23	Y	3 Night	8	C	156	20	212	16	33	49
Tue	2020/11/24	Y	3 Night	8	C	506	63	651	34	44	78
Wed	2020/11/25	Y	3 Night	8	C	388	49	521	104	63	167
Mon	2020/05/04	Y	1 Morning	8	A	416	52	586	42	102	144
Thu	2020/05/07	Y	1 Morning	8	A	676	85	1087	76	74	150
Wed	2020/12/02	Y	1 Morning	8	A	739	92	1101	68	82	150
Mon	2021/02/01	Y	1 Morning	8	A	68	9	99	84	66	150
Wed	2021/01/27	Y	1 Morning	8	B	770	96	1174	76	76	152
Tue	2021/02/09	Y	1 Morning	8	C	810	101	1269	77	75	152
Wed	2020/11/18	Y	1 Morning	8	C	675	84	918	74	82	156
Tue	2020/08/25	Y	1 Morning	8	C	654	82	926	56	101	157
Tue	2020/04/28	Y	1 Morning	8	B	463	58	726	36	125	161
Wed	2020/07/29	Y	1 Morning	8	A	675	84	845	94	68	162

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Tue	2020/09/22	Y	1 Morning	8	B	806	101	1163	93	70	163
Thu	2020/11/12	Y	1 Morning	8	A	803	100	1141	95	68	163
Tue	2020/06/23	Y	1 Morning	8	C	592	74	777	47	117	164
Fri	2020/08/21	Y	1 Morning	8	A	572	72	732	70	95	165
Tue	2020/05/05	Y	1 Morning	8	A	681	85	1051	92	74	166
Thu	2020/10/29	Y	1 Morning	8	C	691	86	1014	97	71	168
Thu	2021/02/25	Y	1 Morning	8	A	633	79	803	94	74	168
Fri	2020/07/10	Y	1 Morning	8	A	622	78	765	74	98	172
Tue	2021/01/05	Y	1 Morning	8	B	793	99	1177	93	80	173
Thu	2020/10/01	Y	1 Morning	8	A	407	51	521	110	64	174
Sat	2020/11/28	Y	4 12 Hr Day	12	A	780	65	1153	104	89	193
Sun	2020/11/29	Y	4 12 Hr Day	12	A	1096	91	1402	85	55	140
Sat	2020/12/19	Y	4 12 Hr Day	12	A	910	76	1210	170	99	269
Sun	2020/12/20	Y	4 12 Hr Day	12	A	995	83	1303	84	92	176
Sat	2020/12/12	Y	4 12 Hr Day	12	B	1147	96	1611	13	35	48
Sun	2020/12/13	Y	4 12 Hr Day	12	B	1280	107	1772	13	28	41
Wed	2020/12/16	Y	4 12 Hr Day	12	B	1293	108	1958	67	83	150
Sat	2020/12/05	Y	4 12 Hr Day	12	C	886	74	1176	14	66	80
Sun	2020/12/06	Y	4 12 Hr Day	12	C	846	71	1178	45	82	127
Tue	2020/12/08	Y	2 Afternoon	8	B	0	0	0	0	0	0
Thu	2020/11/26	Y	2 Afternoon	8	A	773	97	1161	76	64	140
Fri	2020/11/27	Y	2 Afternoon	8	A	741	93	1044	79	68	147
Mon	2020/12/14	Y	2 Afternoon	8	A	757	95	1042	43	54	97
Tue	2020/12/15	Y	2 Afternoon	8	A	876	110	1235	99	65	164
Thu	2020/12/17	Y	2 Afternoon	8	A	790	99	1164	56	59	115
Fri	2020/12/18	Y	2 Afternoon	8	A	720	90	978	26	59	85
Mon	2020/12/07	Y	2 Afternoon	8	B	712	89	968	71	57	128
Thu	2020/12/24	N	3 Night	8	B	0	0	0	0	0	0

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Wed	2020/12/09	Y	2 Afternoon	8	B	723	90	1232	117	86	203
Thu	2020/12/10	Y	2 Afternoon	8	B	893	112	1357	62	50	112
Fri	2020/12/11	Y	2 Afternoon	8	B	865	108	1209	27	42	69
Mon	2020/11/30	Y	2 Afternoon	8	C	834	104	1063	67	61	128
Tue	2020/12/01	Y	2 Afternoon	8	C	917	115	1273	86	60	146
Wed	2020/12/02	Y	2 Afternoon	8	C	705	88	1051	20	44	64
Thu	2020/12/03	Y	2 Afternoon	8	C	652	82	919	23	61	84
Fri	2020/12/04	Y	2 Afternoon	8	C	667	83	864	23	49	72
Mon	2020/12/21	Y	2 Afternoon	8	C	768	96	1016	22	56	78
Tue	2020/12/22	Y	2 Afternoon	8	C	733	92	992	30	67	97
Wed	2020/12/23	Y	2 Afternoon	8	C	670	84	943	120	94	214
Thu	2020/12/24	Y	2 Afternoon	8	C	267	33	150	108	117	225
Sat	2020/12/12	Y	5 12 Hr Night	12	A	664	55	933	18	43	61
Sun	2020/12/13	Y	5 12 Hr Night	12	A	357	30	495	13	31	44
Sat	2020/12/05	Y	5 12 Hr Night	12	B	389	32	516	329	67	396
Sun	2020/12/06	Y	5 12 Hr Night	12	B	452	38	629	50	55	105
Fri	2020/12/25	N	4 12 Hr Day	12	C	0	0	0	0	0	0
Sat	2020/11/28	Y	5 12 Hr Night	12	C	698	58	1033	70	65	135
Sun	2020/11/29	Y	5 12 Hr Night	12	C	873	73	1117	51	42	93
Wed	2020/12/16	Y	5 12 Hr Night	12	C	1194	100	1808	50	71	121
Sat	2020/12/19	Y	5 12 Hr Night	12	C	610	51	811	289	99	388
Sun	2020/12/20	Y	5 12 Hr Night	12	C	858	72	1124	103	78	181
Mon	2020/12/07	Y	3 Night	8	A	590	74	803	82	62	144
Tue	2020/12/08	Y	3 Night	8	A	340	43	532	950	53	1003
Wed	2020/12/09	Y	3 Night	8	A	623	78	1062	136	71	207
Thu	2020/12/10	Y	3 Night	8	A	739	92	1123	74	56	130
Fri	2020/12/11	Y	3 Night	8	A	649	81	907	18	44	62
Mon	2020/11/30	Y	3 Night	8	B	497	62	634	21	63	84

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Tue	2020/12/01	Y	3 Night	8	B	297	37	412	24	73	97
Wed	2020/12/02	Y	3 Night	8	B	549	69	819	17	36	53
Thu	2020/12/03	Y	3 Night	8	B	410	51	577	48	62	110
Fri	2020/12/04	Y	3 Night	8	B	439	55	569	34	50	84
Mon	2020/12/21	Y	3 Night	8	B	723	90	955	48	75	123
Tue	2020/12/22	Y	3 Night	8	B	477	60	645	29	91	120
Wed	2020/12/23	Y	3 Night	8	B	450	56	633	106	132	238
Fri	2020/12/25	N	5 12 Hr Night	12	B	0	0	0	0	0	0
Thu	2020/11/26	Y	3 Night	8	C	567	71	852	118	100	218
Fri	2020/11/27	Y	3 Night	8	C	630	79	887	96	77	173
Mon	2020/12/14	Y	3 Night	8	C	623	78	856	78	88	166
Tue	2020/12/15	Y	3 Night	8	C	713	89	1004	107	88	195
Thu	2020/12/17	Y	3 Night	8	C	609	76	897	58	80	138
Fri	2020/12/18	Y	3 Night	8	C	467	58	634	89	126	215
Sat	2020/12/26	Y	4 12 Hr Day	12	C	545	45	783	40	60	100
Sat	2020/12/26	Y	5 12 Hr Night	12	B	317	26	456	9	54	63
Sun	2020/12/27	Y	4 12 Hr Day	12	C	388	32	557	12	83	95
Sun	2020/12/27	Y	5 12 Hr Night	12	B	333	28	478	562	286	848
Wed	2020/04/22	Y	1 Morning	8	C	600	75	870	74	101	175
Mon	2020/12/28	Y	2 Afternoon	8	B	753	94	1078	127	86	213
Mon	2020/12/28	Y	3 Night	8	A	501	63	717	224	128	352
Fri	2020/10/23	Y	1 Morning	8	A	700	88	904	111	65	176
Tue	2020/12/29	Y	2 Afternoon	8	B	967	121	1308	104	60	164
Tue	2020/12/29	Y	3 Night	8	A	641	80	866	125	59	184
Fri	2020/06/05	Y	1 Morning	8	C	571	71	743	64	114	178
Wed	2020/12/30	Y	2 Afternoon	8	B	835	104	1218	165	60	225
Wed	2020/12/30	Y	3 Night	8	A	599	75	873	65	84	149
Fri	2020/05/29	Y	1 Morning	8	A	576	72	759	81	98	179

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Thu	2020/12/31	Y	2 Afternoon	8	B	99	12	133	22	95	117
Thu	2020/12/31	N	3 Night	8	A	0	0	0	0	0	0
Fri	2021/01/01	N	4 12 Hr Day	12	B	0	0	0	0	0	0
Fri	2021/01/01	N	5 12 Hr Night	12	A	0	0	0	0	0	0
Sat	2021/01/02	Y	4 12 Hr Day	12	B	900	75	1294	46	65	111
Sat	2021/01/02	Y	5 12 Hr Night	12	A	500	42	719	14	50	64
Sun	2021/01/03	Y	4 12 Hr Day	12	B	916	76	1180	48	64	112
Sun	2021/01/03	Y	5 12 Hr Night	12	A	571	48	736	63	80	143
Wed	2021/02/10	Y	1 Morning	8	C	648	81	843	96	84	180
Mon	2021/01/04	Y	2 Afternoon	8	A	758	95	1111	112	82	194
Mon	2021/01/04	Y	3 Night	8	C	653	82	956	146	102	248
Wed	2020/10/28	Y	1 Morning	8	C	727	91	1071	116	68	184
Tue	2021/01/05	Y	2 Afternoon	8	A	734	92	1090	162	93	255
Tue	2021/01/05	Y	3 Night	8	C	633	79	940	165	103	268
Mon	2020/08/03	Y	1 Morning	8	C	561	70	768	59	131	190
Wed	2021/01/06	Y	2 Afternoon	8	A	637	80	905	203	136	339
Wed	2021/01/06	Y	3 Night	8	C	226	28	321	60	164	224
Fri	2020/10/16	Y	1 Morning	8	B	325	41	647	105	86	191
Thu	2021/01/07	Y	2 Afternoon	8	A	584	73	800	164	83	247
Thu	2021/01/07	Y	3 Night	8	C	382	48	523	189	159	348
Thu	2021/03/11	Y	1 Morning	8	B	709	89	940	90	101	191
Fri	2021/01/08	Y	2 Afternoon	8	A	669	84	859	86	98	184
Fri	2021/01/08	Y	3 Night	8	C	677	85	870	156	111	267
Sat	2021/01/09	Y	4 12 Hr Day	12	A	1082	90	1530	89	91	180
Sat	2021/01/09	Y	5 12 Hr Night	12	C	850	71	1202	98	69	167
Sun	2021/01/10	Y	4 12 Hr Day	12	A	406	34	580	20	58	78
Sun	2021/01/10	Y	5 12 Hr Night	12	C	823	69	1177	184	204	388
Tue	2020/09/15	Y	1 Morning	8	C	671	84	884	80	117	197

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2021/01/11	Y	2 Afternoon	8	C	658	82	979	128	95	223
Mon	2021/01/11	Y	3 Night	8	B	732	92	1090	149	88	237
Fri	2020/08/28	Y	1 Morning	8	C	479	60	619	91	110	201
Tue	2021/01/12	Y	2 Afternoon	8	C	755	94	969	107	75	182
Tue	2021/01/12	Y	3 Night	8	B	767	96	985	85	71	156
Fri	2021/01/22	Y	1 Morning	8	C	702	88	1067	117	88	205
Wed	2021/01/13	Y	2 Afternoon	8	C	983	123	1534	67	71	138
Wed	2021/01/13	Y	3 Night	8	B	587	73	917	50	56	106
Wed	2020/05/27	Y	1 Morning	8	A	586	73	776	106	101	207
Thu	2021/01/14	Y	2 Afternoon	8	C	825	103	1266	82	82	164
Thu	2021/01/14	Y	3 Night	8	B	724	91	1111	96	73	169
Fri	2020/08/14	Y	1 Morning	8	B	570	71	804	101	107	208
Fri	2021/01/15	Y	2 Afternoon	8	C	504	63	629	207	118	325
Fri	2021/01/15	Y	3 Night	8	B	645	81	804	64	74	138
Sat	2021/01/16	Y	4 12 Hr Day	12	C	664	55	786	97	95	192
Sat	2021/01/16	Y	5 12 Hr Night	12	B	630	53	745	53	52	105
Sun	2021/01/17	Y	4 12 Hr Day	12	C	872	73	1092	22	70	92
Sun	2021/01/17	Y	5 12 Hr Night	12	B	523	44	655	70	71	141
Fri	2021/01/29	Y	1 Morning	8	B	904	113	1447	132	76	208
Mon	2021/01/18	Y	2 Afternoon	8	B	672	84	917	122	92	214
Mon	2021/01/18	Y	3 Night	8	A	526	66	718	174	133	307
Tue	2020/08/18	Y	1 Morning	8	A	942	118	1203	135	75	210
Tue	2021/01/19	Y	2 Afternoon	8	B	410	51	591	277	135	412
Tue	2021/01/19	Y	3 Night	8	A	346	43	499	283	226	509
Thu	2021/02/18	Y	1 Morning	8	B	901	113	1299	122	90	212
Wed	2021/01/20	Y	2 Afternoon	8	B	632	79	974	256	92	348
Wed	2021/01/20	Y	3 Night	8	A	498	62	767	234	149	383
Wed	2020/09/30	Y	1 Morning	8	A	835	104	1119	137	77	214

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Thu	2021/01/21	Y	2 Afternoon	8	B	699	87	1052	200	96	296
Thu	2021/01/21	Y	3 Night	8	A	531	66	800	146	90	236
Wed	2020/09/23	Y	1 Morning	8	B	734	92	1011	137	79	216
Fri	2021/01/22	Y	2 Afternoon	8	B	680	85	1035	143	98	241
Fri	2021/01/22	Y	3 Night	8	A	636	80	968	87	114	201
Sat	2021/01/23	Y	4 12 Hr Day	12	B	1106	92	1848	121	110	231
Sat	2021/01/23	Y	5 12 Hr Night	12	A	582	49	973	292	135	427
Sun	2021/01/24	Y	4 12 Hr Day	12	B	605	50	921	291	175	466
Sun	2021/01/24	Y	5 12 Hr Night	12	A	361	30	549	378	216	594
Wed	2020/12/30	Y	1 Morning	8	C	202	25	294	72	144	216
Mon	2021/01/25	Y	2 Afternoon	8	A	552	69	876	158	128	286
Mon	2021/01/25	Y	3 Night	8	C	646	81	1026	310	151	461
Fri	2021/01/08	Y	1 Morning	8	B	813	102	1044	141	77	218
Thu	2020/04/30	Y	1 Morning	8	B	433	54	591	128	98	226
Wed	2020/11/11	Y	1 Morning	8	A	691	86	983	157	83	240
Fri	2020/05/22	Y	1 Morning	8	B	506	63	645	139	104	243
Thu	2020/12/24	Y	1 Morning	8	A	432	54	242	131	113	244
Wed	2020/08/26	Y	1 Morning	8	C	8	1	11	50	195	245
Wed	2021/01/06	Y	1 Morning	8	B	313	39	444	159	86	245
Tue	2020/12/29	Y	1 Morning	8	C	790	99	1068	172	80	252
Thu	2020/09/03	Y	1 Morning	8	B	510	64	608	183	78	261
Thu	2020/10/08	Y	1 Morning	8	C	664	83	875	168	97	265
Fri	2020/06/12	Y	1 Morning	8	B	769	96	1060	179	90	269
Thu	2020/08/13	Y	1 Morning	8	B	638	80	878	168	101	269
Tue	2020/08/04	Y	1 Morning	8	C	676	85	903	184	100	284
Tue	2021/02/23	Y	1 Morning	8	A	690	86	1061	181	104	285
Fri	2020/07/03	Y	1 Morning	8	B	582	73	712	184	102	286
Tue	2020/05/19	Y	1 Morning	8	B	666	83	983	195	103	298

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Wed	2021/02/03	Y	1 Morning	8	A	845	106	1289	201	100	301
Tue	2020/09/08	Y	1 Morning	8	A	674	84	970	215	87	302
Tue	2021/03/09	Y	1 Morning	8	B	574	72	886	183	121	304
Tue	2020/04/21	Y	1 Morning	8	C	758	95	979	178	129	307
Tue	2020/09/01	Y	1 Morning	8	B	616	77	833	206	105	311
Tue	2021/01/26	Y	1 Morning	8	B	840	105	1381	208	110	318
Thu	2021/01/21	Y	1 Morning	8	C	602	75	907	218	104	322
Sat	2021/01/30	Y	4 12 Hr Day	12	A	1023	85	1489	247	127	374
Sun	2021/01/31	Y	4 12 Hr Day	12	A	750	63	1021	70	89	159
Sat	2021/02/20	Y	4 12 Hr Day	12	A	1433	119	2138	44	55	99
Sun	2021/02/21	Y	4 12 Hr Day	12	A	847	71	1400	16	52	68
Sat	2021/02/13	Y	4 12 Hr Day	12	B	1333	111	2003	34	71	105
Sun	2021/02/14	Y	4 12 Hr Day	12	B	1223	102	1917	19	59	78
Sat	2021/02/06	Y	4 12 Hr Day	12	C	1215	101	1687	14	50	64
Sun	2021/02/07	Y	4 12 Hr Day	12	C	1185	99	1657	23	52	75
Tue	2021/01/26	Y	2 Afternoon	8	A	612	77	1007	186	146	332
Wed	2021/01/27	Y	2 Afternoon	8	A	649	81	989	176	104	280
Thu	2021/01/28	Y	2 Afternoon	8	A	789	99	1237	215	95	310
Fri	2021/01/29	Y	2 Afternoon	8	A	839	105	1343	156	97	253
Mon	2021/02/01	Y	2 Afternoon	8	C	0	0	0	0	0	0
Tue	2021/02/16	Y	2 Afternoon	8	A	693	87	1056	217	96	313
Wed	2021/02/17	Y	2 Afternoon	8	A	804	101	1221	158	111	269
Thu	2021/02/18	Y	2 Afternoon	8	A	967	121	1394	123	83	206
Fri	2021/02/19	Y	2 Afternoon	8	A	939	117	1317	98	78	176
Mon	2021/02/08	Y	2 Afternoon	8	B	780	98	1265	35	85	120
Tue	2021/02/09	Y	2 Afternoon	8	B	739	92	1157	114	93	207
Wed	2021/02/10	Y	2 Afternoon	8	B	610	76	793	111	82	193
Thu	2021/02/11	Y	2 Afternoon	8	B	698	87	849	94	92	186

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Fri	2021/02/12	Y	2 Afternoon	8	B	800	100	1090	103	68	171
Mon	2021/02/15	Y	2 Afternoon	8	A	0	0	0	0	0	0
Tue	2021/02/02	Y	2 Afternoon	8	C	750	94	1174	122	105	227
Wed	2021/02/03	Y	2 Afternoon	8	C	854	107	1304	188	84	272
Thu	2021/02/04	Y	2 Afternoon	8	C	798	100	1072	85	73	158
Fri	2021/02/05	Y	2 Afternoon	8	C	801	100	1042	55	67	122
Mon	2021/02/22	Y	2 Afternoon	8	C	764	96	1170	92	80	172
Tue	2021/02/23	Y	2 Afternoon	8	C	695	87	1069	203	91	294
Wed	2021/02/24	Y	2 Afternoon	8	C	635	79	890	111	124	235
Thu	2021/02/25	Y	2 Afternoon	8	C	721	90	915	69	84	153
Sat	2021/02/13	Y	5 12 Hr Night	12	A	1116	93	1676	79	56	135
Sun	2021/02/14	Y	5 12 Hr Night	12	A	594	50	930	14	48	62
Sat	2021/02/06	Y	5 12 Hr Night	12	B	722	60	1002	12	24	36
Sun	2021/02/07	Y	5 12 Hr Night	12	B	855	71	1195	13	41	54
Sat	2021/01/30	Y	5 12 Hr Night	12	C	646	54	940	48	87	135
Sun	2021/01/31	Y	5 12 Hr Night	12	C	772	64	1052	109	118	227
Sat	2021/02/20	Y	5 12 Hr Night	12	C	861	72	1285	58	63	121
Sun	2021/02/21	Y	5 12 Hr Night	12	C	939	78	1551	23	53	76
Mon	2021/02/08	Y	3 Night	8	A	633	79	1026	95	126	221
Tue	2021/02/09	Y	3 Night	8	A	535	67	837	176	94	270
Wed	2021/02/10	Y	3 Night	8	A	470	59	612	128	90	218
Thu	2021/02/11	Y	3 Night	8	A	588	74	716	121	80	201
Fri	2021/02/12	Y	3 Night	8	A	855	107	1165	120	78	198
Mon	2021/02/01	Y	3 Night	8	B	590	74	858	426	145	571
Tue	2021/02/02	Y	3 Night	8	B	773	97	1209	233	104	337
Wed	2021/02/03	Y	3 Night	8	B	688	86	1050	89	70	159
Thu	2021/02/04	Y	3 Night	8	B	831	104	1116	105	71	176
Fri	2021/02/05	Y	3 Night	8	B	407	51	530	22	66	88

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Mon	2021/02/22	Y	3 Night	8	B	524	66	803	179	138	317
Tue	2021/02/23	Y	3 Night	8	B	552	69	849	186	119	305
Wed	2021/02/24	Y	3 Night	8	B	427	53	599	206	104	310
Thu	2021/02/25	Y	3 Night	8	B	857	107	1088	94	63	157
Tue	2021/01/26	Y	3 Night	8	C	548	69	901	244	134	378
Wed	2021/01/27	Y	3 Night	8	C	317	40	484	289	242	531
Thu	2021/01/28	Y	3 Night	8	C	649	81	1018	183	114	297
Fri	2021/01/29	Y	3 Night	8	C	627	78	1002	162	134	296
Mon	2021/02/15	Y	3 Night	8	C	0	0	0	0	0	0
Tue	2021/02/16	Y	3 Night	8	C	586	73	893	109	124	233
Wed	2021/02/17	Y	3 Night	8	C	676	85	1028	169	121	290
Thu	2021/02/18	Y	3 Night	8	C	849	106	1225	77	81	158
Fri	2021/02/19	Y	3 Night	8	C	820	103	1151	94	87	181
Thu	2020/06/11	Y	1 Morning	8	B	688	86	1018	219	107	326
Wed	2021/02/24	Y	1 Morning	8	A	510	64	715	220	115	335
Wed	2020/09/09	Y	1 Morning	8	A	648	81	926	252	84	336
Wed	2020/12/09	Y	1 Morning	8	C	695	87	1184	267	80	347
Thu	2020/11/26	Y	1 Morning	8	B	440	55	661	207	148	355
Thu	2021/01/28	Y	1 Morning	8	B	725	91	1136	244	115	359
Wed	2021/03/10	Y	1 Morning	8	B	639	80	897	238	125	363
Wed	2020/08/12	Y	1 Morning	8	B	587	73	774	252	113	365
Tue	2021/01/19	Y	1 Morning	8	C	458	57	661	257	125	382
Tue	2020/09/29	Y	1 Morning	8	A	641	80	821	326	84	410
Wed	2020/06/10	Y	1 Morning	8	B	575	72	847	299	121	420
Fri	2020/06/19	Y	1 Morning	8	A	609	76	858	339	87	426
Mon	2020/12/28	Y	1 Morning	8	C	694	87	992	340	101	441
Tue	2020/07/28	Y	1 Morning	8	A	567	71	796	354	101	455
Thu	2020/03/26	Y	1 Morning	8	A	62	8	77	221	255	476

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Wed	2020/05/20	Y	1 Morning	8	B	676	85	987	393	95	488
Wed	2021/01/20	Y	1 Morning	8	C	217	27	335	362	267	629
Thu	2020/07/09	Y	1 Morning	8	A	540	68	701	613	108	721
Tue	2021/02/16	Y	1 Morning	8	B	730	91	1113	660	225	885
Sat	2021/03/13	Y	4 12 Hr Day	12	A	990	83	1475	42	65	107
Sun	2021/03/14	Y	4 12 Hr Day	12	A	783	65	1130	23	65	88
Sat	2021/03/06	Y	4 12 Hr Day	12	B	379	32	873	46	52	98
Sun	2021/03/07	Y	4 12 Hr Day	12	B	1687	141	2248	28	42	70
Sat	2021/02/27	Y	4 12 Hr Day	12	C	1217	101	1632	64	70	134
Sun	2021/02/28	Y	4 12 Hr Day	12	C	1062	89	1470	38	66	104
Sat	2021/03/20	Y	4 12 Hr Day	12	C	1088	91	1402	14	27	41
Sun	2021/03/21	Y	4 12 Hr Day	12	C	763	64	992	21	26	47
Mon	2021/03/22	Y	4 12 Hr Day	12	C	676	56	823	32	71	103
Mon	2021/03/08	Y	2 Afternoon	8	A	707	88	1070	76	97	173
Tue	2021/03/09	Y	2 Afternoon	8	A	551	69	851	277	155	432
Wed	2021/03/10	Y	2 Afternoon	8	A	717	90	1007	222	104	326
Thu	2021/03/11	Y	2 Afternoon	8	A	669	84	887	126	126	252
Fri	2021/03/12	Y	2 Afternoon	8	A	793	99	1094	79	72	151
Mon	2021/03/01	Y	2 Afternoon	8	B	881	110	1207	81	89	170
Tue	2021/03/02	Y	2 Afternoon	8	B	803	100	1111	118	68	186
Wed	2021/03/03	Y	2 Afternoon	8	B	595	74	739	23	60	83
Thu	2021/03/04	Y	2 Afternoon	8	B	718	90	879	49	66	115
Fri	2021/03/05	Y	2 Afternoon	8	B	881	110	1347	106	85	191
Tue	2021/03/23	Y	2 Afternoon	8	B	794	99	951	45	54	99
Wed	2021/03/24	Y	2 Afternoon	8	B	749	94	919	22	33	55
Thu	2021/03/25	Y	2 Afternoon	8	B	819	102	1147	96	53	149
Fri	2021/02/26	Y	2 Afternoon	8	C	935	117	1504	106	93	199
Mon	2021/03/15	Y	2 Afternoon	8	C	642	80	844	18	70	88

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Tue	2021/03/16	Y	2 Afternoon	8	C	554	69	698	14	42	56
Wed	2021/03/17	Y	2 Afternoon	8	C	732	92	921	15	44	59
Thu	2021/03/18	Y	2 Afternoon	8	C	880	110	1119	60	57	117
Fri	2021/03/19	Y	2 Afternoon	8	C	954	119	1369	30	36	66
Sat	2021/03/06	Y	5 12 Hr Night	12	A	697	58	1605	19	59	78
Sun	2021/03/07	Y	5 12 Hr Night	12	A	951	79	1268	39	63	102
Sat	2021/02/27	Y	5 12 Hr Night	12	B	370	31	497	22	48	70
Sun	2021/02/28	Y	5 12 Hr Night	12	B	550	46	762	18	55	73
Sat	2021/03/20	Y	5 12 Hr Night	12	B	833	69	1073	18	31	49
Sun	2021/03/21	Y	5 12 Hr Night	12	B	182	15	237	19	26	45
Mon	2021/03/22	Y	5 12 Hr Night	12	B	237	20	289	32	100	132
Sat	2021/03/13	Y	5 12 Hr Night	12	C	683	57	1017	69	58	127
Sun	2021/03/14	Y	5 12 Hr Night	12	C	307	26	444	14	65	79
Mon	2021/03/01	Y	3 Night	8	A	730	91	1000	93	89	182
Tue	2021/03/02	Y	3 Night	8	A	704	88	973	81	69	150
Wed	2021/03/03	Y	3 Night	8	A	237	30	294	16	44	60
Thu	2021/03/04	Y	3 Night	8	A	596	75	729	56	77	133
Fri	2021/03/05	Y	3 Night	8	A	751	94	1148	137	97	234
Tue	2021/03/23	Y	3 Night	8	A	563	70	674	29	48	77
Wed	2021/03/24	Y	3 Night	8	A	389	49	477	14	30	44
Thu	2021/03/25	Y	3 Night	8	A	763	95	1069	113	82	195
Fri	2021/02/26	Y	3 Night	8	B	701	88	1128	176	95	271
Mon	2021/03/15	Y	3 Night	8	B	414	52	545	28	56	84
Tue	2021/03/16	Y	3 Night	8	B	246	31	310	19	34	53
Wed	2021/03/17	Y	3 Night	8	B	679	85	853	45	39	84
Thu	2021/03/18	Y	3 Night	8	B	698	87	887	24	44	68
Fri	2021/03/19	Y	3 Night	8	B	529	66	759	28	30	58
Mon	2021/03/08	Y	3 Night	8	C	579	72	877	170	121	291

Day	Date	24hr	Time of Day	Duration	Shift	Trucks (No.)	Per Hour	Volumes (ETU's)	Staging (ETU's)	Terminal (ETU's)	Total (ETU's)
Tue	2021/03/09	Y	3 Night	8	C	635	79	980	324	131	455
Wed	2021/03/10	Y	3 Night	8	C	542	68	760	144	118	262
Thu	2021/03/11	Y	3 Night	8	C	703	88	931	209	116	325
Fri	2021/03/12	Y	3 Night	8	C	548	69	756	45	50	95
				8 760		615 209	69766	843 501	85 914	77 747	163 661

Appendix 6: Weekly Truck and Trains Visits 2022

Date	No. of Trucks	No. of Trains
2022/01/10	1926	7
2022/01/11	2003	9
2022/01/12	1911	9
2022/01/13	1717	7
2022/01/14	1900	8
2022/01/15	1699	7
2022/01/16	1818	10
Total	12974	57

Appendix 7: Simulation Model Results

Rail										Truck							
Rail Network and Dry Port Connection										Truck Network Connection							
	Wagons	Containers	Equipment Type	Estimated Distance	Average L/100km	Train Quantity	Duration	Fuel CO2 Factor	Estimated tCO2e pa	Containers	Truck Type	Estimated Distance	Average L/100km	Trucks Quantity	Duration	Fuel CO2 Factor	Estimated tCO2e pa
Scenario 1	50	148000	Diesel electric engine	120	10	4	363	2,67	4 652	624 000	Diesel engine	120	24	624 000	363	2,67	4 798 310
	100	296400	Diesel electric engine	120	10	4	363	2,67	4 652	475 800	Diesel engine	120	24	475 800	363	2,67	3 658 712
	150	444600	Diesel electric engine	120	10	4	363	2,67	4 652	327 600	Diesel engine	120	24	327 600	363	2,67	2 519 113
Scenario 2	50	148000	Diesel electric engine	120	10	4	363	2,67	4 652	624 000	Diesel engine	120	24	624 000	363	2,67	4 798 310
	100	296400	Diesel electric engine	120	10	4	363	2,67	4 652	475 800	Diesel engine	120	24	475 800	363	2,67	3 658 712
	150	444600	Diesel electric engine	120	10	4	363	2,67	4 652	327 600	Diesel engine	120	24	327 600	363	2,67	2 519 113
Scenario 3	50	148000	Diesel electric engine	120	10	4	363	2,67	4 652	624 000	Diesel engine	120	24	624 000	363	2,67	4 798 310
	100	296400	Diesel electric engine	120	10	4	363	2,67	4 652	475 800	Diesel engine	120	24	475 800	363	2,67	3 658 712
	150	444600	Diesel electric engine	120	10	4	363	2,67	4 652	327 600	Diesel engine	120	24	327 600	363	2,67	2 519 113

Notes: A simulation model rail results predicted content performance and same emission output. The results of a simulation model provided a valuable insight for a decision-making in increasing the number of wagons. The simulation result indicated that increasing the number of wagons will not increase the emission release in the Durban Container Terminal integrated logistics system. On the other hand, truck network releases more emissions when you increase the number of trucks. Simulation model result recommends the use of rail for the promotion of sustainable development, since this reduces the emissions released.

														Current	4 801 567	
Equipment										Renewable						
Operation Logistic										Renewable technology and alternative energy supply						
Equipment Type	Estimated Distance	Average L/100km	Equipment Quantity	Duration	Fuel CO2 Factor	Estimated tCO2e pa				Equipment Type	Adjusted Electricity Consumption (kWh)	Electricity CO2 Factor	Estimated tCO2e pa		Total Estimated tCO2e pa	
Scenario 1	Hybrid Straddle	255	7	116	363	2,67	200 685	303 905		Ship to Shore	12 331 473	0,97	11 962	14 722	5 121 590	107%
	Hybrid Haulers	150	10	71	363	2,67	103 221			Rail Mounted Gantry	2 845 725	0,97	2 760			
	Hybrid Straddle	255	7	116	363	2,67	200 685	303 905		Ship to Shore	12 331 473	0,97	11 962	14 722	3 981 991	83%
	Hybrid Haulers	150	10	71	363	2,67	103 221			Rail Mounted Gantry	2 845 725	0,97	2 760			
	Hybrid Straddle	255	7	116	363	2,67	200 685	303 905		Ship to Shore	12 331 473	0,97	11 962	14 722	2 842 393	59%
	Hybrid Haulers	150	10	71	363	2,67	103 221			Rail Mounted Gantry	2 845 725	0,97	2 760			
Scenario 2	Diesel Straddle	150	11	80	363	2,67	127 936	486 301		Ship to Shore	12 331 473	0,97	11 962	14 722	5 303 986	110%
	Hybrid Haulers	255	10	145	363	2,67	358 365			Rail Mounted Gantry	2 845 725	0,97	2 760			
	Diesel Straddle	150	11	80	363	2,67	127 936	486 301		Ship to Shore	12 331 473	0,97	11 962	14 722	4 164 387	87%
	Hybrid Haulers	255	10	145	363	2,67	358 365			Rail Mounted Gantry	2 845 725	0,97	2 760			
	Diesel Straddle	150	11	80	363	2,67	127 936	486 301		Ship to Shore	12 331 473	0,97	11 962	14 722	3 024 788	63%
	Hybrid Haulers	255	10	145	363	2,67	358 365			Rail Mounted Gantry	2 845 725	0,97	2 760			
Scenario 3	Hybrid Straddle	200	7	100	363	2,67	135 689	259 554		Ship to Shore	12 331 473	0,97	11 962	14 722	5 077 239	106%
	Hybrid Haulers	180	10	71	363	2,67	123 865			Rail Mounted Gantry	2 845 725	0,97	2 760			
	Hybrid Straddle	200	7	100	363	2,67	135 689	259 554		Ship to Shore	12 331 473	0,97	11 962	14 722	3 937 640	82%
	Hybrid Haulers	180	10	71	363	2,67	123 865			Rail Mounted Gantry	2 845 725	0,97	2 760			
	Hybrid Straddle	200	7	100	363	2,67	135 689	259 554		Ship to Shore	12 331 473	0,97	11 962	14 722	2 798 041	58%
	Hybrid Haulers	180	10	71	363	2,67	123 865			Rail Mounted Gantry	2 845 725	0,97	2 760			

Notes: A simulation model hybrid port equipment results predicted decrease emission release. The results of a simulation model provided a valuable insight for a decision-making in migrating to hybrid port equipment. The simulation result indicated that changing to hybrid port equipment will decrease the emission release in the Durban Container Terminal integrated logistics system. The adoption of renewable technology produces the same result as the hybrid port equipment. Simulation model result recommends the use of hybrid port equipment and renewable technology for the promotion of sustainable development, since this reduces the emissions released.

The overall simulation model result Scenario one is the recommended integrated operating model since it has no significant operational changes within the DCT terminal. The hybrid equipment and energy-saving technology can be introduced gradually during the port equipment end-of-life replacement period. The significant change will be in the DCT integrated operation, introducing a dry port and upgrading the rail infrastructure to accommodate the train's 150 wagons. This integrated operating model will reduce DCT's operations CO2 release contribution by 37%. The increase in wagons by 150 in the rail network and the introduction of dry ports maintain its current CO2 release profile, while the road (trucks) CO2 release profile reduces by 47%. This promotes the reduction of container trucks, calling for a DCT terminal, unlocks decent work and economic growth, and creates sustainable cities and communities within the Midlands region.