Report on Baseline Emission Inventory in Operation Terminal 3 of Tanjung Priok Port

March 2015

CLIMATE AND CLEAN AIR COALITION TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

UNEP

PUSTRAL-UGM
Pusat Studi Transportasi dan Logistik

PREFACE

This report will present the result of emission inventory of Tanjung Priok Port as performed by the Center for Transportation and Logistics Studies, Universitas Gadjah Mada (PUSTRAL-UGM) in collaboration with Operation Terminal 3 of Tanjung Priok Port and supported by funding from Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC) through the United Nations Environment Programme (UNEP).

The emission inventory is aimed to measure air pollution level and as reference to take mitigation action on the impact of air pollution from port activities.

The researchers contributing in this study include Restiti Sekartini, Tory Damantoro, and Yusa Cahya Permana. In this occasion, we shall give our greatest appreciation and gratitude to the management of Operation Terminal 3 of Tanjung Priok Port for their cooperation and dedication to support our researchers in collecting the field data, in discussing research assumptions and in formulating several scenarios that are used in this study. We do realize that without their support, this study will not produce the expected result. In addition, we shall express our gratitude to the Sustainable Port Development Project of GIZ which has facilitated close cooperation between PUSTRAL and Operation Terminal 3 as well as to CCAC and UNEP which had provided comprehensive support to the study.

We do hope that this study would be useful for environmental preservation, particularly that of in Operation Terminal 3 of Tanjung Priok Port and other Indonesia ports in general.

Sincerely,

Research Team

The Center for Transportation and Logistics Studies, Universitas Gadjah Mada

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EXECUTIVE SUMMARY

The Managing Directors of Tanjung Priok Port expressed their strong commitment in implementating sustainable port development and operation. Therefore, they do welcome the technical support from UNEP which has assigned to PUSTRAL to study Baseline Emission Inventory of air pollution frpfrom port activities. The Emission Inventory (EI) is necessary in the development planning and operation of ports in which EI could provide important information on air quality and could facilitate the role of the port in maintaining air quality in DKI Jakarta Province.

After conducting a series of discussions with Tanjung Priok managing directors, internal workshop with Tanjung Priok staffs (on 13 June 2014) and workshops with related stakeholders (on 15 and 16 July 2014), the following agreements regarding the implementation of the study had been concluded:

- The area of the study is limited to Operation Terminal 3 (OT 3) which has become the pilot area for service improvement for HSE (Health, Safety and Environment) aspects;
- The statistical data used in this study are those collected from January to March 2014 which is used as the initial analysis on the current data availability and management as compared with the expected available data for EI analysis.
- Based on the business process of OT 3, the sources of emission may include vessel (ocean going vessel and domestic), harbor craft, cargo handling equipment (CHE) and truck operating in OT 3 area.
- The pollutants being measured include NOx, CO, PM^{10}, $PM^{2.5}$, SO_2, Black Carbon and CO_2.
- Methodology used in this study is based on the one that is developed by United States-Environmental Protection Agency, US-EPA – ICF International in 2009, "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories," using "streamlined bottom-up" approach (taking into account energy consumption and activity of the emission sources); therefore, in the case of data are not available, the study will use data from relevant literatures.
- More accurate data regarding vessel could be acquired from Port Authority/Harbor Master of Tanjung Priok Port. It is agreed that the data shall be used for the next study.

The emission inventory performed successfully in Tanjung Priok Port. Howerver, to achieve more accurate result and to simplify the implementation of regular emission inventory as well as to estimate emission in the future, it is necessary for TO 3 to redesign their data management to be more suitable for EI from what they have that mainly was designed for business purpose.

The following parts describe the study finding.

Table 1-1 presented vessel as the largest emission cotributor, followed by CHE. Meanwhile, the contribution of harbor craft and head truck to emission is not significant. This fact is common for a cargo terminal.

Table 1-1. Air Pollution from the Activities in Operation Terminal 3 of Tanjung Priok Port (January-March 2013)

	Source of Emission	Emission (Ton)						
		NOx	CO	PM10	PM2.5	SO2	BC	CO2
1	Vessel	110.08	8.83	12.13	10.61	133.59	2.97	7,783.34
2	Harbor Craft	-	8.60	1.63	0.21	0.20	0.88	466.20
3	CHE	-	72.13	23.18	3.43	3.35	1.37	4,516.46
4	Head Truck	-	0.91	0.48	0.00	0.00	0.00	1,545.69
	Total (Jan - Mar 2014)	**110.08**	**90.46**	**37.42**	**14.26**	**137.15**	**5.22**	**14,311.69**
	Estimation for 2014	**440.32**	**361.84**	**149.69**	**57.03**	**548.58**	**20.90**	**57,246.75**

Table 1-2 presents the comparison of emission of various ports in the world in relation with throughput of the ports for each pollution parameter being measured.

Table 1-2. Comparison of Pollution Resulted from Vessel Operation

No	Port	Year	Ship Call	Throughput (TEUs)	Emission (Ton/Year)						
					NOx	CO	PM10	PM2.5	SO2	Black Carbon	CO2
1	TO 3 Tanjung Priok	2014 (estimation	1,344	679,432	440	35	49	42	534	12	31,133
2	Hong Kong*	2007	37,150	23,998,000	17,100	na	1,000	na	8,200	na	na
3	Kaohsiung - Taiwan*	2007	4,035	10,200,000	1,679	na	102	na	813	na	na
4	Singapore*	2007	2,742	27,935,000	1,492	na	89	na	682	na	na
5	Xiamen China*	2007	1,360	4,627,000	1,004	na	62	na	470	na	na
6	South Carolina**	2013	1,704	1,600,000	1,560	174	188	na	na	na	na
7	Los Angeles***	2012	1,953	8,100,000	3,402	423	106	na	na	na	na
8	Long Beach****	2011	2,036	6,000,000	4,321	473	134	na	na	na	na
9	Virginia*****	2011	2,153	1,920,000	2,814	264	248	228	1,761	na	na

na = not available (not measured)

Source of Data:

* Science of The Total Environment, Elsevier Journal (www.elsevier.com), Estimation of Exhaust Emission from Vessel in Hong Kong

** South Carolina Ports, 2011 Air Emissions Inventory Update, April 2013

*** Port of Los Angeles, Inventory of Air Emissions 2012

**** Port of Long Beach, 2012 Air Emission Inventory

***** 2011 Comprehensive Air Emissions Inventory Update

Based on data presented in Table 1-2, the emission per TEU is analized as presented in Table 1-3.

Table 1-3. Comparison of Pollutions per TEU of Some Ports in the World

No	Port	Year	Ship Call	Throughput (TEUs)	Emission (gram/TEU)						
					Nox	CO	PM10	PM2.5	SO2	Black Carbon	CO2
1	TO 3 Tanjung Priok	2014 (estimation)	1,344	679,432	648	52	71	62	786	17	45,823
2	Hong Kong*	2007	37,150	23,998,000	713	na	42	na	342	na	na
3	Kaohsiung - Taiwan*	2007	4,035	10,200,000	165	na	10	na	80	na	na
4	Singapore*	2007	2,742	27,935,000	53	na	3	na	24	na	na
5	Xiamen China*	2007	1,360	4,627,000	217	na	13	na	102	na	na
6	South Carolina**	2013	1,704	1,600,000	975	109	117	na	na	na	na
7	Los Angeles***	2012	1,953	8,100,000	420	52	13	na	na	na	na
8	Long Beach****	2011	2,036	6,000,000	720	79	22	na	na	na	na
9	Virginia*****	2011	2,153	1,920,000	1,466	138	129	119	917	na	na

In term of emission per-TEU for vessel source, Operation Terminal 3 of Tanjung Priok Port is ranked in the middle as compared to other ports in the world, while the lowest is Singapore Port and the highest is Virginia Port. Nevertheless, it should be noted that the data of emission inventory of the ports are collected in different period/year due to the limitation of data availability.

Beside CO_2, SO_2 emission of in Operation Terminal 3 of Tanjung Priok Port is relatively higher than other pollution parameters. The main reason is that the berthing time is longer, which is causing longer engine boiler operation. For this case, more accurate data regarding berthing time is needed; otherwise, further survey may be necessary to validate the average berthing time and the activity of the vessel when berthing.

It is absolutely possible to reduce emission which may contribute to the operation efficiency of Operation Terminal 3 of Tanjung Priok. Some actions which could be implemented include:

- Reducing the berthing time or providing off shore power supply of electricity
- Replacing/changing the equipment technology and/or CHE fuel so that it produce lower emission
- Controlling the idling time of the truck and managing the traffic of the truck in the terminal to be more efficient.

1. Introduction

1.1. Background

Baseline emission inventory in Tanjung Priok Port becomes one of activity components of "Supporting the Development of a Sustainable and Clean Ports Program for the Port Tanjung Priok, Jakarta" Project, as collaboration between the Center for Transportation and Logistics Studies, Universitas Gadjah Mada (PUSTRAL-UGM) and the United Nations Environment Programme (UNEP).

The baseline emission inventory is developed with the aim of:

- Understanding the needs and benefits of emission inventory
- Investigating the methodology and data requirements for the emission inventory
- Conducting initial calculation of emission using data and reference available
- Investigating further actions that need to be prepared to refine and improve the emission inventory more accurately in the future.

The managing directors (management) of Tanjung Priok Port have expressed their commitment to fully support the effort of baseline emission inventory activities. They consider that the result of the study could be a valuable input and taken into consideration in the development planning and port operation. In addition, it is also agreed that comprehensive emission inventory which covers all sources of port-related air emission will be required to inform and facilitate the role of Tanjung Priok Port in maintaining air quality in DKI Jakarta Province.

The expected output of this study is the availability of Baseline Emission Inventory Report for Tanjung Priok Port. The report shall also include an analysis of the data collected, the data needs assessment and recommendation for the implementation of more accurate emission inventory in the future.

1.2. Definition and Benefits of Emission Inventory

Emission inventory is a quantification of all emission criteria and other pollutants (including toxic pollutant and greenhouse gases) which may be produced in one area in certain period of time and based on its sources (US-EPA – ICF international 2009; "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories and California Air Resources Board – 2010).

Emission inventory may provide benefits to:

- Analyze the emission level during the assessment period;
- Assess the trend of emission in the future since emission inventory shall be updated periodically;
- Evaluate the effectiveness of emission reduction efforts which has been implemented;
- Support the achievement of emission reduction efforts of certain pollutant with the largest source contribution or for certain geographic areas;
- Evaluate the cost-effectiveness for various emission reduction efforts;
- Record the progress of emission reduction over time as a result of the implementation of technology and efficiency improvements.

1.3. Scope of Study

1.3.1. Area of Study

Tanjung Priok Port consists of several terminals, either those directly/solely managed by PT Pelabuhan Indonesia II of Tanjung Priok Branch or those jointly managed by other private sectors. Operation Terminals which are directly operated by PT Pelabuhan Indonesia II of Tanjung Priok Branch include Operation Terminal 1, Operation Terminal 2 and Operation Terminal 3. The Operation Terminal 3 (hereinafter referred to as OT 3) has been stated as pioneer/research terminal, both for service aspects and working health and safety aspects as well as environment aspect. Therefore, PUSTRAL-UGM and PT Pelabuhan Indonesia of Tanjung Priok Branch have concluded to conduct the baseline emission inventory in the **area of OT 3**.

1.3.2. Period of Baseline Emission Inventory

The greatest challenge in conduccting the emission inventory is the availability and level of accuracy of the required data.

This study is the initial steps of a series of processes that should be accomplished to complet emission inventory with qualified data so that the result of emission inventory will be more accurate.

Currently, data processing system in Tanjung Priok Port is focused on the needs of the business administration aspects of the port so that the collection of data required for emission inventory will be challenging. As the tryout of baseline emission inventory in OT 3 area, it is agreed to use **the available data for the period of January to March 2014.**

1.3.3. Pollutant Being Measured

Emission sources considered in this study include mobile emission sources from port-related activities in OT 3 area, both sea or land-based activities.

Exhaust emissions produced from various sources in the port area could have local or global impact. Emissions which could have local impact include fine dust or particulate matter (PM up-to 10 micrometers in size or up to 2.5 micrometers in size), dust from diesel or diesel particulate matter (DPM), Nitrogen Oxide (NOx), Sulfur Oxide (SOx), Hydrocarbon (HC) and Carbon Monoxide (CO). Furthermore, exhaust emissions which could result in global impact or commonly called as Green House Gas (GHG) include Carbon Dioxide equivalent (CO2e), Carbon Dioxide (CO2), Methane (CH4), and Nitrous Oxide (N2O).

In accordance to the terms of reference of the study, the emission which shall be measured include Nitrogen Oxide (NOx), Carbon Monoxide (CO), Particulate Matter < 10 microns (PM10) and 2.5 microns (PM2.5), Black Carbon (CB), Sulfur Dioxide (SO2) and Carbon Dioxide (CO2).

The characteristics of each measured pollutant are as follows:

Nitrogen Oxide (NOx)

NOx is produced from the reaction of nitrogen and oxygen gases in the air during combustion, particularly at high temperatures. NOx is reactive, generally colorless and odorless. NOx is a precursor for the formation of ozone. NOx is potential to trigger respiratory and infectious diseases.

Meanwhile, the exposure of ozone may trigger breathe difficulty, lung damage, and cardiovascular malfunction.

Carbon Monoxide (CO)
Carbon Monoxide (CO) is produced from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce Carbon Dioxide (CO2). CO is colorless, odorless and tasteless, but highly toxic.

CO combines with hemoglobin to produce carboxyhemoglobin, which usurps the space in the hemoglobin that normally carries oxygen, but is inefficient for delivering oxygen to bodily tissue. CO could interrupt heart contractions.

PM 10 and PM 2.5
Particulate Matter (PM) is microscopic solid or liquid matter suspended in the Earth's atmosphere. Particulates are the deadliest form or air pollution due to their ability to penetrate deep into the lungs so that it could increase the risk potential of human health.

Sulfur Dioxide (SO2)
The emission of SO2 from motorized vehicle is in line with the sulfur content of the fuel. High concentration SO2 could affect human respiration and aggravate the condition of people with respiration or cardiovascular disease.

Black Carbon (BC)
Black Carbon (BC) is the most strongly light-absorbing component of particulate matter (PM) and is formed by the incomplete combustion of fossil fuel, biofuels and biomass. BC is emitted directly into the atmosphere in the form of fine particle (PM 2.5). BC can lead to premature death

Carbon Dioxide (CO2)
Carbon Dioxide (CO2) is the primary greenhouse gas emitted through human activities. CO2 is colorless and odorless. CO2 is naturally present in the atmosphere as part of the Earth's carbon cycle. The main human activity that emits CO2 is the combustion of fossil fuel for energy and transportation.

2. Method of Emission Inventory

2.1. Approach to Emission Inventory

Methodology of emission inventory consists of "top-down" and "bottom-up" approach (California Air Resources Board Emission Inventory, http://www.arb.ca.gov/ei/). Definitions of the approach are as follows:

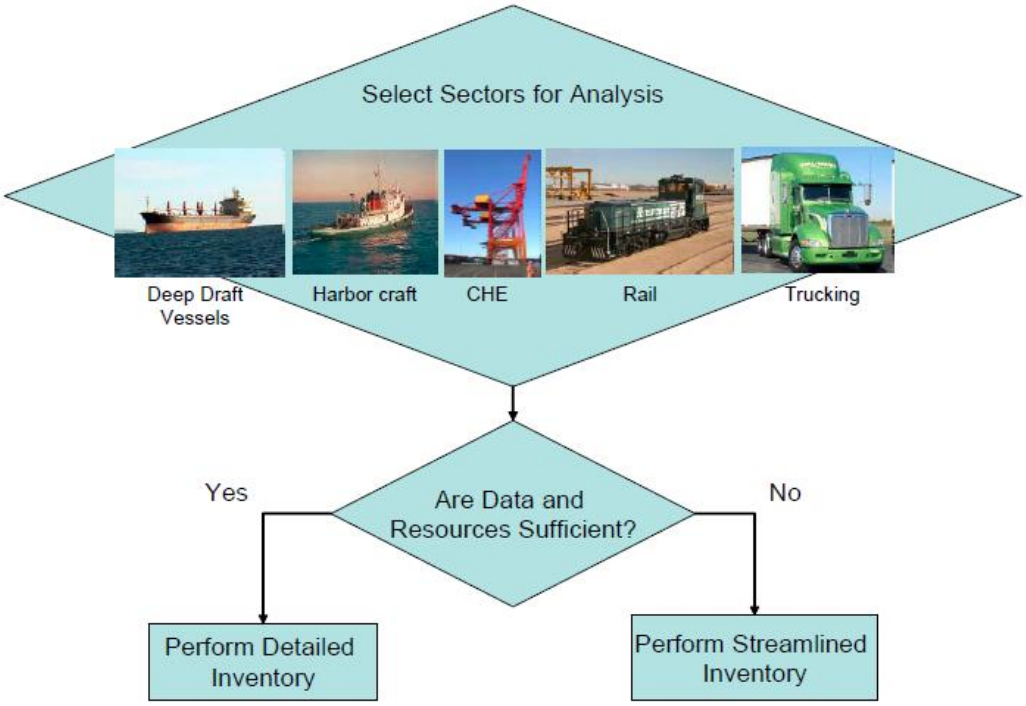
- "Top-down" approach is based on the option of large-scale variables (for example, the amount of sold fuel or fuel consumption in national scale) which are then broken down into smaller scale by using a proxy variable or representing variable (for example population or data of registered vehicle).
- "Bottom-up" approach generally adopts energy consumption and activity based method. In the emission inventory for transportation sector, for example, the exhausted pollutants is projected

from specific data such as number of vehicle, category and technical specification of vehicles, and vehicle activities (travel distance and time).

In transportation sector, emission inventory has been conducted in many main ports around the world, including those in the ASEAN region (Summary Report of Emission Inventory for ASEAN Ports, ASEAN-GIZ Sustainable Port Development Project, 2012). Unfortunately, emission inventory has not been implemented in Indonesian ports.

Based on the published emission inventory reports, the common methodology used in emission inventory is the methodology developed by United States – Environmental Protection Agency, US-EPA – ICF International 2009; "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories." The basic concept of the emission inventory methodology uses bottom-up approach by investigating energy consumption together with activities of emission source related to port activity. Based on the methodology developed by US-EPA, the steps for emission inventory in port area can be described as presented in Figure 2-1.

Figure 2-1. Steps for Emission Inventory in Port Area



Source: USEPA – ICF International, 2009

The emission inventory methodology used in this study is "bottom-up" approach which is based on the energy consumption and activity; and conducted in simple manner or streamlined inventory. The methodology is appropriate for this current study considering that:

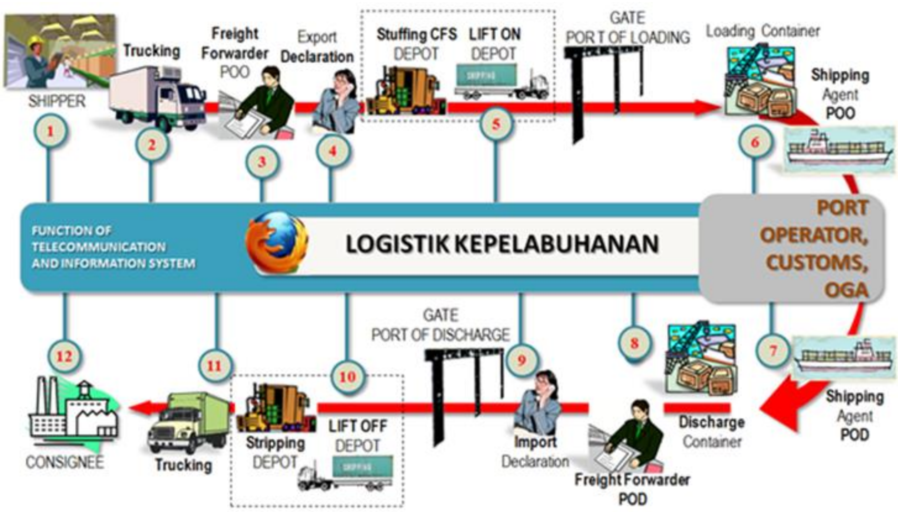
- The mobile sources of emission come particularly from sea-based and land-based activities and limited in specific area, i.e. Operation Terminal 3;
- Tanjung Priok Port has not specially documented the accurate data for the purpose of periodic emission inventory. For this study, therefore, in the case that data required for the study are not available, the team will not conduct a detailed survey, but will be adopt data available in the

references, for example from US-EPA – ICT International 2009, California Air Resource Board Emission Inventory 2011 (CARB 2011), or using surrogate data from emission inventory reports published by several main ports such as Hong Kong Port, South Caroline Port, Port of Los Angeles and Virginia Port.

2.2. Sources of Emission in Port Area

In order to understand the sources of emission of port services, Figure 2-2 presents the business process of port services in general which is taken from*:* http://www.supplychainindonesia.com/.

Figure 2-2. Business Process of Port Services



Based on the emission inventory method developed by US-EPA – ICF International 2009, sources of emission in the port could be categorized into 5 main sources as presented in Table 2-1.

Table 2-1. Sources of Emission in Port Area

No	Category	Types
1	Ocean Going Vessels	Container ships, Tanker ships, Bulk carrier ship, Cruise ships, Reefer ships, Roll-on/Roll-off ships, Vehicle carrier ships
2	Harbor Craft/vessels	Tugboats and push boats, Ferries, Excursion vessels, Fishing vessels, Dredging equipment
3	Cargo Handling Equipment	Terminal tractors, Top and side loaders, Forklifts, Wharf cranes, Rubber tire gantry cranes, Skid loaders
4	Locomotives	Line haul locomotives & Switch yard locomotives
5	Vehicles	Other port vehicles

Source: USEPA – ICF International 2009

Based on the business process of port services and referring to the emission inventory method developed by US-EPA, the emission sources in OT 3 could be identified as follows:

- International and inter-island **vessels**. Based on the transported cargo, vessels entered OT 3 could be categorized into container, bag cargo, dry bulk, liquid bulk, general cargo and unitized vessels.

- Harbor Craft is defined as vessels which operates inside or around the port such as tug boat, pilot boat, mooring boat, passenger boat (ferry), cruise, fishing vessel, dredging and dredging support vessels (USEPA-ICF, 2009). Harbor Craft in OT 3 consists of tug boats, pilot boats and mooring boats.
- **Cargo Handling Equipment (CHE)** includes loading-unloading equipments.
- **Land transportation (truck)** operates in the area of OT 3.

3. Review of Operation Terminal 3 (OT 3) of Tanjung Priok Port

3.1. Sea and Land Borders

Physical conditions of OT 3 are as follows:

- Length of wharf: 2,178 m
- Depth: 9m – 12m

For the purpose of this study, the sea and land borders of the study area are as follows:

- Sea side, the first 25 nm (nautical miles) from the port entrance as recommended by USEPA-ICF International 2009
- Land side, starting from the entry gate of OT 3.

The emission inventory is performed for wharf managed by OT 3, including:

- East-side wharf (Dock 300 or ex TBB, 301, 302, 303, 304, and 305) serving international shipping
- West-side wharf (208, 209, 209L, 210, 211, 212, and 213) serving domestics shipping

The lay-out of Tanjung Priok Port and Development Plan of OT 3 is available in Annex 1a and 1b, respectively.

3.2. Activity in OT 3

Business activities performed in OT 3 include boat services and goods services.

Boat services include:

- Pond water and port for shipping traffic and berths
- Piloting, tugs boat and ship maneuvering
- Hoteling facility: mooring and loading-unloading of goods and animal

Figure 3-1 presents boat services in OT 3.

Figure 3-1. Boat Services in OT 3 of Tanjung Priok Port

Tug Boat

Maneuvering

Mooring

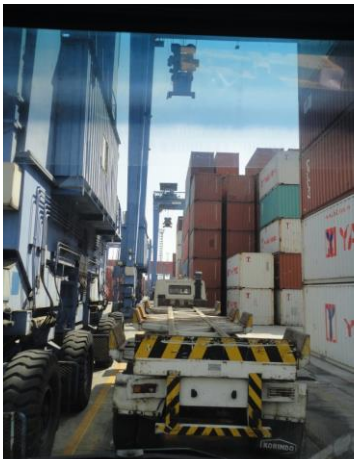
Source: Documentation of Field Survey of ship maneuvering on May 7, 2014

Goods services include:

- Loading-unloading: container, bag cargo, dry bulk, liquid bulk, general cargo, unitized
- Container yard
- Bulk terminal to serve loading-unloading based on the commodity

Figure 3-2. Goods Services in OT 3 of Tanjung Priok Port

Head truck moves to container yard



Container from the container yard is lifted to the head truck using RTGC

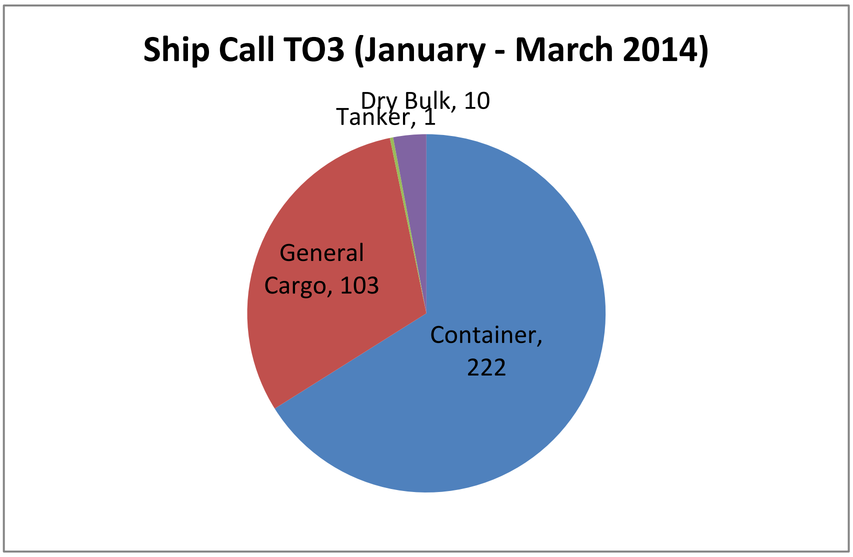
Container is lifted from the head truck to the ship using HMC

Source: Documentation of Field Survey "Time in Motion" on May 8, 2014

Activities of OT 3OT 3 during the period of January-March 2014:

- Ship Call: 150 international shipping and 186 domestics shipping (intersuler).

Figure 3-3. Ship Call TO 3 of Tanjung Priok Port (January – March 2014)



- The total throughout of container was 169,858 TEUs, consisted of 116,130 TEUs of domestics freight and 53,728 TEUs of international freight.
- From the total container:
  - Domestics: 4.59% through truck losing (direct transport) and 95.41% through container yard;
  - International: 0.02% through truck losing and 99.98% through container yard.

The scope of study, data source and calculation method for each emission source will be described further in the following sections.

4. Vessel (Ocean Going Vessel & Domestics)

4.1. Emission Inventory Methodology for Vessel

Based on the USEPA – ICF International 2009, the emission per ship is calculated using the following equation:

E= P x LF x A x EF

Where:

E = Emission (gram/year)

P = Maximum Continuous Rated Power (kilowatts [kW]); size of the installed engine, propulsion engine and auxiliary engine.

LF = Load Factor (percent of vessel's total power in use for each operation mode)

A = Activity (hour/year); duration for each operation mode within one year period

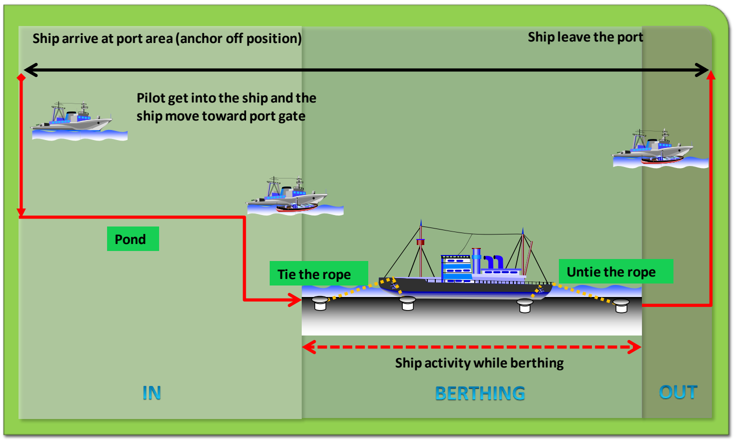
EF = Emissions Factor (gram per kilowatt-hour, g/kWh); level of emission for each pollutant parameter

As the preparation prior to emission inventory of vessel, the team processes the available statistical data to acquire the characteristics and profile of vessel activity which represents the actual operatiing conditions in the port.

4.2. Business Process of Vessel Services

The business process of vessel services in Tanjung Priok Port is presented in Figure 4-1.

Figure 4-1. Business Process of Vessel Services



In the business process, the following components are involved:

- Anchoring service includes certain sea area (designated within specific coordinate) which forms port pond which is used as facility to safely anchor ships while waiting for the next process, i.e. berthing.
- Pilot service includes activities to assist the ship captain so that the navigation could be performed safely, orderly and smoothly by providing information about important condition of the water for the purpose of ship safety and environment
- Tug service includes the activities of pushing/towing, guiding, keeping= or holding the maneuvering vessels to dock (tie and untie rope); providing buoy, breasting dolphin, skirt and other boat using tugboat.

4.3. Ship Call Characteristics in OT 3

4.3.1. Vessel Types/Category

Vessel types vary based on engine size and speed. The detailed data of ship call in OT 3 for the period of January-March 2014 are available in Annex 2.

For the purpose of emission inventory, the ship call activity has been categorized by the transported cargo, i.e. (1) container, (2) general cargo (including bulk, bag cargo, unitized), (3) tanker (liquid bulk) and dry bulk (bulk carrier).

In the period of January – March 2014, there were 336 vessels entering OT 3, consisted of 186 domestic shipping and 150 international shipping. The number of vessel by category is presented in Table 4-1.

Table 4-1. Number of Vessels by Category for the Period of January – March 2014

Category	Domestic	International	Total
Container	173	49	222
General Cargo	12	91	103
Tanker	1	0	1
Dry Bulk	0	10	10
Total	186	150	336

Source: process from the vessel data in OT 3 for the period of January – March 2014

4.3.2. Power Engine

Vessel engine consists of:

- Propulsion engine, also called as **main engine**
- **Auxiliary engine** is generally used to generate electricity and operate equipments such as lights, pumps, electronics, etc. The size of auxiliary engine is usually calculated using ratio of average auxiliary engine to main engine.
- Boiler is used to produce heat and to keep bunker fuel remains warm (necessary to maintain the viscosity for pumping). Boiler usually operates during maneuvering and hoteling mode. When the vessel in cruise mode, boiler is off since the ship utilizes the heat of the main engine.

Operation Terminal 3 of Tanjung Priok does not register the engine power of the incoming vessels. The recorded data merely include length over all (LOA), draft and gross register tonnage (GRT).

To acquire the figures of main engine power, equation developed by Carlo Trozzi "Emission Estimate Methodology for Maritime Navigation-2010" has been used. The equation correlates GRT and power. Considering that data of ship production year are not available, the formula for world vessel in 1997 has been used. The emission inventory for ports in ASEAN region also has been performed using the formula (Report Emission Inventory for ASEAN Ports, ASEAN-GIZ Sustainable Port Development Project—Prepared by URS Australia Pty Ltd, August 2012)

Table 4-2. Correlation between Main Engine Power and Gross Tonnage – GT (Trozzi, 2010)

Vessel Category	World Vessel 2010 (kW)	World Vessel 1997 (kW)
Liquid Bulk	$14.755*GT^{0.6082}$	$29.821*GT^{0.5552}$
Dry Bulk	$14.755*GT^{0.6082}$	$89.571*GT^{0.4446}$
Container	$2.9165*GT^{0.8719}$	$1.3284*GT^{0.9303}$
General Cargo	$5.56482*GT^{0.7425}$	$10.539*GT^{0.6760}$
RoRo	$164.578*GT^{0.4350}$	$35.93*GT^{0.5885}$
Passenger	$9.55078*GT^{0.7570}$	$1.39129*GT^{0.9222}$

In accordance to the ship call data available in OT 3 for the period of January – March 2014, the average GRT of international vessel and domestics vessels is calculated by vessel category. Result of the calculation is presented in Table 4-3.

Table 4-3. Average GRT of Ship Call in OT 3 and Estimation of Power Engine (January – March 2014)

Category	Average GRT (Ton)			Average GT (1GT=1.875 GRT)	Conversion Formula; 1997 World Fleet (kW)	Average Engine Power (kW)
	Domestic	International	Average			
Container	10,360	16,009	13,185	7,032	$1.3284*GT^{0.9303}$	5,038
General Cargo	6,072	14,678	10,375	5,533	$10.539*GT^{0.6760}$	3,573
Tanker (Liquid Bulk)	-	5,025	5,025	2,680	$29.821*GT^{0.5552}$	2,387
Dry Bulk	-	15,597	15,597	8,319	$89.571*GT^{0.4446}$	4,955

Source:
Emission Estimate Methodology for Maritime Navigation by Carlo Trozzi
GT = Gross Tonnage, GRT = Gross Register Tonnage
Note, IGT = 1.875 GRT

The auxiliary engine power is estimated from its ratio to the main (propulsion) engine power (USEPA – ICF, 2009). The estimation of auxiliary engine power by ship category is presented in Table 4.4. Meanwhile, the estimation of boiler engine power is presented in Table 4.5.

Table 4-4. Estimation of Auxiliary Engine Power by Ship Category

Vessel Category	Power of Propulsion Engine (kW)*	Ratio of Auxiliary Engine / Propulsion Engine**	Power of Auxiliary Engine (kW)	Total Power (kW)
Container	5,038	0.220	1,108	6,146
General Cargo	3,573	0.191	682	4,256
Tanker	2,387	0.211	504	2,890
Dry Bulk	4,955	0.222	1,100	6,055

Notes:

*Calculated using formula as developed by Trozzi - 2010 for 1997 World Vessel Fleet
** From USEPA - ICF, 2009, Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories

Table 4-5. Estimation of Boiler Power (Default)

Vessel Category	Power of Boiler Per Operation Mode (kW)			
	Cruise	RSZ	Maneuver	Hoteling/ Berthing
Container	-	-	506	506
General Cargo	-	-	106	106
Tanker	-	-	371	3,000
Dry Bulk	-	-	109	109
Others	-	-	371	371

Source: USEPA - ICF, 2009, Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories

4.3.3. Load Factor

Load factor of the propulsion engine varies by each vessel speed. During cruise speed, the LF of propulsion engine is assumed to be 83%. On other operational mode/condition, LF will be calculated using Propeller Law in which actual speed of vessel is compared with the maximum speed and then ranked by 3cubed. The equation is as follow:

$LF = (AS/MS)^3$

Where:

LF = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

Referring to USEPA-ICF International 2009, LF fewer than 20% is still possible since the main engine is sometimes turned off and on when maneuvering in order to reduce the speed.

Data of maximum speed of vessel can be obtained from the technical specification of the vessel. Furthermore, data of actual speed of vessel could be obtained from Automatic Identification System (AIS) or literature data regarding typical speed of vessel in various operation modes.

Considering that data of speed for ship-call in OT 3 are not available, typical speed information as provided in USEPA – ICF, 2009 has been used. Furthermore, the "Maneuvering Standard in Tanjung Priok Port" has stipulated that:

- Maximum speed of vessel is the cruise speed divided by 0.94;
- The speed during RSZ mode operation (within the breakwater area) and during maneuvering mode operation is stipulated in the "Maneuvering Standard in Tanjung Priok Port" in which speed for RSZ is 6 knot and 5 knot for maneuvering. Using the conversion of 1 knot = 1.852 km/hour, the speed for RSZ will be 11.11 km/hour and speed for maneuvering will be 9.26 km/hour.

Based on the estimation speed above, the load factor for propulsion engine could be calculated. Furthermore, load factor for auxiliary engine will vary by type and operation mode of vessels. Several studies have indicated that auxiliary engine will remain running in all operation modes. In this study, LF of auxiliary engine is estimated based on the assumption provided by USEPA - ICF, 2009. The result of LF calculation for propulsion and auxiliary engine is presented in Table 4-6.

Table 4-6. Load Factor*of Propulsion and Auxiliary Engine*

Type of Vessel and Operation Mode	Propulsion Engine			LF of Auxiliary Engine**
	Actual Speed (km/hour)	Maximum Speed	Load Factor*	
Container				
Cruise	40.00	42.56	0.83	0.13
RSZ	11.11		0.02	0.25
Maneuver	9.26		0.01	0.48
Hoteling/Berthing	0		-	0.19
General Cargo				
Cruise	28.15	29.95	0.83	0.17
RSZ	11.11		0.05	0.27
Maneuver	9.26		0.03	0.45
Hoteling/Berthing	0		-	0.22
Tanker				
Cruise	27.41	29.16	0.83	0.24
RSZ	11.11		0.06	0.28
Maneuver	9.26		0.03	0.33
Hoteling/Berthing	0		-	0.26
Dry Bulk				
Cruise	26.85	28.57	0.83	0.17
RSZ	11.11		0.06	0.27
Maneuver	9.26		0.03	0.45
Hoteling/Berthing	0		-	0.10

Notes:
* = LF of Propulsion Engine = $(AS/MS)^3$, where AS = Actual Speed, MS = Maximum Speed
** LF of Auxiliary Engine, taken from USEPA- ICF 2009
During Hoteling/Berthing mode, propulsion engine is off

The estimation speed by type and operation mode of vessel is presented in Table 4-7.

Table 4-7. Estimation Speed by Type and Operation Mode of Vessel

Type of Vessel	Cruise Speed		Maximum Speed (km/hour)	Estimated Speed Per Operation Mode	
	knot	km/hour		RSZ	Maneuver
Container	21.60	40.00	42.56	11.11	9.26
General Cargo	15.20	28.15	29.95	11.11	9.26
Tanker	14.80	27.41	29.16	11.11	9.26
Dry Bulk	14.50	26.85	28.57	11.11	9.26
Other	13.00	24.08	25.61	11.11	9.26

Source: USEPA – ICF, 2009, *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*
RSZ speed (6 knot) & Maneuvering speed (5 knot) are based on the Maneuvering Standard of Tanjung Priok Port

4.4. Profile of Vessel Activities

4.4.1. Operation Mode

Vessels operate in various operation modes with different speed; therefore, the load of engine and the resulted emission will vary. The operation modes consist of:

- **Cruise Mode** (hour/call), usually performed in wide-open ocean in which the movement of vessel is not disturbed. In this mode, the typical speed is 94% of its maximum speed. During cruise mode, propulsion engine and auxiliary engine are operating together.
- **Reduce Speed Zone Mode (RSZ Mode)**, performed when the vessel operate below its cruise speed but above its maneuvering speed and in which its propulsion and auxiliary engines operate.
- **Maneuvering Mode** (hour/call), performed when the vessel is to moor, usually assisted by pilot boat. All engines are still running.
- **Hoteling Mode** (hour/call), performed when the vessel is tied up in the wharf, the propulsion engine is off and auxiliary engine and boiler remain running.

4.4.2. Distance of Each Operation Mode

As presented in the map of Tanjung Priok Port, available in Annex 1a, the travel distance for each operation mode is described as follows:

- Vessel operates in "Cruise Mode" as long as 25 nm (Nautical Miles) or 46.3 km (1 nm = 1.852 km) before it reaches sea buoy position or Sinker 1 position.
- Vessel will anchor in Sinker 1 position while waiting for Pilot Officer. Pilot boat moves from the harbor to the anchored vessel with average travel distance of 5.58 km (please refer to the map of Tanjung Priok Port) per ship call. After the pilot gets into the vessel, the vessels moves forward to the harbor pond (bordered by breakwater) from Sinker 1 position up to red light signal position or with distance of 723.58 m + 2,462.54 m = 3,186.12 m. During this process, the vessel operates in RSZ Mode.
- From the harbor pond to the mooring place, the vessel operates in Maneuvering Mode with travel distance of about 1,481.28 m + 908.77 m = 2,390.05 m.
- In the wharf, the vessel operates in Hoteling Mode while it loads and unloads freight.

4.4.3. Duration for Each Operation Mode

Based on the speed and travel distance data, the duration for each operation mode could be estimated. The duration for maneuvering mode is usually added by 15 minutes for tie process. Data of the duration for hoteling mode or berthing is collected from Marketing Division of OT 3 of Tanjung Priok Port. The estimated duration for each operation mode is presented in Table 4-8.

Table 4-8. Estimated Time for Each Operation Mode

Type of Vessel	Distance (m) Per Operation Mode			Vessel Speed(km/hour)*			Duration Per Call (hour)**		
	Cruise	RSZ	Maneuver	Cruise	RSZ	Maneuver	Cruise	RSZ	Maneuver
Container	46,300.00	3,186.12	2,390.05	40.00	11.11	9.26	2.31	0.57	0.77
General Cargo	46,300.00	3,186.12	2,390.05	28.15	11.11	9.26	3.29	0.57	0.77
Tanker	46,300.00	3,186.12	2,390.05	27.41	11.11	9.26	3.38	0.57	0.77
Dry Bulk	46,300.00	3,186.12	2,390.05	26.85	11.11	9.26	3.45	0.57	0.77

Notes: Duration Per-Call = when the vessel gets in and out of the port

The "time" for maneuvering is added by 15 minutes for tying process

Data of the time needed for hoteling or berthing are collected from OT 3, as presented in Table 4-9.

Table 4-9. Estimated Time for Hoteling/Berthing

Type of Vessel	Average Berthing Time (hour)		
	Domestic	International	Average
Container	31.23	22.59	26.91
General Cargo	82.75	37.87	60.31
Tanker	65.92	0	65.92
Dry Bulk	0	90.33	90.33

Source: The berthing time is analyzed based on the data collected from Marketing Division of OT3, Jan-Mar 2014

4.5. Emission Factor

Emission Factor is a representative value which correlates the quantity of pollutant released to the atmosphere from an activity related to pollutant source. The emission factor of vessel engine varies depending on the speed (rotation) of engine and the consumed fuel.

In general, VESSEL uses residual oil (RO) or marine diesel oil (MDO) or marine gas oil (MGO) as its fuel. MDO and MGO are usually utilized to run auxiliary engine and to clean up and cold start-up of the main (propulsion) engine.

The vessel engine rotation comprises of slow-speed diesel (SSD), medium-speed diesel (MSD) and high-speed diesel (HSD).

The emission factor for vessel is adopted from “USEPA Current Methodologies Report (ICF, 2009)” as presented in Table 4-10. The emission factor is based on the Entec’s Study on July 2002, as prepared for European Commission. The study has assumed that main (propulsion) engine uses residual oil (RO).

Table 4-10. Emission Factor of OGV

Type of Boat	Emission Factor, g/kWh								
	Engine Type	Fuel	Sulfur (%)	NOx	CO	PM10	PM2.5	SO2	CO2
Propulsion Engine	SSD	RO	2.70%	18.10	1.40	1.42	1.31	10.29	620.62
Auxiliary Engine	SSD	RO	2.70%	14.70	1.10	1.44	1.32	11.98	677.91
Boiler	SSD	RO	2.70%	2.10	0.20	0.80	0.60	16.50	970.71

Source: USEPA – ICF, 2009, *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*

Furthermore, according to “Air Emission Inventory of South Caroline Ports, 2013”:

- Vessel usually uses bunker fuel or residual oil (RO) though since 2010 US-EPA and IMO (International Maritime Organization) has strictly regulated the emissions of sulfur and NOx of vessel entering into ECA – Emission Control Area (the entire coastline of USA and Canada, both Pacific and Atlantic, andGulf of Mexico). However, this regulation has not been implemented strictly. Furthermore the sulfur content of RO is 2.7%.
- All vessel engines use slow-speed diesel (SSD) except for cruise vessel which uses medium-speed diesel.

Therefore, for the purpose of this study, it is assumed that vessels entering OT 3 uses engine with RO fuel, slow-speed diesel and a sulfur content of 2.7%.

For load factor of propulsion engine under 20%, correction factor will be applied to calculate the increase of emission per kW. The reason is that propulsion engine does not operate efficiently on low LF which resulted in higher emission per kW. The correction factor is presented in Table 4-11.

Table 4-11. Correction Factor for Propulsion Engine with Low LF

LF	Nox	CO	PM10	PM2.5	SO2	CO2
1%	11.47	19.32	19.17	19.17	5.99	5.82
2%	4.63	9.68	7.29	7.29	3.36	3.28
3%	2.92	6.46	4.33	4.33	2.49	2.44
4%	2.21	4.86	3.09	3.09	2.05	2.01
5%	1.83	3.89	2.44	2.44	1.79	1.76
6%	1.6	3.25	2.04	2.04	1.61	1.59
7%	1.45	2.79	1.79	1.79	1.49	1.47
8%	1.35	2.45	1.61	1.61	1.39	1.38
9%	1.27	2.18	1.48	1.48	1.32	1.31
10%	1.22	1.96	1.38	1.38	1.26	1.25
11%	1.17	1.79	1.3	1.3	1.21	1.21
12%	1.14	1.64	1.24	1.24	1.18	1.17
13%	1.11	1.52	1.19	1.19	1.14	1.14
14%	1.08	1.41	1.15	1.15	1.11	1.11
15%	1.06	1.32	1.11	1.11	1.09	1.08
16%	1.05	1.24	1.08	1.08	1.07	1.06
17%	1.03	1.17	1.06	1.06	1.05	1.04
18%	1.02	1.11	1.04	1.04	1.03	1.03
19%	1.01	1.05	1.02	1.02	1.01	1.01
20%	1	1	1	1	1	1

Source: USEPA – ICF, 2009

Black Carbon (BC) emission is estimated based on various researches as found in the references regarding Black Carbon (BC) Emission Inventory Methods and Comparisons – EPA’s National Emission Inventory 2012. BC for vessel is 28% from PM 2.5.

Tabel 4-12. Emission Factor of Propulsion Engine, Auxiliary Engine and Boiler (g/kW-hr)

For All Vessel Category	Emission Factor, g/kWh								
	Engine Type	Fuel Type	Sulphur (%)	Nox	CO	PM10	PM2,5	SOX	CO2
Propulsion Engine	SSD	RO	2,70%	18,10	1,40	1,42	1,31	10,29	620,62
Auxiliary Engine	SSD	RO	2,70%	14,70	1,10	1,44	1,32	11,98	677,91
Boiler	SSD	RO	2,70%	2,10	0,20	0,80	0,60	16,50	970,71

Source: USEPA – ICF, 2009, *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*

4.6. Result of Emission Load of Vessel

The result of emission calculation for vessel is presented in Table 4-12.

Table 4-123. Estimation of Emission Load of Vessel (January – March 2014)

Vessel Category	Num of Ship	Data of Propulsion		Total Emission of Propulsion Engine, Auxiliary Engine, and Boiler (Gram)						
		Power (kW)	Activity (hour)	Nitrogen Oxide (NOx)	Carbon Monoxide (CO)	PM10	PM2.5	Sulfur Dioxide (SO2)	Black Carbon	CO2
Container	222	5,038		**69,667,350**	**5,629,211**	**7,997,970**	**6,937,021**	**91,820,699**	**1,942,366**	**5,352,825,423**
Cruise			2.31	40,009,696	3,091,932	3,160,114	2,914,690	23,014,100	816,113	1,384,742,475
RSZ			0.57	1,475,397	193,538	168,992	155,603	817,364	43,569	30,999,637
Maneuver			0.77	3,343,872	355,551	439,492	392,802	3,048,435	109,985	150,374,812
Hoteling/Berthing			26.91	24,838,384	1,988,190	4,229,373	3,473,926	64,940,800	972,699	3,786,708,498
General Cargo	103	3,573		**35,204,100**	**2,777,785**	**3,500,298**	**3,128,595**	**33,827,997**	**876,007**	**1,966,005,114**
Cruise			3.29	18,778,701	1,451,041	1,484,518	1,369,188	10,818,267	383,373	650,726,544
RSZ			0.57	517,139	70,693	53,032	48,832	328,993	13,673	14,070,239
Maneuver			0.77	814,496	98,366	92,856	84,304	642,014	23,605	29,725,756
Hoteling/Berthing			60.31	15,093,764	1,157,685	1,869,892	1,626,271	22,038,723	455,356	1,271,482,576
Tanker	1	2,387		**678,453**	**60,040**	**181,846**	**140,347**	**3,450,128**	**39,297**	**202,748,723**
Cruise			3.38	127,352	9,835	10,111	9,324	73,911	2,611	4,439,166
RSZ			0.57	3,382	434	336	309	2,224	87	101,831
Maneuver			0.77	5,564	727	771	671	7,717	188	398,613
Hoteling/Berthing			65.92	542,154	49,044	170,629	130,043	3,366,277	36,412	197,809,113
Dry Bulk	10	4,955		**4,530,024**	**360,269**	**454,023**	**404,205**	**4,492,938**	**113,177**	**261,756,924**
Cruise			3.45	2,663,325	205,764	210,795	194,411	1,537,483	54,435	92,442,269
RSZ			0.57	73,459	9,481	7,296	6,717	48,104	1,881	2,192,267
Maneuver			0.77	125,836	16,032	14,079	12,841	92,342	3,595	4,184,125
Hoteling/Berthing			90.33	1,667,404	128,992	221,853	190,237	2,815,009	53,266	162,938,263
Number of Vessel	336									
Total Emission (g)				**110,079,927**	**8,827,305**	**12,134,137**	**10,610,168**	**133,591,762**	**2,970,847**	**7,783,336,183**
Total (kg)				110,080	8,827	12,134	10,610	133,592	2,971	7,783,336
Total (ton/3 month)				110.08	8.83	12.13	10.61	133.59	2.97	7,783
Estimation for one year (ton)	**1,344**			**440.32**	**35.31**	**48.54**	**42.44**	**534.37**	**11.88**	**31,133**

The summary of the calculation result of emission of vessel is presented in table 4-14 to 4-16.

Table 4-13. Summary of Calculation Result of Emission of Vessel by Type of Vessel

Category	Emission (Ton)						
	NOx	CO	PM10	PM2.5	SO2	BC	CO2
Container	69.67	5.63	8.00	6.94	91.82	1.94	5,352.83
General Cargo	35.20	2.78	3.50	3.13	33.83	0.88	1,966.01
Tanker	0.68	0.06	0.18	0.14	3.45	0.04	202.75
Dry Bulk	4.53	0.36	0.45	0.40	4.49	0.11	261.76
Total (January - March 2014)	**110.08**	**8.83**	**12.13**	**10.61**	**133.59**	**2.97**	**7,783.34**
Estimation for 2014	**440.32**	**35.31**	**48.54**	**42.44**	**534.37**	**11.88**	**31,133.34**

Table 4-14. Summary of Calculation Result of Emission of Vessel by Engine Category

Source of Emission	Emission						
	NOx	CO	PM10	PM2.5	SO2	BC	CO2
Propulsion Engine	63.52	5.17	5.15	4.75	35.42	1.33	2,077.21
Auxiliary Engine	38.01	2.84	3.72	3.41	30.97	0.96	261.79
Boiler Engine	8.55	0.81	3.26	2.44	67.20	0.68	3,953.44
Total (January - March 2014)	**110.08**	**8.83**	**12.13**	**10.61**	**133.59**	**2.97**	**6,292.44**
Estimation for 2014	**440.32**	**35.31**	**48.54**	**42.44**	**534.37**	**11.88**	**25,169.76**

Table 4-15. Summary of Calculation Result of Emission of Vessel by Operation Mode

Operation Mode	Emission						
	NOx	CO	PM10	PM2.5	SO2	BC	CO2
Cruise	61.58	4.76	4.87	4.49	35.44	1.26	2,132.35
Reduced Speed Zone	2.07	0.27	0.23	0.21	1.20	0.06	47.36
Maneuvering	4.29	0.47	0.55	0.49	3.79	0.14	184.68
Hoteling/Berthing	42.14	3.32	6.49	5.42	93.16	1.52	5,418.94
Total (January - March 2014)	**110.08**	**8.83**	**12.13**	**10.61**	**133.59**	**2.97**	**7,783.34**
Estimation for 2014	**440.32**	**35.31**	**48.54**	**42.44**	**534.37**	**11.88**	**31,133.34**

5. Harbor Craft

5.1. Emission Inventory Methodology for Harbor Craft

Harbor Crafts in OT 3 included in the emission inventory are pilotage fleet consisted of tug boat, pilot boat and mooring boat. Emission of each fleet is calculated using the following equation:

E= P x LF x A x EF

Where:

E = Emission (gram/year)

P Total Power, including propulsion engine and auxiliary engine power (kW)

LF = Load Factor (% of Vessel total power for each operation mode)

A = Activity (hour/year)

EF = Emissions Factor (gram per kilowatt-hour, g/kW-hr)

5.2. Business Process of Harbor Craft

The business process of harbor craft involving pilotage fleets in OT 3 includes maneuvering services process consisted of (1) vessel entering the breakwater and turnaround, (2) vessel berthing and (3) vessel getting out of the port.

The execution of maneuvering in Tanjung Priok Port is stipulated in the "Standard of Ship Maneuvering of Port of Tanjung Priok", particularly for each wharf and also for ship-to-ship.

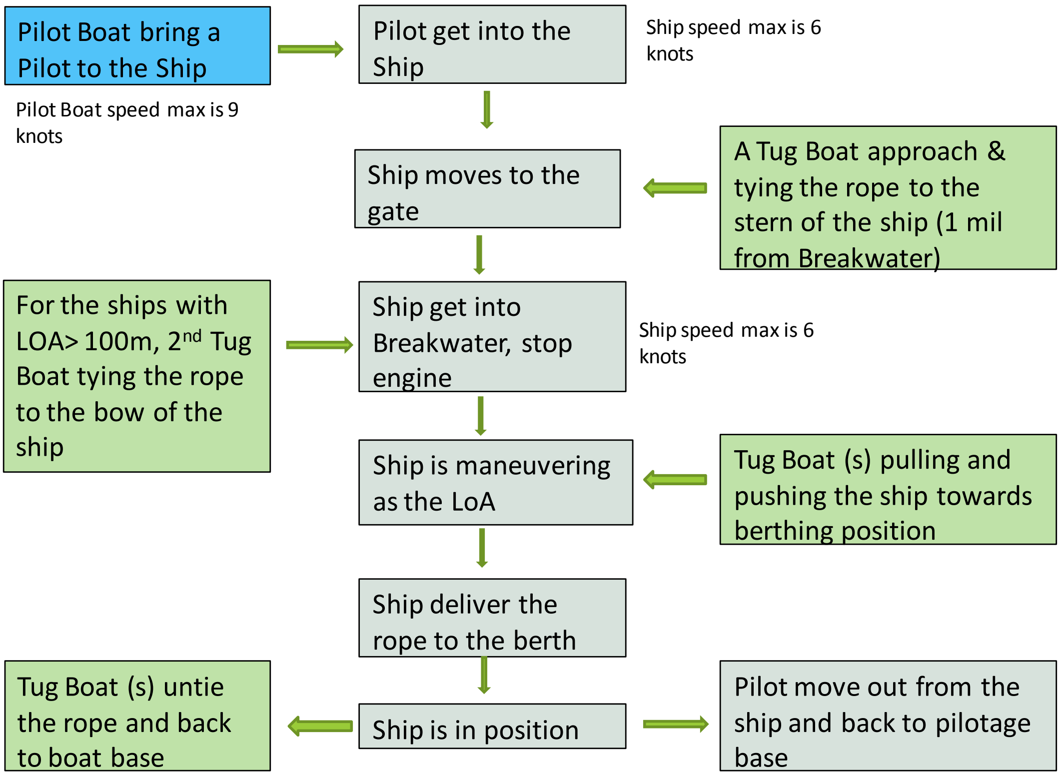
The following section describes maneuvering services in Tanjung Priok Port:

- Vessel entering the port:
  - Pilot boat escorts the pilot to the vessel. Pilot gets into the vessel. The maximum allowable speed of the pilot boat inside the breakwater is 9 knots while speed outside the breakwater could be more than 9 knots depending on the needs.
  - After the pilot gets into the vessel and the vessel is ready, tug boat from the base will go to the port gate; tug boat will tie rope to the stern of the ship (1 mil from breakwater)
  - For vessel with LOA > 100m, the second tug boat will tie rope to the bow of the ship after it gets into the breakwater.

  The illustration of business process of vessel getting into the port is presented in Figure 5-1.
- Berthing Process
  - When the bow is closeto the wharf, the vessel sends the rope to the determined wharf border which could be assisted by mooring boat.
- Vessel Outgoing Process

- Pilot gets into the vessel
- When ready, tug boat will tie rope to the bow. For vessel with LOA > 100, the second tug boat will tie rope to the stern.
- Tug(s) boat pull the vessel from the wharf.
- After reaching safe distance from the wharf and the nearby vessel, tug boat stops pulling and standby; vessel move slowly to the breakwater gate.
- Near the port gate, tugs boat releases the rope and goes back to the base.
- Vessel gets out from the breakwater and goes to Pilot Boarding Ground (PBG) in safe speed.
- Pilot boat picks up the pilot in PBG location to be escorted to the base.

Figure 5-1. Business Process of Vessel Getting into the Port



Source: Standard of Ship Maneuvering of Port of Tanjung Priok

5.3. Harbor Craft Characteristics

The technical data of pilotage fleets in 2013 are presented in Table 5-1 while the detail data are available in Annex 3.

Table 5-1. Technical Data of Pilotage Fleet in 2013

No	Boat Type	Number	Year of Production	Average Power of Main Engine (hP)	Average Power of Supporting Engine (hP)	Max Spedd Mil/Hour
1	Tug Boat	18	1987 - 2012	2 x 1228	2 x 217	12
2	Pilot Boat	11	1980 -2012	2 x 282	1 x 18	16
3	Mooring Boat	7	1980 - 2010	1 x 105		10
4	Survey Boat	1	1999	2 x 375	1 x 27	11

Furthermore, the average power of pilotage fleet is presented in Table 5-2.

Table 5-2. Average Power and Load factor of Pilotage Fleet

No	Pilotage Fleet	Average Power (hP)*		Load Factor**		Total Power
		Propulsion Engine	Auxiliary Engine	Propulsion Engine	Auxiliary Engine	
1	Tug Boat	1,227.94	216.68	0.79	0.56	1,091.41
2	Pilot Boat	281.82	17.70	0.45	0.56	136.73
3	Mooring Boat	112.14	6.70	0.45	0.56	54.22

Source:

*Average Number from Data of Pilotage Fleet

** USEPA - ICF International 2009

5.4. Profile of Harbor Craft Activities

The maneuvering process is performed by pilotage officers with the support of the following facilities:

- Land transportation (car) and sea transportation (pilot boat) for Pilot officers.
- Tug boat to assist vessel maneuvering. The use of tug boat will highly depend on the LOA of the vessel being served
- Mooring boat to assist the vessel during mooring period.

The use of pilot boat is of the following stipulations:

- To escort pilot to the Pilot Boarding Ground (PBG) position and then the pilot boat back to the base;
- Pick up the pilot who has completed his job in PBG to go back to the base;
- It is possible that one pilot boat carries more than one pilot, either to escort or to pick up. For the purpose of emission calculation, however, it is assumed that one pilot boat serves one pilot.
- It is assumed that travel distance of pilot boat is always the same, i.e. base – farthest sea buoy – base = 2 x (908.77 + 1481.28 + 2462.54 + 723.58) / 1000 m = 11.15 km.
- It is assumed that pilot boat runs on the same speed, i.e. 9 knot or 16.67 km/hour.

The use of tug boat is of the following stipulations:

- The service of tug boat highly depends on vessel LOA;
    - Vessel with LOA< 70 m does not require tug boat service
    - Vessel with LOA > 70 m but <100m requires 1 tug boat.

- Vessel with LOA > 100 m requires 2 tug boats.

- It is assumed that all ship calls in OT 3 uses tug boat service for mooring and lraving the port. Due to limited available data on moving boat, the emission for this type of boat is neglected.
- It is assumed that travel distance of tug boat (either using 1 boat or 2 boats) is base – port gate – base or = 2 x (908.77 + 1481.28) / 1000m = 4.78 km.
- The speed of tug boat during pulling and not pulling will be different; however, to simplify the calculation of emission, it is assumed that average speed is the same as safe speed of vessel in the breakwater, i.e. 6 knot or 11.11 km/hour.

Table 5-3 presents the estimation of tug boat usage serving ship call in OT 3 for the period of January – March 2014.

Table 5-3. Estimation of Tug Boat Usage (January – March2014)

LOA (m)	The Shortest Vessel LOA (m)	Number of Vessel per LOA Category			Number of Required Tub Boat Services (in and out the port)*		
		70 - 100 m	> 100 m	Total	70 - 100 m	> 100 m	Total
January Domestics	82.30	7	60	67	14	240	254
January International	99.50	1	56	57	2	224	226
February Domestics	85.95	4	52	56	8	208	216
February International	74.00	1	38	39	2	152	154
March Domestics	78.00	3	60	63	6	240	246
March International	80.00	2	52	54	4	208	212
Total		18	318	336	36	1,272	1,308

Notes:

The need of tug boat: 0 for LOA <70m, 1 for LOA <100m, and 2 for LOA > 100m (based on the Vessel Maneuvering Standard of Tanjung Priok Port)

* Number of tug boat per-vessel (including in and out port process)

Use of Mooring Boat

Mooring boat is used to assist tying rope when the vessel is going to moor or untying rope when the vessel is leaving. In accordance to the result of discussion with the Pilot Division and OT 3, mooring boat is rarely used. The tying of rope could be performed by the workers without the assistant of mooring boat. For this study therefore, emission of mooring boat will be neglected.

Furthermore, based on the above process, the profile of pilotage fleet activities could be summarized as presented in Table 5-4.

Table 5-4. Profile of Pilotage Fleet Activity

No	Type of Boat	Number of Utilization (go-back)	Average Speed (Km/hour)	Distance per trip, go-back (Km)	Total Number Utilization of Time (hour)
1	Tug Boat	1,308	11.11	4.78	562.8
2	Pilot Boat	672	16.67	11.15	449.5
3	Mooring Boat	-			0

Notes & Assumptions:

- 1 Trip = boat base - destination (PBG for pilot boat; 1 mil after port gate for tug boat) - base

- Estimation for pilot boat utilization for 336 ship call (1x go-back to escort pilot to the vessel going into the port + 1x go-back to pick up pilot from the PBG)

- Mooring boat is rarely used so that it is neglected

For more accurate data to be used in the future, it is suggested to conduct survey on vessel maneuvering and interview with Pilot Staff or other related parties.

5.5. Emission Factor

Emission factor for pilotage fleet will use data from USEPA based on the power for Tier0 engine category, as presented in Table 5-5.

Table 5-5. Emission Factor of Pilotage Fleet

Type of Boat	Total Power (kW)	Emission Factor (gr/kWh)					
		NOx	CO	PM10	PM2.5	SO2	CO2
Tug Boat	1,091.41	13.00	2.5	0.3	0.29	1.3	690
Pilot Boat	136.73	10.00	1.5	0.4	0.39	1.3	690
Mooring Boat	54.22	10.00	1.7	0.4	0.39	1.3	690

Source: USEPA - ICF International 2009

The calculation of Black Carbon Emission will use the same reference as VESSEL, i.e. 28% of PM2.5.

5.6. Calculation of HarborCraft Emission

Based on the above presented data, the calculation of emission for the period of January-March 2014 is done and the result is presented in Table 5-6.

Table 5-6. Estimation of Emission of Harbor Craft Source (January-March 2014)

Type of Boat	Average Total Power (kW)	Total Activity (hours)	Emission (gram)						
			Nitrogen Oxide (NOx)	Carbon Monoxide (CO)	PM10	PM2.5	Sulfur Dioxide (SO2)	Black Carbon	CO2
Tub Boat	1,091	562.76	7,984,584	1,535,497	184,260	178,732	798,458	50,045	423,797,172
Pilot Boat	137	449.48	614,572	92,186	24,583	23,845	79,894	6,677	42,405,484
Mooring Boat	54	-	-	-	-	-	-	-	-
Total Jan-Mar 2014 (Kg)			8,599.16	1,627.68	208.84	202.58	878.35	56.72	466,202.66
Total Jan-Mar 2014 (Ton)			8.60	1.63	0.21	0.20	0.88	0.06	466.20
Estimation for 1 year (Ton)			34.40	6.51	0.84	0.81	3.51	0.23	1,864.81

6. Cargo Handling Equipment (CHE)

6.1. Emission Inventory Method for CHE

Based on the reference as available in USEPA-ICF International 2009 and California Air Resources Board (CARB) – 2011, the calculation of emission for CHE could be performed using modeling. Data input for the modeling includes: type of equipment, type of engine, year of engine fabrication, type of retrofit/repower, year of chassis fabrication, type of fuel, number of operating hours in one year, power (hP), cumulative operating hour and fuel consumption per equipment.

In this study, however, due to limited data and resource available, the calculation of emission for CHE is performed using simple method or streamlined inventory method.

The equation to calculate emission for each CHE is as follow:

$$\boldsymbol{E = P \times A \times LF \times EF}$$

Where:

E = Emission, gram/year

P = Power, hp orkW

A = Activity, hours/year

LF = Load Factor (ratio of average usage during normal operation to maximum load)

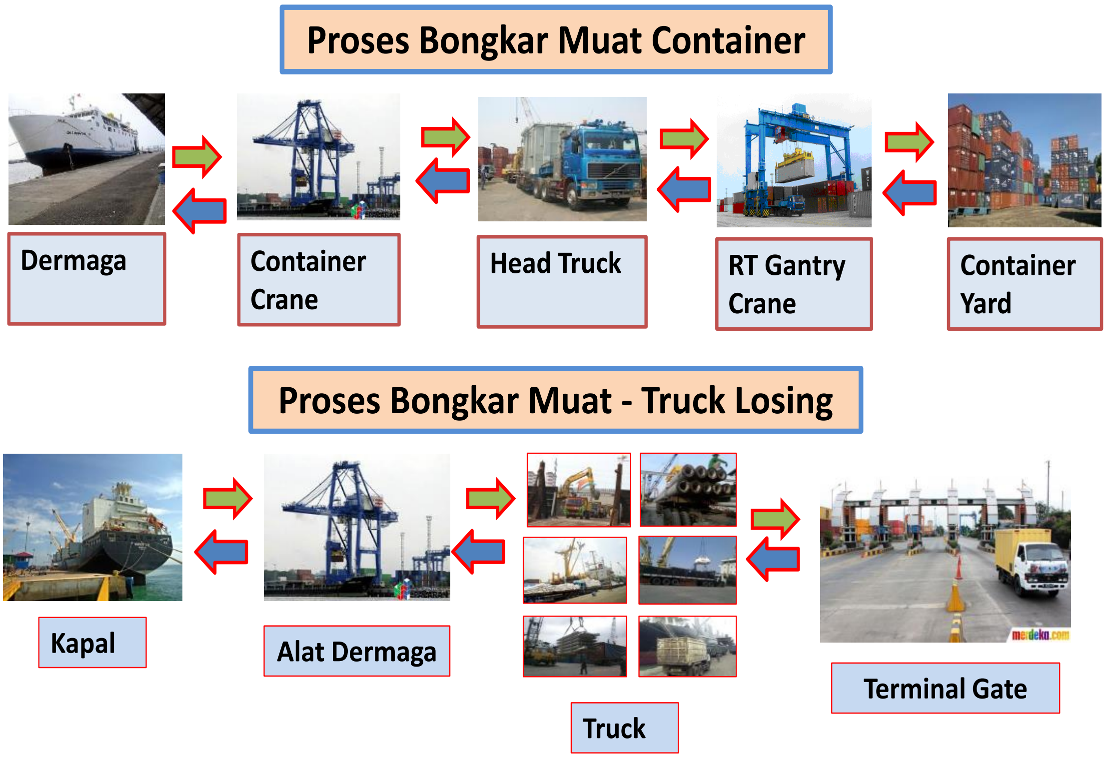
EF = Emission Factor, gram pollutant per-working unit (g/hp-hour or g/kW-hour)

6.2. Business Process of Goods Service

The business process for liquid bulk cargo, dry bulk cargo, bag cargo and unitized is generally the same as container; however, for this case, it is done through truck losing. In the future, OT 3 will only serve container and will eliminate truck losing.

The illustration of goods service is presented in Table 6-1.

Table 6-1. Loading-Unloading Process of CHE



Furthermore, the activities and the required equipments are presented in Table 6-2.

Table 6-2. Activities and Required Loading-Unloading Equipment

No	Activity	Description	Equipment
1	Unloading/Loading	Unload container from the ship to the truck and the reverse	Gantry Crane, Ship Crane
2	Haulage	Moving/transporting container from apron to container yard	Head Truck
3	Discharging	Moving container from apron the container yard	Top Loader, Forklift
4	Lift On	Lifting container on the stack	Transtainer, Top Loader, Forklift
	Lift Off	Pulling down container from the stack	

5	Stripping	Load is disembarked from the container	Forklift
	Stuffing	Load is embarked to the container	
6	Delivery	Transport the container outside the terminal	Head Truck

Source: http://www.supplychainindonesia.com/

Container loading/export activities are the movement flow of goods from land transport to sea transport using container system. The process is as follows:

- Container is transported using land transport facility (trailer) to the destination terminal;
- Container is managed and stacked in the container yard using yard equipments (such as rail mounted gantry crane - RMGC, rubber tire gantry crane - RTGC, reach stacker and forklift) while waiting for the ship;
- When the ship arrives and be ready in the wharf, containers are lifted to the head truck using the yard equipments;
- Head truck moves forward to the wharf apron where the ship moors;
- Using wharf equipments (usually quay container crane – QCC and harbor mobile crane – HMC), container in the head truck is loaded to the ship;
- When all containers have been loaded to the ship, the ship leaves the port to go to the destination port.

For importing of goods, on the other hand, the process of unloading or the flow of goods from the ship to the container yard is as follow:

- Ship arrives and moors in the wharf;
- Head truck goes to the wharf apron where the ship moors;
- Container is lifted from the ship using wharf equipments and placed in the head truck;
- Head truck moves to the container yard;
- In the container yard, the container is lifted using yard equipments and stacked in the container yard while waiting for the trailer to be further transported;
- Trailer gets into the terminal and moves to the container yard; using the yard equipments, container is lifted to the trailer;
- Trailer gets out from the terminal and goes to the destination.

6.3. CHE Characteristics and CHE Activities in OT 3

Cargo handling equipments include all equipments to move cargo (including container, general cargo, bulk and unitized) from the ship to the truck and vice versa. CHE could be the source of PM pollutant which is significant in port environment.

CHE in OT 3 of Tanjung Priok Port includes:

- Wharf equipments, including quay container crane (QCC) and harbor mobile crane (MHC)
- Yard equipments, including rail mounted gantry crane (RMGC), rubber tire gantry crane (RTGC), reach stacker and forklift

The detail data of the equipments is presented in Table 6-3.

Table 6-3. Summary of CHE Data in OT 3

No	Type of Equipment	Number	Average Capacity (Ton)
1	Quay Container Crane (QCC)	9	40
2	Harbor Mobile Crane (HMC)	10	100
3	Rail Mounted Gantry Crane (RMGC)	5	35
4	Rubber Tired Gantry Crane (RTGC)	22	40
5	Reach Stacker	13	45
6	Forklift	8	7.5
7	Weigh Bridge	2	100
	Total Number	69	

The illustration of several CHE utilized in OT 3 is presented in Figure 6-1.

Figure 6-1. Illustration of CHE Equipments

Source: SPD Project, Presentation on Port Structure & Terminal Operations, Captain Suwak Chuanak & Yosthana Siphomsay, Iloilo 25 April 2011.

In this study, data required to calculate the emission of CHE are not available. Therefore, several assumptions and estimations have been used, as presented in Table 6-4.

Table 6-4. Assumptions to Calculate Emission of CHE Source

Data	Assumption, Estimation, Conversion for Calculation
Unit of CHE Power in kva (kilo volt ampere)	1 kvA = 1000 kW 1 kW = 1,340 hP
Some equipments are broken and not operate	Excluded from the calculation
Equipment power (reach stacker and some of HMC) is not available; however, there is equipment data from similar equipment of different brad	Using available data from other equipment brand
Forklift power and RTG Power are not available	Adopted from Los Angeles Port, Inventory of Air Emission, 2012
Activity of the equipment only available for the period of January and February 2014	The data for March 2014 is made equal to January 2014

Based on the above assumptions, the equipment characteristics and activities of CHE in OT 3 could be summarized. The result is presented in Table 6-5.

Table 6-5. Summary of Characteristics and Activity Profiles of CHE

No	Type of Equipment	Number	Average Capacity (Ton)	Source of Energy	Average Power		Average Activity (hr/3 months)	Average Production Year	Average Equipment Age (year)
					kW	hP			
1	Quay Container Crane (QCC)	9	40	Diesel	858	1,150	191.6	1989	25
2	Harbor Mobile Crane (HMC)	10	100	Diesel	731	979	863.1	2007	7
3	Rail Mounted Gantry Crane (RMG	5	35	Diesel	870	1,166	511.6	1982	32
4	Rubber Tire Gantry Crane (RTGC)	22	40	Diesel	400	536	795.8	2004	10
5	Reach Stacker	13	45	Diesel	250	335	490.8	2009	5
6	Forklift	8	7.5	Diesel	124	166	540.0	2006	8
	Number	67							

Notes:
Part of power data is assumed or based on the data from other port for different brand
Part of activity data is assumed for 8 hours per day and 20 days per month
1 hP = 0.746 kW or 1 kW = 1.340 hP

6.4. Calculation of CHE Emission for OT 3

6.4.1. Load Factor of Engine - LF

Load factor of engine represents the average operation level of engine in a given application as a fraction or percentage of the maximum power of the engine as indicated by the manufacturer. In this study, load factor data is adopted from CARB – 2011 as presented in Table 6-6.

Table 6-6. Load Factor by Type of CHE

No	Type of CHE	LF
1	Quay Container Crane (QCC)	0.43
2	Harbor Mobile Crane (HMC)	0.43
3	Rail Mounted Gantry Crane (RMGC)	0.20
4	Rubber Tire Gantry Crane (RTGC)	0.20
5	Reach Stacker	0.59
6	Forklift	0.51

Source: CARB, 2011

6.4.2. Emission Factor

The calculation of emission of CHE is performed using streamlined method in which emission factor of CHE is determined based on the engine power and production year of the engine.

The oldest engine currently used in OT 3 is that manufactured in 1977 (i.e. Rail Mounted Gantry Crane), while the newest engine is that manufactured in 2013 (i.e. Harbor Mobile Crane). Currently, all cargo handling equipments in OT 3 operate using diesel fuel.

Another consideration in determining emission factor for emission inventory is the quality of diesel fuel. In Indonesia, it should be noted that some diesel fuels still contain high levels of sulfur. According to the Ministry of Environment (2014), the sulfur content in diesel fuel could reach 3500 ppm. However, Indonesia has Pertamina Dex solar fuel which its sulfur content is 200 ppm.

With the high level of sulfur content in the diesel fuel, the data from USEPA-ICT 2009 will be applied for engine of TIER 0 category. TIER 0 engines does not apply modern emission control system and its operation is managed mechanically rather than electronically. In this study, therefore, the emission factor is based on the equipment power. The detail of emission factor is presented in Figure 6-7.

Table 6-7. Emission Factor of CHE by Equipment Power

Power (hP) of CHE	NOx	CO	PM10	PM2.5	SO2	CO2
>100 s/d 175	8.4	2.7	0.4	0.39	0.16	526
>175 s/d 300	8.4	2.7	0.4	0.39	0.16	526
>300 s/d 600	8.4	2.7	0.4	0.39	0.16	526
>600 s/d 750	8.4	2.7	0.4	0.39	0.16	526
>750	8.4	2.7	0.4	0.39	0.16	526

Source: USEPA - ICF 2009, Emission Factor for Non-Road Source, TIER 0

6.4.3. Calculation Result of Emission of CHE

Based on the available data and the assumptions, the emission of CHE has been calculated. The result is presented in Table 6-8.

Table 6-8. Calculation Result of Emission of CHE Source

No	Equipment	Number	Power (hp)	Activity (hour)	LF	Emission (Kilo gram)						
						Nitrogen Oxide (NOx)	Carbon Monoxide (CO)	PM10	PM2.5	Sulfur Dioxide (SO2	Black Carbon	CO2
	Emission Factor (gr/hp-hour)					**8.4**	**2.7**	**0.4**	**0.39**	**0.16**		**526**
1	Quay Container Crane (QCC)	9	1,150	192	0.43	7,163	2,303	341	333	136	93	448,568
2	Harbor Mobile Crane (HMC)	10	979	863	0.43	30,523	9,811	1,453	1,417	581	397	1,911,304
3	Rail Mounted Gantry Crane (RMGC)	5	1,166	512	0.20	5,010	1,610	239	233	95	65	313,719
4	Rubber Tire Gantry Crane (RTGC)	22	536	796	0.20	15,766	5,068	751	732	300	205	987,250
5	Reach Stacker	13	335	491	0.59	10,594	3,405	504	492	202	138	663,394
6	Forklift	8	166	540	0.51	3,070	987	146	143	58	40	192,228
	Total (January - March 2014) - Kg	**67**				**72,126**	**23,183**	**3,435**	**3,349**	**1,374**	**938**	4,516,461
	Total (January - March 2014) - Ton					**72.1**	**23.2**	**3.4**	**3.3**	**1.4**	**0.9**	4,516
	Estimation for 1 year (ton)					288.50	92.73	13.74	13.39	5.50	3.75	18,066

7. Land Transportation (Heavy Duty Vehicle)

7.1. Identification of Heavy Duty Vehicle in OT 3

Based on the literature, the scope of emission inventory for land transportation shall include emission produced from the truck getting in and out of the port. Currently, there is no system to manage the movement and circulation of trucks in and out of port terminal. In addition, it is found that some trucks get in the terminal without carrying any definitive cargo to be transported. Therefore, it will be difficult to conduct an emission inventory in this unsystematic condition as various and wide ranges of data are required. Besides, in the near future OT 3 will stop truck losing system which allows trucks coming from the outside of the port could directly transport cargo from and to the ship. In the future, all trucks will only be allowed to transport cargo from and to the container yard.

Under these conditions, it is agreed that emission inventory for land transportation activities in Operation Terminal 3 will merely cover the operation of heavy duty vehicle, i.e. head trucks used in OT 3 (haulage process).

7.2. Methodology

The emission for head truck activity is calculated both during operating/running condition (vehicle km travelled, VKM) and during idling condition (hour).

The calculation of emission for truck is based on USEPA-ICF 2009, using the following equation:

E = A x EF

Where:

E = Emission (gram/year)

A = Activity (hour orkm travelled/year)

EF = Emission Factor (gram/hour or gram/km)

Head truck is operated by Stevedoring Company of Tanjung Priok partner which particularly handles for container. For other cargo (liquid bulk, dry bulk, bag cargo and general cargo), truck losing system has been used.

7.3. Characteristics and Activity Profile of Head Truck in OT 3

Head truck has been extensively used to transport cargo from the ship to the container yard and vice versa. All head trucks use diesel fuel.

Table 7-1 presents the current data of head truck in OT 3 of Tanjung Priok Port.

Table 7-1. Data of Head Truck in TO3

NO	Head Truck ID Number	Owner	Number	Brand/ Type	Year of Production	Capacity (Ton)	Fuel	Power (hP)	Remark
International Shipping									
1	HT 01 ~15	PT. OJA	15	NISSAN	2013	50	Solar	330	
2	HT 16 ~20	PT. OJA	5	NISSAN	1987	50	Solar	330	
3	HT 30~48	PT. TSJ	18	VOLVO	1994	50	Solar	330	
Inter Island (Intersuler) Shipping									
1	HT MSA	PT. MSA	8	HINO	2011	40"	Solar	330	8 unit
2	HT LT	PT. ESCORINDO	17	ISUZU	2012	40"	Solar	330	17 unit
3	HT PNP	PT.PNP	12	SCANIA	1997	50"	Solar	330	data obtained from website of PT. PNP

Notes: figures printed in red mean that the data are unavailable; assumptions have been used

As presented in Table 7-1, some figures (truck power and number of truck owned by PT PNP) are the assumptions inferred from the information available on the website of PT PNP.

The data on truck activity, both numbers of operating hours per year and vehicle km travelled, are not available, particularly in OT 3. Therefore, in this study the calculation of emission is conducted using several assumptions and the result of field observation performed in May 7, 2014 (limited survey on time in motion) as well as interview with the driver. The assumptions are as follows:

- All head trucks are articulated container trailer (could transport two container in one trip)
- Head trucks are parked outside the terminal (become the responsibility of stevedoring company). Trucks will enter OT 3 area only when they will operate.
- The principal for container placement is that container is placed and stacked in the nearest container yard.
- Truck will take detour route as from the ship to the container yard and then back to ship. Break time (shift) will be every ± 4 hours.
- Number of operating trucks is adjusted with the agreed closing time.
- Truck spends more time in idling position since truck should be in queue while waiting for the container to be loaded (in the apron) and to be unloaded (in the container yard). Besides, traffic in the location is frequently congested.
- Truck either with or without load is assumed to produce the same level of emission.
- According to the interview with the driver and the result of field observation, the actual speed of the truck is about 5-15 km/hour.

7.4. Calculation of Emission of Head Truck

7.4.1. Estimation of Km Travelled of Head Truck

With limited available data, the possible thing is that to calculate the emission of head truck by estimating the vehicle km travelled (VKT) and the idling time of the truck. VKT is estimated as follows:

- Container is transported from the ship to the nearest container yard. By this, the longest vehicle km traveled as well as the shortest vehicle km traveled could be measured. For the purpose of emission calculation, average vehicle km traveled has been taken.
- 1 round trip includes travel from the container – wharf (apron) – back to the container yard or 2 x average vehicle km traveled.
- The number of cargo in the form of container = 95.41% (please refers to the throughout data of OT 3 from January – March 2014) x total number (container/box)
- The total number of trips per month = number of container/2, assuming that 1 truck transports 2 containers.
- The total number of vehicle km traveled of the truck per month = number of trip x average vehicle km traveled.

The estimation of vehicle km traveled of the truck is calculated using the above assumption. The result is presented in Table 7-2.

Table 7-2. Estimation of Vehicle Km Traveled of Head Truck

No	Code	Closest Container Yard	Number of Container - Box (Jan-Mar)				Number of Truck		Distance for 1 trip (M0			VKT (km)
			Jan	Feb	Mar	Total	Truck Loosing	Container Yard	Closest	Farthest	Average	
1	208	1A, 1B, 1C	-	-	-	-	-	-	321.42	438.42	379.92	-
2	209	2A, 2B, 2C	3,385	4,877	4,846	13,107	301	6,253	378.5	495.5	437	2,732
3	210	3A, 3B, 3C	13,413	12,763	14,307	40,482	929	19,312	321.42	438.42	379.92	7,337
4	211	4A, 4B, 4C	747	3,127	939	4,813	110	2,296	378.5	495.5	437	1,003
5	212	5A	12,633	10,234	13,871	36,738	843	17,526	289.25	289.25	289.25	5,069
6	213	6A	2,004	2,111	3,417	7,532	173	3,593	289.25	289.25	289.25	1,039
7	300	2I	-	-	-	-	-	-	289.25	289.25	289.25	-
8	301	1I, 3H	1,254	409	1,769	3,432	79	1,637	730	869.2	799.6	1,309
9	302	1I, 4H, 2H	1,254	409	-	1,663	38	793	730	869.2	799.6	634
10	303	3D, 3E, 3F	827	-	156	982	23	468	213.66	330.66	272.16	127
11	304	2D, 2E, 2F	3,009	111	918	4,038	93	1,926	378.5	495.5	437	842
12	305	1D, 1E, 1F	7,594	7,578	9,325	24,497	562	11,686	378.5	495.5	437	5,107
	Domestics		**32,181**	**33,112**	**37,378**	**102,671**		**48,979**	**1,978**	**2,446**	**2,212**	**17,181**
	International		**13,937**	**8,507**	**12,167**	**34,611**		**16,511**	**2,720**	**3,349**	**3,035**	**8,019**
	Total		**46,118**	**41,619**	**49,545**	**137,282**		**65,490**	**4,698**	**5,796**	**5,247**	**25,201**

Source: Marketing Division of OT3

Assumptions:

- 1 Head Truck loads 2 boxes (container)
- 1 trip = 1 cycle trip (container yard - ship - container yard)
- Travel Distance is estimated from the OT3 Layout Plan
- Container to/from the container yard comprises of 95.41% domestics, 99.98% international, the rest is truck losing

7.4.2. Estimation of Idling Time

Field observation has been conducted on May 7, 2014 for one round trip (ship – container yard – ship), with the ship in D305 location and container yard in 1F to 3F. The result is as follows:

- Truck with load (moving from the container yard) moves to D305 on travel speed of 5-10 km/hour;
- Approaching the ship, the truck queues for unloading, with idling time of around 15 minutes;
- Loading time takes 3 minutes per container. As the truck carries 2 containers, each truck takes 6 minutes for unloading time;
- Truck goes back to the container yard on travel speed of 5-10 km/hour (with several stop & go)
- The truck queues in the container yard while waiting for the container to be loaded, taking time of 20 minutes;
- Loading time in the container yard is 3 minutes per container; 6 minutes per truck.

Based on the field observation result, it is revealed that idling time for one round trip is around 47 minutes. After discussion with the OT 3 Team, however, the figure is an extreme condition. According to their experience, the normal idling time is around 20 minutes. For this study, therefore, it is assumed that the average idling time is 20 minutes.

7.4.3. Emission Factor

Emission factor is calculated when the truck is moving as well as in idling position. According to the data provided by CARB – 2011, emission factor will vary toward vehicle speed. In this study, idling condition means the truck operates in the speed of 0 km/hour. Meanwhile, the truck commonly moves in the speed of 5 – 15 km/hour. Based on the data, the emission factor uses data provided by CARB – 2011, as presented in Table 7-3.

Table 7-3. Emission Factor of Head Truck by Travel Speed

Speed		EF Unit	NOx	CO	PM10	PM2.5	SO2	CO2
mph	km/hour							
0 (Idle)	0 (Idle)	gr/hour	28.2877	16.6140	0.0629	0.0579	0.0396	54,947.38
1 to 5	1.6 to 8.0	gr/mi	18.5872	7.3365	0.1015	0.0934	0.0171	22,102.58
		gr/km	11.5520	4.5597	0.0631	0.0580	0.0106	13,736.85
6 to 10	9.7 to 16.1	gr/mi	13.9498	4.5914	0.0868	0.0799	0.0171	22,102.58
		gr/km	8.6699	2.8536	0.0539	0.0497	0.0106	13,736.85

Source: CARB (2011) and Study of Green House Gas of Transportation Sector (for CO2), Ministry Energy and Mineral Resource (2012)

7.4.4. Calculation Result

Table 7-4. Result of Emission Calculation of Head Truck Source (January – March 2014)

No	Truck Activity	Unit		Nitrogen Oxide (NOx)	Carbon Monoxide (CO)	PM10	PM2.5	Sulfur Dioxide (SO2	Black Carbon	CO2
A	**Truck in Running Condition**									
	EF for truck speed of 5-10 km/hour	gr/km		11.55	4.56	0.06	0.06	0.01	0.02	13,736.85
	Estimation of Total Travel Distance (January - March 2014)	Km	25,201							
	Emission (January - March 2014)	**Kg**		**291.12**	**114.91**	**1.59**	**1.46**	**0.27**	**0.41**	346,179.63
B	**Truck in Idling Condition**									
	EF when truck in idling condition	gr/hour		28.29	16.61	0.06	0.06	0.04	0.02	54,947.38
	Average idling time per trip	hour	0.33333							
	Estimation of total travel (January - March 2014)		65,490							
	Total idling time	hour	21,830							
	Emission (January - March 2014)	**Kg**		**617.52**	**362.69**	**1.37**	**1.26**	**0.86**	**0.35**	1,199,508.23
	Total Emission of Head Truck (January - March 2014)	**Kg**		**908.64**	**477.59**	**2.96**	**2.73**	**1.13**	**0.76**	**1,545,687.86**
	Total Emission of Head Truck (January - March 2014)	**Ton**		**0.9086**	**0.4776**	**0.0030**	**0.0027**	**0.0011**	**0.0008**	**1,545.69**

Notes: Idling time is 20 minutes per one round trip, based on the internal workshop held on June 13, 2014

As presented in Table 7-4, the emission of CO2 is much higher than other pollutant parameters. In terms of truck activity, it is revealed that idling position produces much higher emission than moving condition for the parameters of CO2, SO2, NOx, and CO.

8. Framework for Air Pollution Management of Port Activity

According to USEPA (2009) and CARB (2010), Emission Inventory (EI) is the quantification or estimation of emission from various pollutants in certain areas based on its sources. Emission inventory is the initial step for air pollution control. The function of emission inventory is to measure the level of pollutant emission load and to identify pollutant sources for both number and type. The result of emission inventory shall be useful to:

1. Analyze the level and trend of emission
2. Develop priority scale for the effort to reduce emission (type, source and area)
3. Evaluate the efforts to reduce emission
4. Record the progress of emission reduction effort

The result of emission inventory could play role as the important input in determining improvement effort to reduce emission effectively and efficiently.

Figure 8-1.Contribution of Each Source to Total Emission

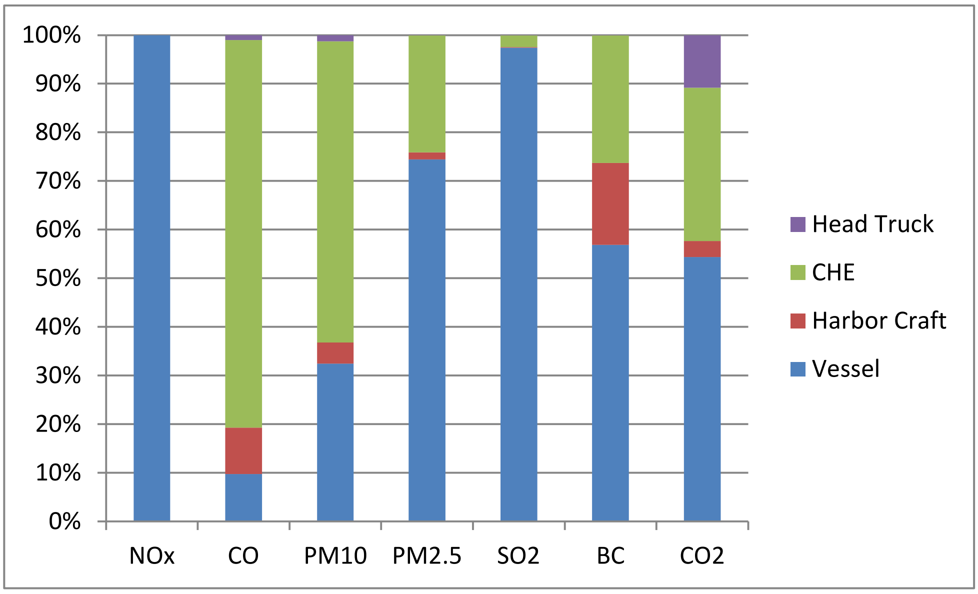
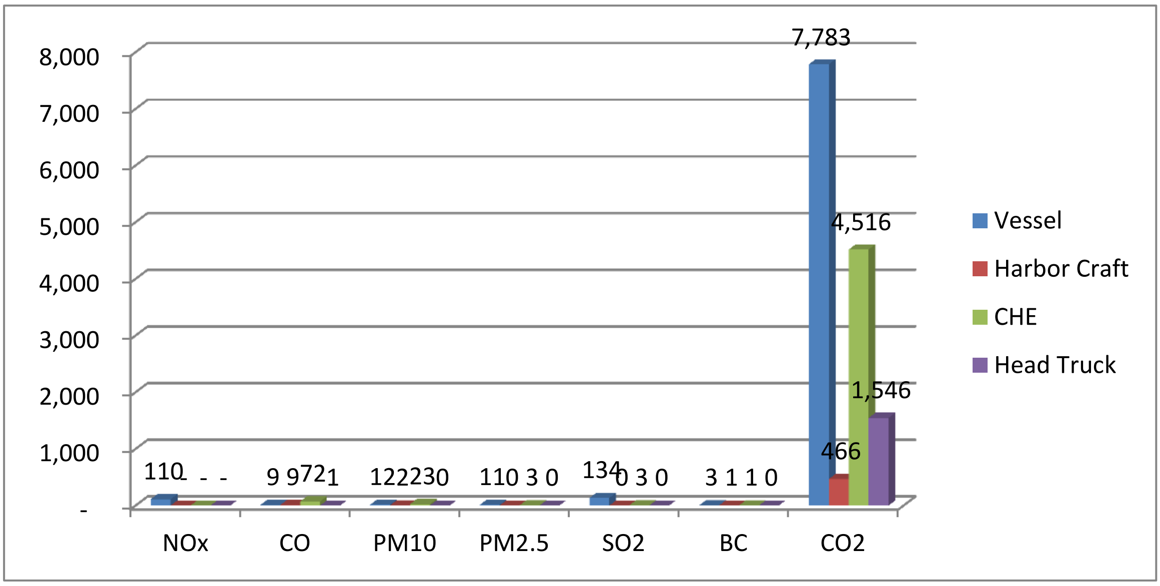


Figure 8-2. Pollution Load by Sources



As an example, from these studies it is revealed that Black Carbon Emission is dominantly produced by vessel activity. Therefore, in the case that it is agreed to control the pollution parameter of Black Carbon, the efforts to reduce emission shall be focused on vessel activities. Several options to reduce emission could be adjusted based on the availability of resources.

Preceded by emission inventory, the activity/effort to reduce air pollution emission with the largest proportion will be effective and with the most efficient cost.

8.1. Framework to reduce emission

When the pollutant emission in certain area has been quantified or estimated, the next step is developing effort to reduce the emission. The effort to reduce emission from port activities could be developed using one of the following approaches: (1) ASIF approach and (2) business process approach.

8.1.1. ASIF approach

The ASIF approach is applied using the following equation:

Emission = Activity x Structure x Fuel Intensity x Fuel Type x Emission Factor

Where *activity* is the proportion of transportation activity demand; *structure* is the transportation mode used to serve/meet the transportation demand, *fuel intensity* is the level of fuel consumption of the transportation mode being used, *fuel type* is the type of the consumed fuel and *emission factor* is the proportion of emission for each unit of fuel.

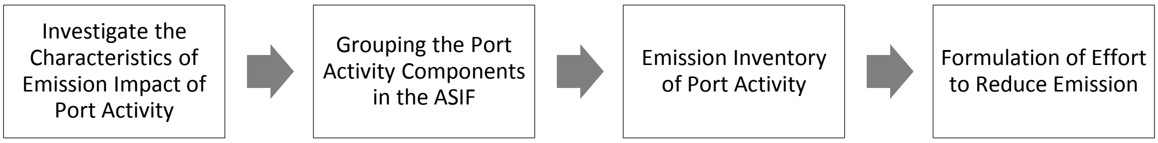
That formula is commonly used to calculate emission of transportation sector and becomes the basic to formulate the efforts to reduce air emission from transportation sector. This approach could be utilized for port activities.

Table 8-1. Framework of Emission Reduction Using ASIF Approach

NO	COMPONENT	FRAMEWORK OF EMISSION REDUCTION	PORT ACTIVITIES
1	Activity	Reduce the number of trip/transportation activity	• Shorten the travel distance of the ship and container movement • Reduce the time for loading-unloading process of container (crane) in the apron/wharf and in the marshal yard • Reduce idling time of head truck
2	Structure	Improve the efficient mode sharing and reduce fuel-consuming mode sharing	Use of more efficient vessel, CHE and truck
3	Fuel Intensity	Improve the use of fuel-saving motor/vehicle technology (hybrid, electric, fuel cell)	Introducing electric motor, hybrid motor and more fuel-efficient motor technology
4	Fuel Type	Increase the use of more environmentally-friendly fuel	Use of diesel dex fuel, electricity, pertamax plus fuel and other environmentally-friendly fuel

In general, the framework to reduce port emission using ASIF approach could be seen in Figure 8-3.

Figure 8-3. Steps to Formulate Mitigation Action using ASIF Approach

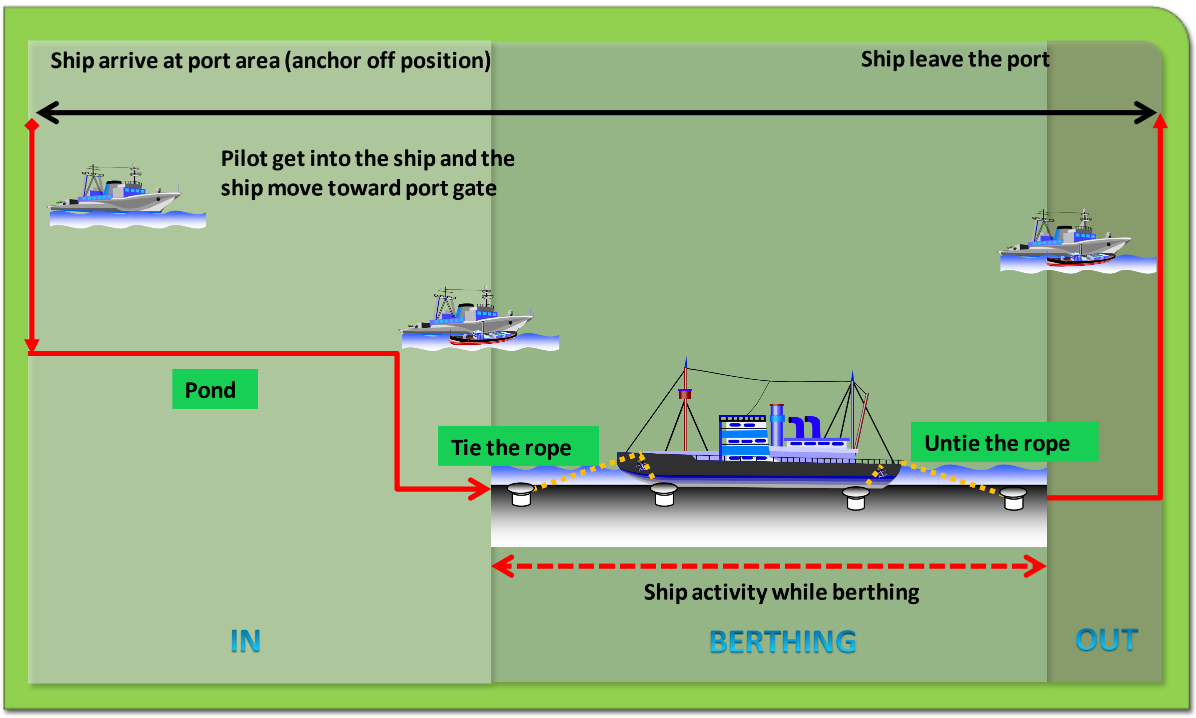


8.1.2. Business Process Approach

The business process approach is the effort to reduce port emission which is based on the activities process in the port. In this study, emission inventory has been implemented using simple method which is associated with the port business activities of Operation Terminal 3 of Tanjung Priok Port. Emission inventory has been conducted for each business process of port operation process. Using this approach, effort to reduce emission could be selected which is in line with expected business performance to be achieved. Therefore, there will be synergy between the objectives of the business and the objective of environment preservation.

Understanding toward the business process is required to simulate the intensity of activities which could produce air pollution. The process of ship movement in the port is presented in Figure 8-4. Based on the analysis of business process, the travelled distance of the ship and the steady time of the ship could be estimated and therefore the fuel consumption and the produced emission also could be calculated.

Figure 8-4. Business Process of Ship Movement



In this study, it is revealed that there are four business process components in the port activity (OT 3 of Tanjung Priok Port) which may produce air pollution. The components are:

1. Vessel
2. Cargo handling equipment
3. Harbor craft; and
4. Head truck

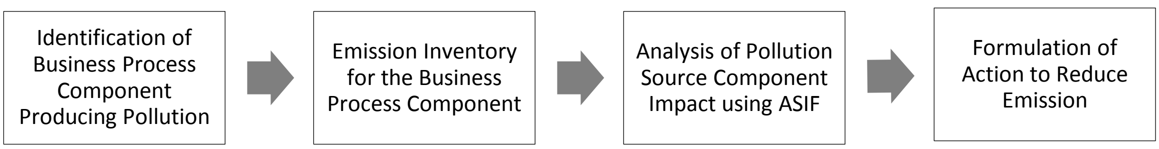
To develop framework of emission reduction using this approach, all components of the port business process shall be investigated by referring to the ASIF approach. Since the business process is closely related with the port activity, result of the research has specifically identified the effort to reduce pollutant emission of the port activity.

Table 8-2. Framework of Emission Reduction using Business Process Approach

No	Component	Framework of Emission Reduction
1	Vessel	A: Reduce the travel distance of the vessel Improvement on circulation in the harbor pond S: The use of large size ship I: The use of efficient-fuel ship engine technology F: The use off shore power, CNG, Biodiesel, environmentally-friendly-fuel
2	Cargo Handling Equipment	A: Improvement on the container movement system Improvement on the data system of stacking and circulation of container Improvement of operation pattern on the marshal yard S: Adjustment of CHE capacity to the handled demand I: Promote the use of fuel-efficient CHE equipments F: The use of clean fuel
3	Harbor Craft	A: Improvement of ship movement pattern Improvement of harbor craft load pattern suitable with the sea flow I: The use of fuel-efficient ship engine technology F: The use of environmentally-friendly fuel
4	Head Truck	A: Improvement on the truck movement pattern in the port Management of queue and congestion S: The use of efficient heavy duty truck I: The use of more efficient truck engine technology F: The use of environmentally-friendly fuel

In general, the framework to reduce air pollution using business process approach could be described as presented in Figure 8-5.

Figure 8-5. Framework to Formulate Mitigation Action Using Business Process Approach



8.2. The Example of Activity to Reduce Air Pollution Emission of Port

Some activities which could be performed to improve the efficiency of port operation which may have impact on emission reduction are as follows.

1. The highest emission produced by VESSEL is during the berthing/hoteling time. Therefore, it should be pursued to improve the operation efficiency in the port so that hoteling time could be shorter.
2. To reduce emission produced from the combustion of diesel fuel such as NOx, PM, SO2 and BC from the VESSEL, the port should provide electricity facility for the berthing ship (dockside power, shore-based electricity power supply)
3. Emission produced by CHE could be reduced by replacing the existing fuel with more environmentally-friendly fuel (ULSD) or replacing the diesel engine with the electric engine.
4. Heavy duty truck getting in and out of the port:
   - Needs to manage logistics and traffic of the truck in the port to shorten idling time and vehicle km traveled
   - Use more clean fuel
   - More sustainable vehicle maintenance
   - The need to have EcoDriving Training for driver

Table 8-3. Examples of Mitigation Actions of Air Pollution in Port

Source	Emission Source	Example of Mitigation Actions
OGV	Combustion	Off shore power
	Type of fuel	The use of clean fuel in the port
	Berthing process	Dwelling time improvement
HC	Combustion	Inspection and Maintenance, ship upgrading
	High intensity	Manual/standard of pilotage
CHE	Combustion	Inspection and Maintenance, upgrading
		Provision of Diesel Dex in the port
	Long time idling process	Standard of cargo handling
		Cargo information system
	Combustion	Automatization
Head Truck	Long idling time	Dwelling time improvement
	Combustion	Automatization

9. MRV Framework for GHG Mitigation of Port Activity

This section discusses the framework of MRV implementation for the mitigation of Green House Gas (GHG) of port activities. MRF (Measurement, Reporting and Verification) framework for port activities refers to Regulation of the President of the Republic of Indonesia Number 71 Year 2011 and Regulation of Minister of Environment Number 15 Year 2013 regarding MRV activity for GHG mitigation.

9.1. Policy Framework

The President Regulation Number 71/2011 has stipulated the activity, policy framework and role distribution in the implementation of GHG emission inventory in Indonesia as the complement of President Regulation Number 61/2011 regarding National Action Plan for GHG Reduction (originally called as *Rencana Aksi Nasional Penurunan Gas Rumah Kaca* - RAN GRK). The President Regulation also stipulates the calculation of the baseline and monitoring of the baseline of mitigation activity as stipulated in the RAN GRK.

For MRV activity, the detail description has been provided in the Regulation of Minister of Environment Number 15/2013 regarding MRV Activity for GHG Mitigation.

9.2. Technical Framework of MRV Obligation

The object of emission reduction from MRV activity is Green House Gas (GHG) as stipulated in Kyoto protocol in which the government of Indonesia has ratified the protocol by issuing Law Number 17/2004. Meanwhile, for local air pollution, MRV is not required.

Currently, mitigation actions which should implement MRV include activities stipulated in the National Action Plan for GHG Reduction (RAN GRK), National Appropriate Mitigation Actions (NAMAs), Nusantara Carbon Scheme and Joint Crediting Mechanism (JCM). Each activity is carried out by those responsible for mitigation project which consist of government and private sector.

The obligation to implement MRV is closely related to the international commitment in every activity in which the effort to reduce emission shall be reported to international forum. In this case, Ministry of Environment has been assigned to ensure that the number of emission reduction resulted from the mitigation actions is acceptable in the international forum.

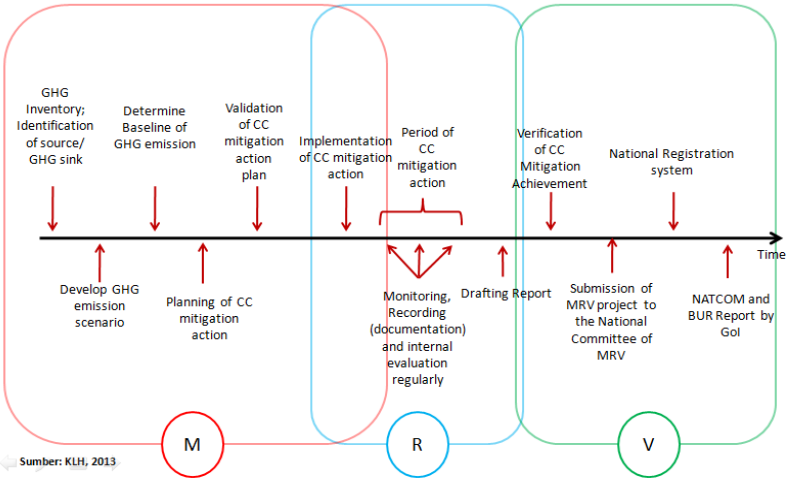
9.3. Framework of MRV Mechanism

The mechanism of MRV implementation by the executing/implementing agency has been stipulated in the Regulation of Minister of Environment Number 15/2013 regarding MRV. MRV starts from emission inventory of GHG to reporting in the international forum by the Government of Indonesia.

Activities in the mechanism are categorized into three components, i.e. measurement, reportingand verification. The framework of MRV implementation as adopted by Ministry of Environment is similar to framework of CDM mechanism in which there is baseline calculation, determining the project limit, development of measurement method and verification by independent body.

Therefore, the preparation of MRV for GHG emission mitigation of port activities shall be planned as early as possible by the project implementing agency. Since the mitigation activity is part of RAN GRK, Ministry of Transportation, represented by Directorate General of Sea Transportation, shall prepare MRV as early as possible.

Figure 9-1. MRV Framework for GHG Mitigation



Measurement

The measurement starts with emission inventory to identify GRH emission source. Subsequently, the baseline scenario of emission growth is developed without the presence of mitigation activity and emission reduction resulted from the mitigation. The next step is the determination of emission baseline to be used as the report framework and verification. Validation toward mitigation action plan will be conducted by national registration body.

Measurement is performed since the planning phase until the completion of the project. The main result of the measurement is baseline figures of GHG emission and number of GRH emission reduction resulted from the mitigation activity.

Reporting

Reporting will include collection of measurement result, result of mitigation action and development of baseline calculation report and GHG emission reduction to be further validated. In the Regulation of Minister of Environment, it is stipulated that the report shall contain:

- Calculation of GHG emission without the presence of mitigation action (Business as usual - BAU scenario).
- Determination of baseline and assumption being used.
- Method used to measure the amount of GHG emission production and reduction based on the data of number, location, area border and time of project implementation.
- Detail description of the mitigation actions.
- Statement of emission reduction target to be achieved by the mitigation action based on the result of initial measurement and calculation.
- Explanation about the management system of the implementation of mitigation action including monitoring system.
- Report on the constraint and problem found during the project implementation.

Evaluation

Evaluation will be conducted toward the result of baseline measurement and the calculation of the GHG emission reduction resulted from the mitigation action and the appropriateness of data being used. After the verification, the project implementation body could register the project to the national registration body, to be further registered and reported in the international forum. The verification is performed by independent body which has been accredited by Ministry of Environment and Forestry.

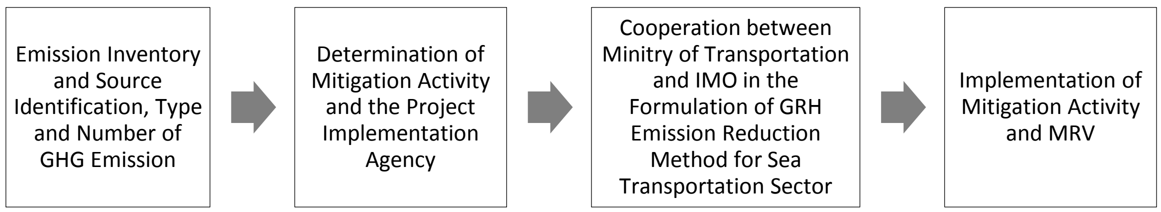
9.4. Emission Inventory and MRV in Port Activities

Emission inventory performed in this study is the first step in the MRV framework. However, the whole step is still very long before the end of MRV implementation.

Therefore, it is necessary to immediately determine the mitigations activities to be performed and the implementation agency. This step is important for the purpose to categorize the GHG emission mitigation actions of port activities into the appropriate groups: either grouped into RAN GRK or other mitigation actions which is obliged to implement MRV.

Since MRV has strong characteristics as part of global commitment, it should be considered to establish cooperation between Ministry of Transportation and IMO in the development of method of baseline measurement and calculation of emission reduction resulted from the mitigation action.

Figure 9-2. Inventory in the MRV Framework



10. Conclusion and Recommendation

Conclusion and recommendation of this study consist of two parts, i.e. for the process and for the final result of baseline emission inventory.

<u>Process</u>

During the implementation of baseline emission inventory in Operation Terminal 3 of Tanjung Priok Port, there are some processes that could become the lessons learned and some notes that shall be considered so that the result of emission calculation could be used wisely. Besides, the lessons learned and the notes could become the important inputs to improve the accuracy of emission calculation in the future.

Table 10-1 presents the process of baseline emission inventory and recommendations for the improvement.

Table 10-1. Process of Baseline Emission Inventory & Recommendation for the Improvement

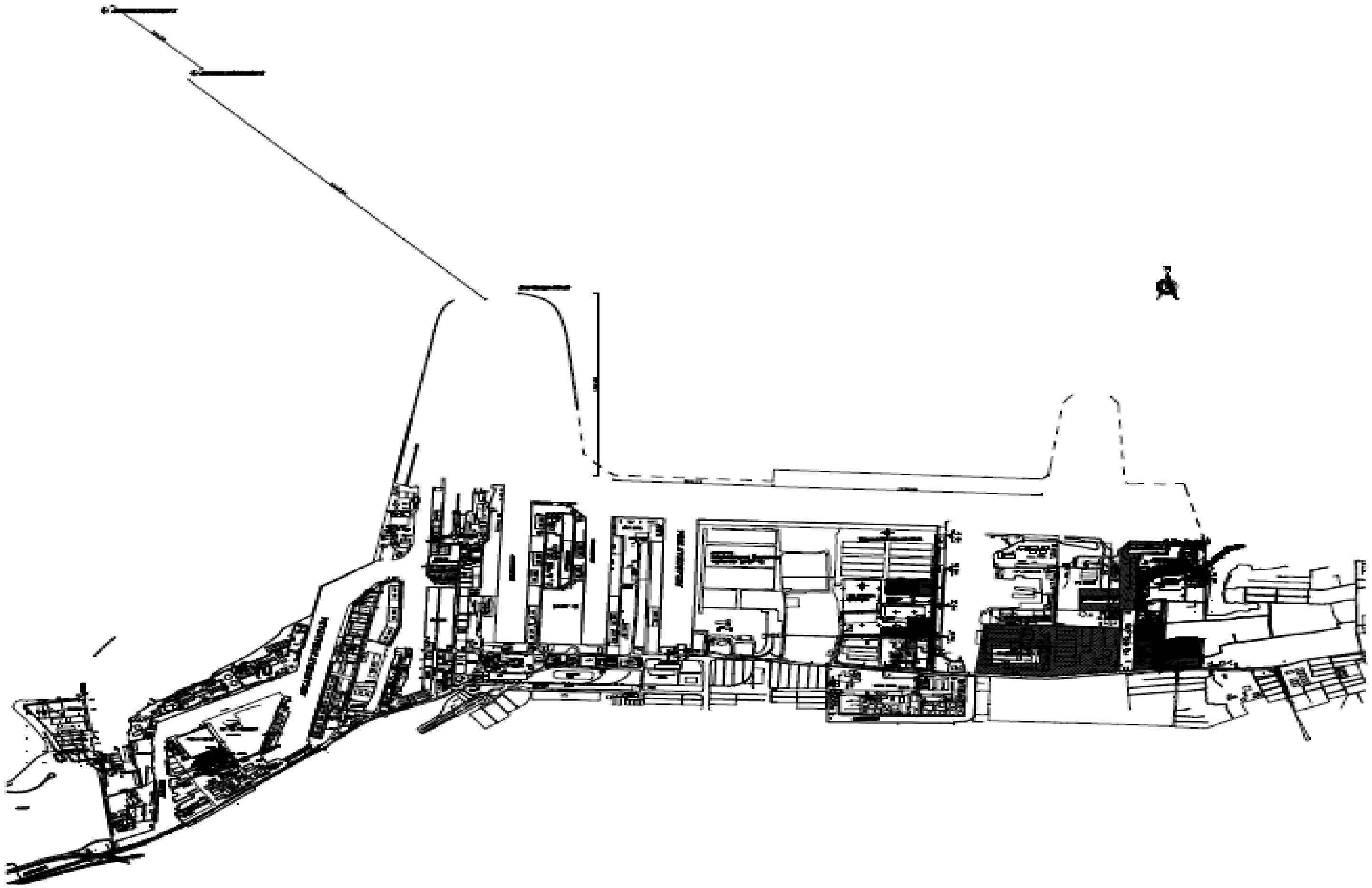
No	Data Analysis & Baseline Emission Inventory Method (January – March 2014)	Recommendation for More Accurate Emission Inventory and the Further Steps
A	**General Process; Data and Variable Assumptions**	
	- The collection and analysis of the data shall be improved through the improvement of data system in OT 3 to ensure the availability of accurate and sustainable data. - Emission inventory from various sources requires detailed data on the characteristics and profile of the activities. The characteristic data include number, type, and power and fuel consumption for each emission source. Meanwhile, data of activity profile include time/duration and/or travel distance which is required for each activity step of every emission source. - The required data are not completely available so that the calculation of baseline emission inventory has been performed using the data provided by US-EPA and CARB and data from other ports. The data from the available references usually represent ports in US which may be partially suitable with the condition of Tanjung Priok Port.	- Sustainable database system in Tanjung Priok Port is required to provide more accurate data for the calculation of emission and for the evaluation of port business process. - Data collection shall be performed periodically by specially assigned organization/unit, which is based on the database system as mentioned above. - Research on the assumption and data which is better suited to the real condition in OT 3 is required to replace the assumption and data acquired from literature. - Preparation to independently update emission inventory could be performed through: • Design/improvement of spreadsheet • Provision of manual and training. - Periodic update of emission inventory and comparing the result with the ambient air quality monitoring result to measure the progress of emission reduction. - Frequency and schedule of emission inventory update is adjusted with the plan to reduce air pollutant emission and other related environment quality improvement plans (ISO 14.000, Environment Management Effort (UKL)/Environment Monitoring Effort (UPL), Environment Impact Analysis, etc).
	Statistical data only available for the period of January – March 2014 (three months). This could not represent the real condition in the field and does not consider seasonal fluctuation in one year.	The use of data with longer range of period (for example last 3 years) will give more accurate condition of the field and could represent the ship characteristics and its activities. This is required to estimate the emission in the future.
B	**Process of Emission Inventory of VESSEL; Data and Variable Assumptions**	
	Data assumption used in calculating vessel emission is as follow: - Data of vessel engine power are not available; therefore, the power of propulsion engine is estimated using Carlo Trozzi formula as presented in "*Emission Estimate Methodology for Maritime Navigation – 2010*" which correlate the vessel power with GRT.	- Improvement on registering system of port operation to acquired more accurate data of ship characteristics. - Collaboration with other related institutions shall be sought to acquire more accurate secondary data. The institution may include: ○ Authority of Tanjung Priok Port ○ IMO or Llyod's Register of Ships, by fulfilling certain requirements

	- The power of auxiliary engine is estimated by its ratio to the propulsion engine (USEPA 2009). - Data of vessel speed is not available; therefore it is assumed that cruise speed of the vessel is the typical speed while the maximum speed is the cruise speed divided by 0.94 (USEPA 2009). - Data of actual speed and travel distance of vessel for each vessel movement phase is not available; therefore, stipulation in the standard of vessel maneuvering in Tanjung Priok Port has been used. - It is assumed that all vessels using Residual Oil (RO).	- Survey regarding the detail characteristics and operation of ship during berthing period and getting out of the port is required. - The ship traffic system and automatic identification system shall start recording the actual speed of the ship for each maneuvering phase.
C	**Process of Emission Inventory of Harbor Craft; Data and Variable Assumptions**	
	- Technical data of pilotage fleets, including tug boat, pilot boat and mooring boat, are incomplete. - Data of pilotage fleet operation, including all services in Tanjung Priok Port are not available so that it is difficult to acquire data of pilotage fleet activity, particularly in OT 3. Therefore, some assumptions have been taken, i.e. travel distance of the fleet from the base to the ship location. - Vessels functioning as dredging are not included in the emission inventory of harbor craft since their activity frequency is relatively low.	Designing database system which categorized based on operation terminal in order to ease emission inventory, either for each terminal or for the entire of Tanjung Priok Port.
D	**Emission Inventory Process for CHE Source; Data and Variable Assumptions**	
	- For most CHE, the data of technical specification is available and relatively comprehensive. However, several equipments do not have data of power. For this study, it is assumed that the power of similar equipments is the same, although it comes from different manufacturer. - Data of operating hours of the equipments is not available; therefore, it is assumed that the average operating hours of the equipment are 8 hours per day.	More accurate registration process of CHE is required to develop the effort of emission inventory and reduction considering that based on the result of field observation and real calculation of emission, it is revealed that loading-unloading process has produced significant level of emission and directly affected the port labors. Things to do in the future are: - Planning of database system of technical and operational data as well as maintenance data with the input from the owner/person in charge (stevedoring company) - Executing a survey on the use of the

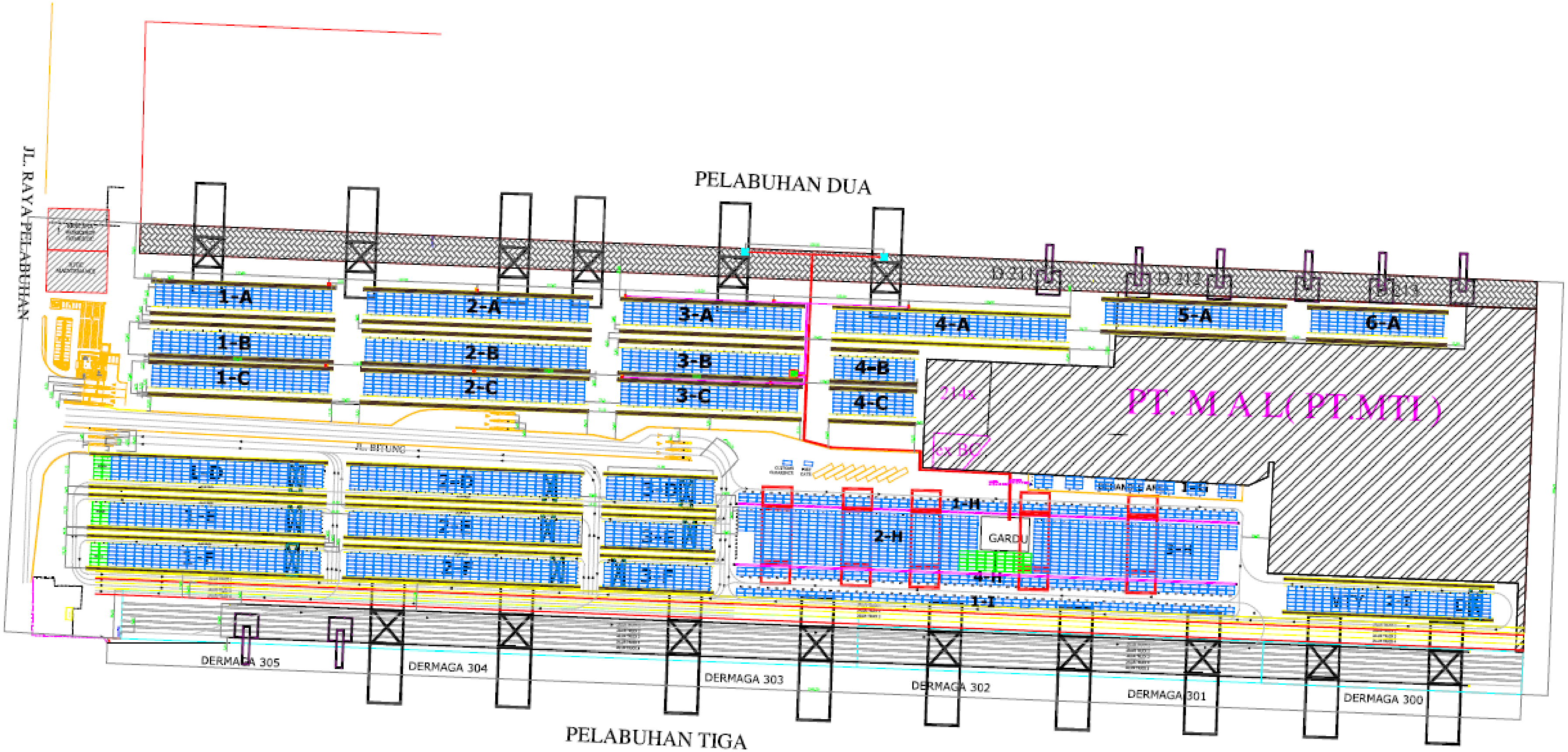
		equipments - Involving stevedoring company in the collection of more accurate and more comprehensive CHE data. Data from stevedoring company will also be used to evaluate the performance of stevedoring company.
	Baseline emission inventory for CHE source is conducted using simple and static calculation approach. For example, the age of instruments and the efforts which have been performed to reduce emission are not considered.	Decision to conduct emission inventory calculation using NON ROAD Model (USEAP – ICF International 2009) or OFF Road Model (CARB, 2011). Data required for the modeling include: - Type of equipment - Type of engine - Production year of engine - Type of engine retrofit/Repower - Year of chassisproduction - Type of fuel consumed - Number of operating hours in one year and the average load - Power (hP) - Cumulative operating hours - Fuel consumption for each equipment - The use of technology to control emission of CHE.
E	**Emission Inventory Process for Truck and Other Vehicle Getting Into OT 3 Area; Data and Variable Assumptions**	
	Considering that detailed survey is not part of this study, limited survey time in motion has been performed for head truck, only for 1 round trip of loading-unloading process. Data collected through this observation include travel distance, speedand idling time.	Design and execution of more accurate time in motion survey.
	Due to the absence of the monitoring system, the baseline emission inventory has not included trucks getting in and out of the port (truck losing and trailer who transport freight from and to the port)	It is necessary to cooperate with ORGANDA (National Employer's Organization of Road Transportation).
	Private vehicle and port staff's vehicle are excluded from the emission inventory in OT 3 since the vehicles are not allowed to get into OT 3 area. Visitors usually use shuttle provided by the port operators.	In the future, if it is found that the activity of shuttle bus in OT 3 area is relatively extensive, the emission of the bus should be considered.

Recommendation to have data management which is necessary to conduct periodic emission inventory will require some changes on the routine recording currently implemented; however, the changes will make the implementation of periodic emission inventory easier in the future. In addition, the changes on data management system will produce important data and information which could be further used in the future, either to improve port productivity, environment improvementor terminal development as a whole.

Annex 1a: Layout of Tanjung Priok Port



Annex 1b: Development Plan of OT 3



Annex 2: Data of Ship in for January – March 2014

Annex 3: Detail of Pillotage Fleet in 2013

Technical Data of Pilotage Fleet – 2013

No	Name & MTB	Year of Production	Propulsion Engine			Auxiliary Engine				Mil/ Hr
			Num.	HP	RPM	Num	KVA	RPM	HP	
I.	**Owned Tug Boat Owner**									
1	TB. BIMA II	1987	2	1,190	1,000	2	215	1,500	325	12
2	TB. BIMA III	1987	2	1,190	1,000	2	215	1,500	325	12
3	TB. BIMA XI	1997	2	1,200	1,000	2	95	1,500	127	12
4	TB. JAYAKARTA 1	2002	2	1,200	1,000	2	195	1,500	325	12
6	TB. JAYAKARTA 3	2002	2	1,600	900	2	215	1,500	325	12
7	TB. JAYAKARTA 4	2004	2	1,200	900	2	195	1,500	325	12
8	TB. BIMA 034	2003	2	1,600	900	2	212.5	1,500	228	12
9	TB. BIMA 035	2003	2	1,600	900	2	212.5	1,500	228	12
10	TB. BESTIWIN	2004	2	607	1,800	2	25.2	1,500	34	10
11	TB. SDS	2004	2	620	1,900	2	28.6	1,500	28.6	10
12	TB. ARJUNA I.206	2007	2	620	1,900	2	85	1,500	92	12
13	TB. ARJUNA II.206	2007	2	620	1,900	2	85	1,500	92	12
14	TB. BATAVIA I - 216	2011	2	1,600	900	2	189	1,500	253	12
15	TB. BATAVIA II - 216	2011	2	1,600	900	2	189	1,500	253	12
16	TB. BATAVIA III - 216	2012	2	1,600	750	2	189	1,500	253	12
17	TB. BATAVIA IV - 216	2012	2	1,600	750	2	189	1,500	253	12
		2,003		**1,228**					**217**	**12**
	Rented Tug Boat									
1	KT. MARTHA INDAH	1991	2	1,000		2	80		115	
II.	**Pilot Boat**									
1	MP.I - F.01	1995	2	255	2,600	1	10	2,400	13.50	10
2	MPC - 04	2001	2	255	2,550	1	10	1,500	13.30	10
3	MPC - 05	2002	2	255	2,550	1	10	1,500	13.30	10
4	MP.II - 012	1980	2	170	2,550	1				8
5	MP.II - C.01	1984	2	255	2,550	1				8
6	MPA - C.01	2010	2	255	2,550	1	34.6	1,500	41.20	18
7	MPA - C.02	2010	2	255	2,550	1	34.6	1,500	41.20	18
8	MPW - AC-01	2011	2	350	2,800	1	5	1,500	8.80	28
9	MPW - AC-02	2011	2	350	2,800	1	5	1,500	8.80	28
10	MPA - C-03	2012	2	350	3,000	1	8	1,500	9.60	20
11	MPA - C04	2012	2	350	3,000	1	8	1,500	9.60	20
				282					**18**	**16**
III.	**Mooring Boat**									
1	MK II - A 01	1991	1	105	2,300					10
2	MPC - 04	2001	1	70	2,300					10
3	MPC - 05	2002	1	105	2,300					10

4	MP.II - 012	1980	1	105	2,300					8
5	MP.II - C.01	1984	1	115	2,300					8
6	MPA - C.01	2010	1	170	2,600					18
7	MPA - C.02	2010	1	115	2,550	1	5.0	1,500	6.70	8
				112					**6.70**	**10**
IV.	**Survey Boat**									
1	KM. BANDAR - I	1999	2	375	2,000	1	20	1,500	27	11

Notes:

All boats use High Speed Diesel (HSD) fuel

Annex 4: Result of Emission Calculation

Based on the result of emission calculation for all source categories in OT 3 of Tanjung Priok Port, the followings could be concluded.

1. General

The result of emission by source category is presented in Table 1.

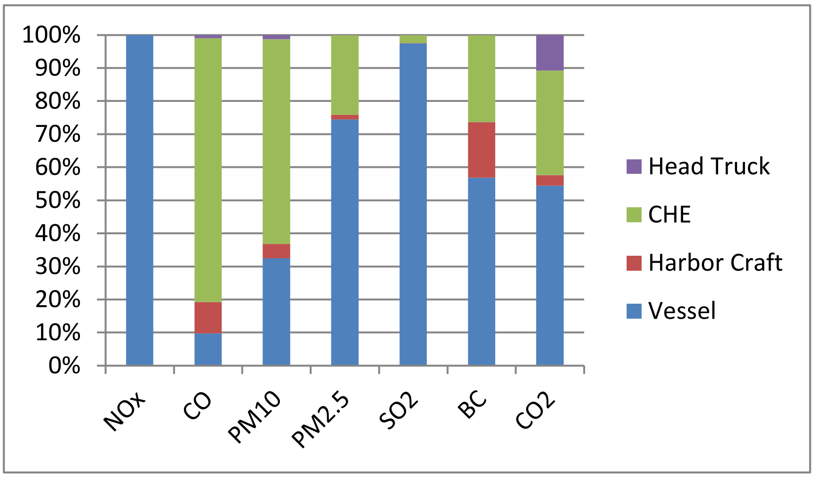
Table 1. Result of Emission Calculation in OT 3 by Source Category

	Emission Source	Emission (Ton)						
		NOx	CO	PM10	PM2.5	SO2	BC	CO2
1	Vessel	110.08	8.83	12.13	10.61	133.59	2.97	7,783.34
2	Harbor Craft	-	8.60	1.63	0.21	0.20	0.88	466.20
3	CHE	-	72.13	23.18	3.43	3.35	1.37	4,516.46
4	Head Truck	-	0.91	0.48	0.00	0.00	0.00	1,545.69
	Total (Jan - Mar 2014)	**110.08**	**90.46**	**37.42**	**14.26**	**137.15**	**5.22**	**14,311.69**
	Estimation for 2014	**440.32**	**361.84**	**149.69**	**57.03**	**548.58**	**20.90**	**57,246.75**

Vessel contributes the largest proportion of emission, followed by CHE. It is absolutely common for a cargo terminal.

Emission in land transportation side is relatively small since the measurement is only for the haulage process using head truck. It is necessary to conduct further survey and to cooperate with ORGANDA and stevedoring company to calculate the emission of truck operating in terminal 3.

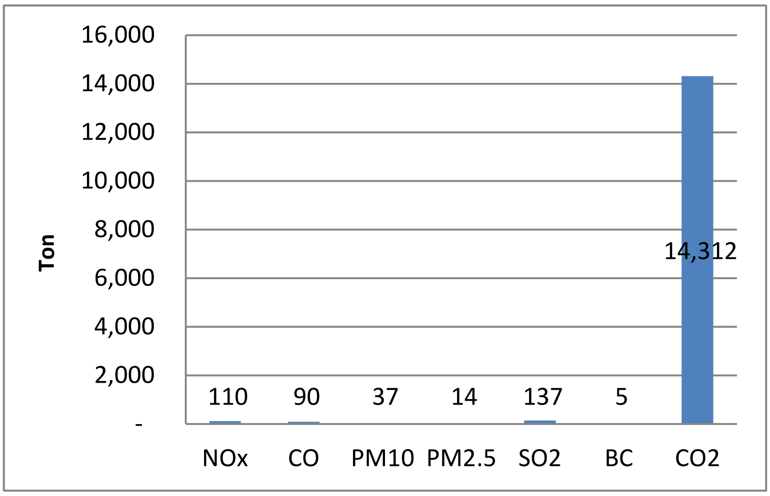
Figure 1. Contribution of Each Emission Source to Total Emission



As presented in Figure 1, emission of SO2 is mainly produced by vessel. The reason is that the vessel uses residual oil as the fuel and that the berthing takes relatively long time.

In terms of pollutant type, the largest emission is CO_2, as presented in Figure 2.

Figure 2. Emission of Pollutant by Type of Pollutant



2. Source of Vessel Emission

The result of calculation of vessel emission in OT 3 by types of vessel is presented in Table 2.

Table 2. Result of Emission Calculation by Type of Vessel

Category	Emission (Ton)						
	NOx	CO	PM10	PM2.5	SO2	BC	CO2
Container	69.67	5.63	8.00	6.94	91.82	1.94	5,352.83
General Cargo	35.20	2.78	3.50	3.13	33.83	0.88	1,966.01
Tanker	0.68	0.06	0.18	0.14	3.45	0.04	202.75
Dry Bulk	4.53	0.36	0.45	0.40	4.49	0.11	261.76
Total (January - March 2014)	**110.08**	**8.83**	**12.13**	**10.61**	**133.59**	**2.97**	**7,783.34**
Estimation for 2014	**440.32**	**35.31**	**48.54**	**42.44**	**534.37**	**11.88**	**31,133.34**

Container ship contributes the largest emission of vessel source in OT 3 since the terminal is going to be container terminal and therefore the number of ship call of container is the largest. Meanwhile, pollutant with the largest emission is SO2 which is produced during berthing period. Table 3 presents the emission produced by vessel operation.

Table3. Vessel Emission by Operation Mode

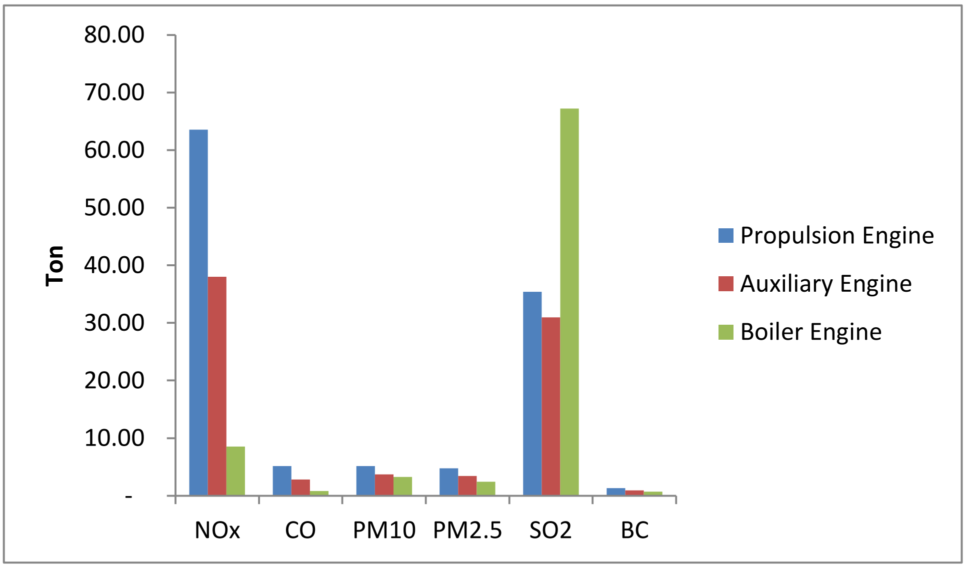
Operation Mode	Emission						
	NOx	CO	PM10	PM2.5	SO2	BC	CO2
Cruise	61.58	4.76	4.87	4.49	35.44	1.26	2,132.35
Reduced Speed Zone	2.07	0.27	0.23	0.21	1.20	0.06	47.36
Maneuvering	4.29	0.47	0.55	0.49	3.79	0.14	184.68
Hoteling/Berthing	42.14	3.32	6.49	5.42	93.16	1.52	5,418.94
Total (January - March 2014)	**110.08**	**8.83**	**12.13**	**10.61**	**133.59**	**2.97**	**7,783.34**
Estimation for 2014	**440.32**	**35.31**	**48.54**	**42.44**	**534.37**	**11.88**	**31,133.34**

As presented in Table 3, the emission of CO_2 will be the largest during cruise mode, reduced speed zone and maneuvering. This is consistent with the case of other ports in the world.

In OT 3, however, the pollutant of SO2 is the largest during berthing period. This fact shall be further investigated with regard to the duration of the berthing ship. In calculation of baseline emission, the data of berthing time is quite long.

Emission of ship is produced by the propulsion engine, auxiliary engine and boiler. Based on ship engine, the emission resulted from ship operation is presented in Figure 3.

Figure 3. Emission of OGV by Engine Category



As previously describe, only boiler engine runs during berthing period. With relatively long period of berthing and emission factor of boiler for SO2 is relatively large, i.e. 16.50 g/kWh, as compared with NOX which only 2.10 g/kWh, the emission of SO2 will be higher.

Table 4 presents the comparison of emission of vessel source in OT 3 with that in other ports.

Table4. Comparison of Emission of Vessel Source in Several Ports in the World

No	Port	Year	Ship Call	Throughput (TEUs)	Emission (Ton/Year)						
					NOx	CO	PM10	PM2.5	SO2	Black Carbon	CO2
1	TO 3 Tanjung Priok	2014 (estimation	1,344	679,432	440	35	49	42	534	12	31,133
2	Hong Kong*	2007	37,150	23,998,000	17,100	na	1,000	na	8,200	na	na
3	Kaohsiung - Taiwan*	2007	4,035	10,200,000	1,679	na	102	na	813	na	na
4	Singapore*	2007	2,742	27,935,000	1,492	na	89	na	682	na	na
5	Xiamen China*	2007	1,360	4,627,000	1,004	na	62	na	470	na	na
6	South Carolina**	2013	1,704	1,600,000	1,560	174	188	na	na	na	na
7	Los Angeles***	2012	1,953	8,100,000	3,402	423	106	na	na	na	na
8	Long Beach****	2011	2,036	6,000,000	4,321	473	134	na	na	na	na
9	Virginia*****	2011	2,153	1,920,000	2,814	264	248	228	1,761	na	na

Based on the data in Table 4, the emission per TEU could be analyzed. The result is presented in Table 5.

Table 5. Comparison of Emission Per TEUs in Several Ports in the World

No	Port	Year	Ship Call	Throughput (TEUs)	Emission (gram/TEU)						
					Nox	CO	PM10	PM2.5	SO2	Black Carbon	CO2
1	TO 3 Tanjung Priok	2014 (estimation)	1,344	679,432	648	52	71	62	786	17	45,823
2	Hong Kong*	2007	37,150	23,998,000	713	na	42	na	342	na	na
3	Kaohsiung - Taiwan*	2007	4,035	10,200,000	165	na	10	na	80	na	na
4	Singapore*	2007	2,742	27,935,000	53	na	3	na	24	na	na
5	Xiamen China*	2007	1,360	4,627,000	217	na	13	na	102	na	na
6	South Carolina**	2013	1,704	1,600,000	975	109	117	na	na	na	na
7	Los Angeles***	2012	1,953	8,100,000	420	52	13	na	na	na	na
8	Long Beach****	2011	2,036	6,000,000	720	79	22	na	na	na	na
9	Virginia*****	2011	2,153	1,920,000	1,466	138	129	119	917	na	na

Emission per TEU, particularly for vessel source, for OT 3 of Tanjung Priok ranks in the middle as compared to other ports; Singapore is the smallest and Virginia is the largest. However, it should be noted that emission inventory of the selected ports is conducted in different year.

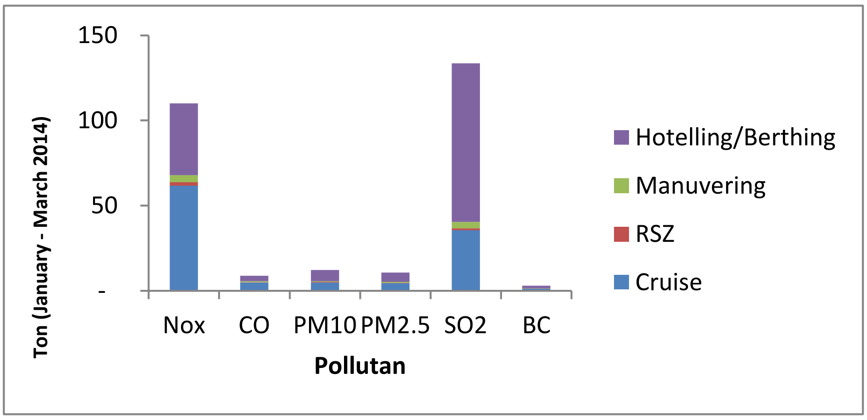
Meanwhile, the average estimated emission produced per ship call is presented in Table 6.

Table 6. Estimation of Emission per Ship Call in Several Ports in the World

No	Port	Year	Ship Call	Throughput (TEUs)	Emission (gram/TEU)						
					Nox	CO	PM10	PM2.5	SO2	Black Carbon	CO2
1	TO 3 Tanjung Priok	2014 (estimasi)	1,344	679,432	328	26	36	32	398	9	23,165
2	Hong Kong*	2007	37,150	23,998,000	460	na	27	na	221	na	na
3	Kaohsiung - Taiwan*	2007	4,035	10,200,000	416	na	25	na	201	na	na
4	Singapore*	2007	2,742	27,935,000	544	na	32	na	249	na	na
5	Xiamen China*	2007	1,360	4,627,000	738	na	46	na	346	na	na
6	South Carolina**	2013	1,704	1,600,000	916	102	110	na	na	na	na
7	Los Angeles***	2012	1,953	8,100,000	1,742	217	54	na	na	na	na
8	Long Beach****	2011	2,036	6,000,000	2,122	232	66	na	na	na	na
9	Virginia*****	2011	2,153	1,920,000	1,307	123	115	106	818	na	na

In terms of vessel operation, the largest emission is produced by vessel during hoteling/berthing condition, as presented in Figure 4.

Figure 4. Emission of OGV Per Operation Mode

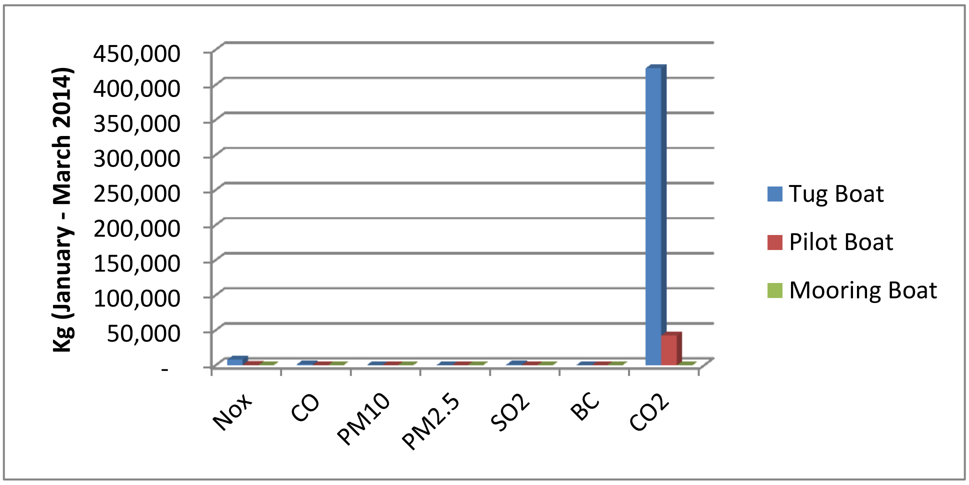


To acquire more accurate measurement of emission during the berthing/hoteling position, survey is required to gather more detail data of the vessel and the operation of the vessel during berthing/hoteling.

3. Emission of Harbor Craft

Figure 5 presents that tug boats produce the largest emission as compared to pilot boat and mooring boat. It is in line with its role during ship maneuvering.

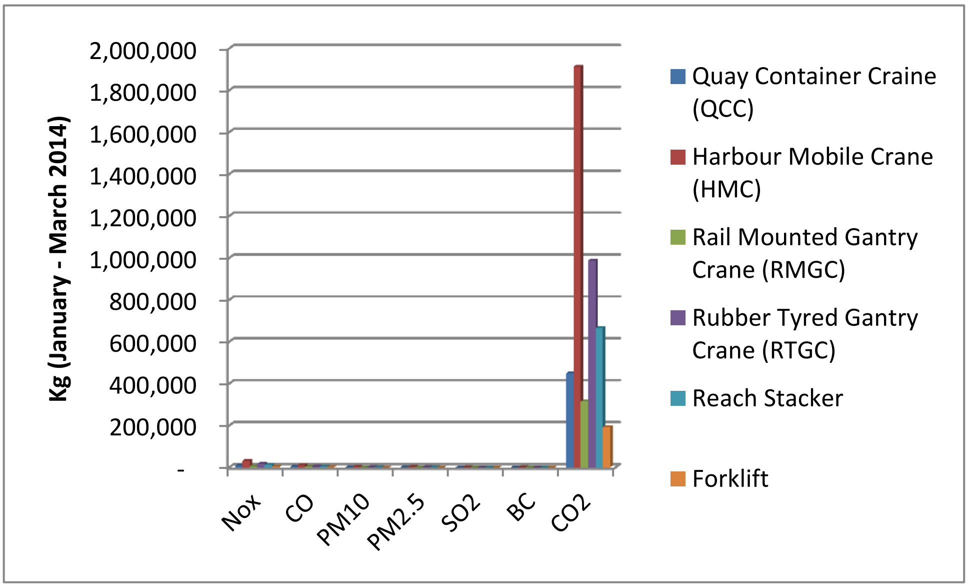
Figure 5. Emission of Harbor Craft



4. Emission of CHE

HMC contributes the largest emission of CHE source due to its intense activities, followed by RTGC and Reach Stacker.

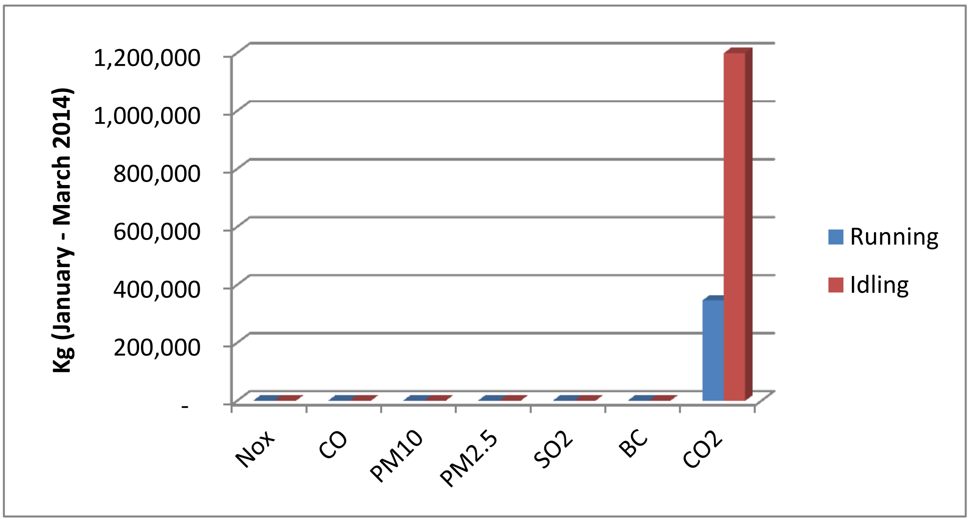
Figure 6. Emission of CHE



5. Emission of Head Truck

It is assumed that idling time for each activity is the same, i.e. 20 minutes. As the result, emission during idling time is much larger than during running time. It is necessary to conduct further survey in order to acquire more accurate idling time. Subsequently, investigation could be performed to find out the cause of long idling time and so that more detail traffic management could be developed.

Figure 7. Emissionof Head Truck



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