INVENTORY OF AIR POLLUTANT EMISSIONS VALPARAÍSO PORT - CHILE

UNEP
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CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

Centro Mario Molina • Chile

Preliminary Report

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1. General Methodology of Emission Inventory

To estimate emissions has been reference to the preliminary report of Terminal 3 Tanjunk Priok port facilitated by UNEP. We have considered four types of sources: ships, tugs, cargo handling and ground transport.

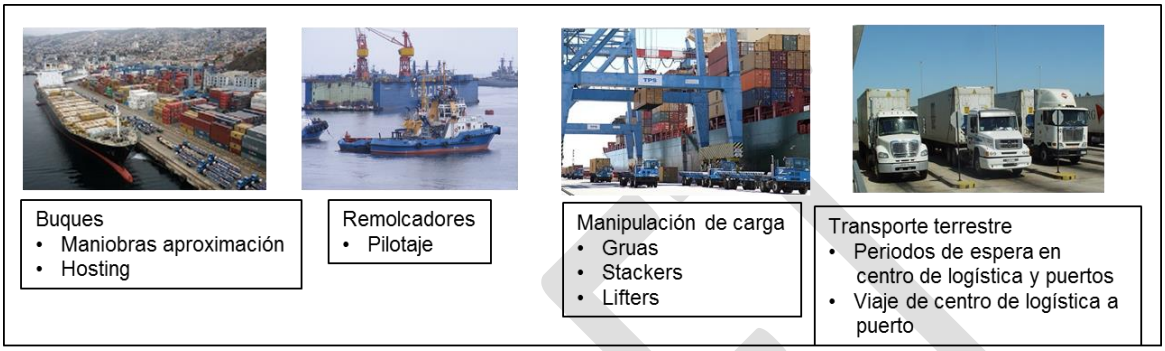

Figure 1: General diagram of the type of sources present in the Port of Valparaíso.

Empresa Portuaria Valparaíso (EPV) has provided information on equipment, operations and fuel consumption has allowed to estimate emissions using emission factors from US EPA, except for travel by the road transport, where emission factors model were used HBEFA 3.1.

It is estimated PM emissions, NOx, CO2 and BC. In the case of the latter it has been used contaminant information literature that relates to total emissions BC PM.

2. General Description of the Port of Valparaíso

Empresa Portuaria Valparaíso (EPV) is to manage, operate, develop and retain the port of Valparaiso, as well as assets held under any title, including all inherent to the port sector related activities and indispensable for the proper compliance with it.

EPV maintains current five concession contracts with major companies of the country and under his guidance the administration of an important public space of Valparaiso, as is the Paseo Muelle Prat.

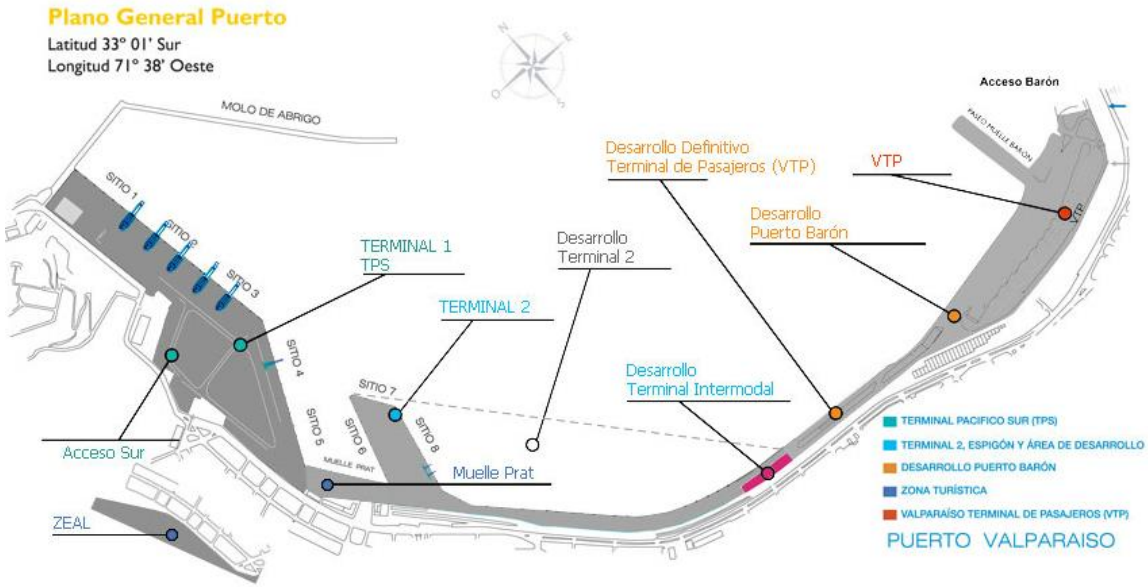

Figure 2 Plano General Puerto Valparaíso.

Main Activities at the Port of Valparaíso.

- **Terminal 1:**

Cargo and passenger terminal receives full container ships, refrigerated, multipurpose and cruises. It is a terminal operated under the concession monkey "Terminal Pacifico Sur Valparaiso (TPS)", comprising a total area of 14.62 [has] including Sites: 1, 2, 3, 4, 5.

- **Terminal 2:**

Cargo and passenger terminal receives full container ships, refrigerated, multipurpose and cruises, this is cute operated under concession "Terminal Cerros of Valparaiso (TCVAL)". A total area of 6.4 [ha], including Sites 6, 7, 8.

- **Passenger Terminal:**

Terminal dedicated to the loading and unloading of passengers arriving and departing on a cruise from the Port Valparaiso. This is under the concession "Passenger Terminal Valparaiso SA (VTP) ".

- **Extension Zone and Logistics Support (ZEAL):**

Entrance and exit both physical and virtual Puerto Valparaiso where entry and exit charges are coordinates to and from the terminals. In this place all the document checks and inspections of public services are developed. It also has an area of value-added services for cargo. Under concession "ZEAL Concessionaire SA (ZSC) ". A total area of 37 [has], to which it is divided into Zone of Core Activities (17 [has]), Zone of Special Services (8 [has]) and Zone Expansion (12 [has]).

- **Muelle Prat**

Public promenade, where visitors can see up close the large ships that dock in Puerto Valparaiso and the operation of their transfer terminals. It features local crafts and service boat ride through the Bay of Valparaíso.

3. Summary of Emissions

A summary of the emissions obtained for each of the fonts presented below. This table including emissions from tugboats in ship emissions.

The amounts obtained are similar to those presented in the report of the three terminal Tanjunk Priok port, which can be considered as a first validation of the results.

Table 1: Summary of Emissions from the Port of Valparaíso

	NOx	PM	BC	CO2 (tot)
Ground Transportation	151	2,2	1,7	5.841
Cargo Handling	331	15,6	4,4	21.118
Ships	282	46,8	13,1	
Total	**764**	**64,6**	**19,2**	**26.959**

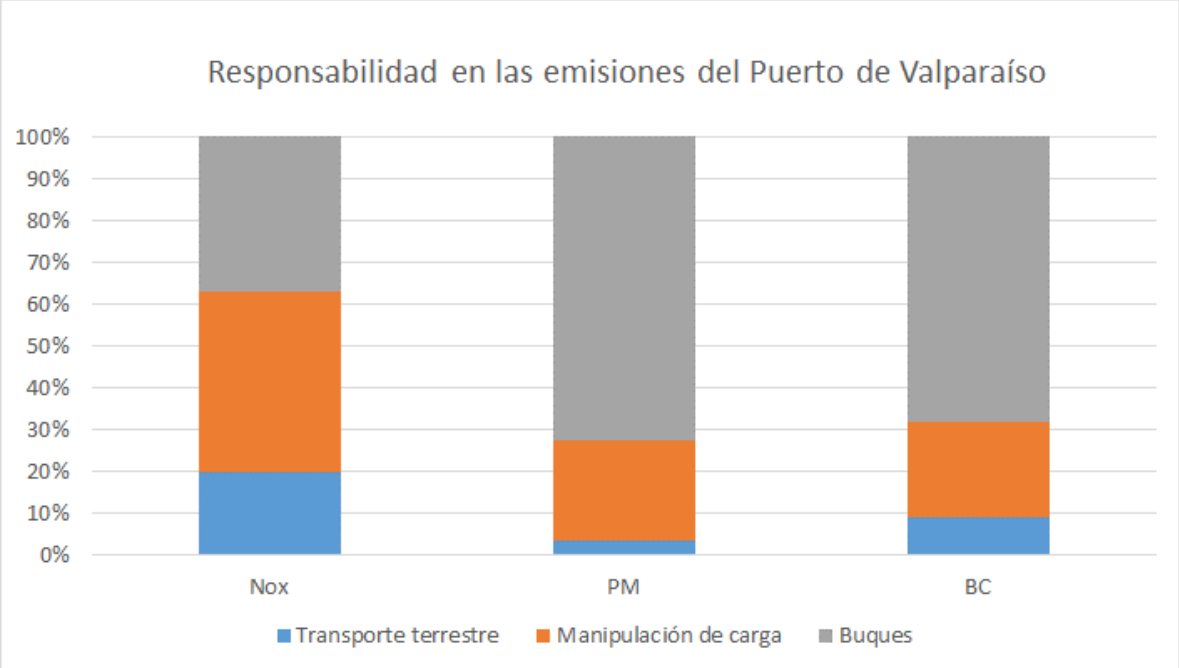

Figure 3: Emission Sources at the Port of Valparaíso.

4. Emissions from Ships

Identify the service process:

The basic operations of ocean vessels correspond to the approach maneuver and the period of stay in the port for the tasks of loading / unloading (hosting), integrating both into a single operation called homing.

EPV has a record of all operations annual landfalls by vessel type, as shown in the following table.

Table 2: Vessel Activity Level at the Port of Valparaíso

TYPE OF VESSEL	LENGTH	NUMBER OF PORT CALLS
Charter_Reefer	(L= entre 130 & 150 Mts)	29
Charter_Reefer	(L= entre 151 & 160 Mts)	26
Charter_Reefer	(L= entre 161 & 180 Mts)	9
Fierro	(L= entre 130 & 150 Mts)	8
Fierro	(L= entre 151 & 160 Mts)	1
Fierro	(L= entre 161 & 180 Mts)	12
Fierro	(L= entre 181 & 200 Mts)	28
Ro_Ro	(L= entre 161 & 180 Mts)	11
Ro_Ro	(L= entre 181 & 200 Mts)	49
Pasajero	(L= entre 130 & 150 Mts)	9
Pasajero	(L= entre 161 & 180 Mts)	3
Pasajero	(L= entre 181 & 200 Mts)	4
Cabotaje_Isla	(L= entre 40 & 60 Mts)	67
Cabotaje	(L= entre 40 & 60 Mts)	2
Otros	(L= entre 40 & 60 Mts)	41

It is considered that all motors are low speed with a motor vessel plus an auxiliary engine. The powers assumed for each type of ship are presented in the following table.

Table 3: Tipo de Buques y Potencia, Puerto Valparaíso

SHIP NAME	TYPE OF SHIP	POWER (Kw)
Charter Reefer	Reefer Coastal	5.046
Fierro	Bulk Over 50,000T	9.327
Fierro	Bulk Over 10,000T	5.720
Fierro	Bulk Over 25,000T	7.492
Ro Ro	RORO Oceanic	14.624
Pasajero	Cruise to 5,000T	16.613
Pasajero	CRUISE OVER 5,000T TO 9,999T	40.736
Pasajero	Cruise Over 10,000T	68.890
Cabotaje Isla	Bulk Coastal	3.020
Cabotaje	Bulk Coastal	3.020
Otros	Bulk Coastal	3.020

A distance of 2.4 kilometers from the point where the pilot assumes control of the ship to maneuver to the port of call is assumed.

From the above information the following EPV estimated fuel consumption by recada of each type of ship. Fuel is Bunker Fuel Oil.

Table 4: Fuel Consumption of Vessels at the Port of Valparaíso

TYPE OF VESSEL	LENGTH	CONSUMO POR RECALADO (lt)
Charter_Reefer	(L= entre 130 & 150 Mts)	4.824
Charter_Reefer	(L= entre 151 & 160 Mts)	7.059
Charter_Reefer	(L= entre 161 & 180 Mts)	7.576
Fierro	(L= entre 130 & 150 Mts)	2.506
Fierro	(L= entre 151 & 160 Mts)	4.706
Fierro	(L= entre 161 & 180 Mts)	4.706
Fierro	(L= entre 181 & 200 Mts)	5.882
Ro_Ro	(L= entre 161 & 180 Mts)	4.706
Ro_Ro	(L= entre 181 & 200 Mts)	5.294
Pasajero	(L= entre 130 & 150 Mts)	34.133
Pasajero	(L= entre 161 & 180 Mts)	38.400
Pasajero	(L= entre 181 & 200 Mts)	38.400
Cabotaje_Isla	(L= entre 40 & 60 Mts)	325
Cabotaje	(L= entre 40 & 60 Mts)	2.506
Otros	(L= entre 40 & 60 Mts)	4.447

To estimate emissions have used the following emission factors Emission estimate methodology document for maritime navigation, Carlo Trozzi, 2010.

Table 5: Ship Emission Factors (g/kwhr)

Phase	Tipo de motor	Combustible	[g/kwhr]		
			NOx	NMVOC	PM
Manoeuvring + hotelling	Medium speed diesel	BFO	14	1,8	2,4

For support ships are considered three tugs, with the following operational information.

Table 6: Fuel consumption vessels (lt)

TYPE OF VESSEL	NUMBER OF TUG	CONSUMO POR RECALADO (lt)	NUMBER OF PORT CALLS (1 SECTION)	NUMBER OF OPERATIONS	CONSUMPTION TOTAL (lt)	Combustible
Remolque	1 Tug	60	146	73	8.760	IFO_380
Remolque	2 Tug	60	904	226	54.240	IFO_380

From the above background the following annual emissions of all oceangoing vessels and support are estimated to operate in the port of Valparaíso.

Table 7: Ship Emissions (ton/year)

Ship Type	[Ton/year]	
	PM	NOx
Ocean going vessels	46,0	268,2
Support ships	0,8	13,7
Total	**46,8**	**282,0**

5. Issues Related to Cargo Handling

It consists of loading and unloading equipment operating in both inland port and the bay, and / or the seaport.

- **Methodology for estimating emissions:**

It used manual US-EPA "Current Methodologies in Preparing Mobile Source Emission Inventories Port-Related" reference. The calculations for this type of pollutant emission sources can be performed by means of the following equation:

$$E = FE \times P \times A \times LF$$

$E = Emisión\ [\frac{Ton}{año}]$

$FE: Factor\ de\ emisión\ \left[\frac{gr}{HP\ hr}\right] o\ [\frac{gr}{kW\ hr}]$

$A = Actiividad\ [\frac{hrs}{año}]$

$LF: Factor\ de\ Carga.$

- **Characteristics of cargo handling equipment at the port of Valparaíso:**

Within land port operations, the most significant are those of the loading and unloading to or from ships. These teams work mostly Diesel and Natural Gas, behaving like off-road transport.

Figure 4 Crane Fork.

Figure 5 Grua RTG (Rubber Tyre Gantry)

Figure 6 Reach stackers

Figure 7 Toplifter.

Figure 8 ManLift.

- **Calculation of emissions in cargo handling equipment:**

Data base used in the "Inventory of Greenhouse Gas Emissions, 2012," for the Port of Valparaíso, considered by EY.

On the basis of data available there are records of Terminal 1, 2 and Zeal ends, so for these 3 areas for NOx, SO2, PM2.5 and BC were estimated by the method of emission factor for the US-EPA.

- **Terminal 1:**

Table 8: Emissions Inventory in Terminal 1 Port of Valparaíso - Mobile Sources

Scope 1 - (A) Mobile Sources					
Emission source	**NOx [Ton/ Year]**	**PM2.5 [Ton/Year]**	**SO2 [Ton/Year]**	**CO2 [Ton/Year]**	**BC [Ton/Year]**
Mobile cranes and fork	18.5	0.9	0.4	1164.7	0.2
RTG	120.0	5.6	2.3	7558.6	1.6
Reachstackers	60.3	2.8	1.1	3797.3	0.8
Toplifter	24.3	1.1	0.5	1526.9	0.3
Tractor	0.1	0.0	0.0	7.8	0.0
Man Lift	0.4	0.0	0.0	23.5	0.0
Cleaning equipment	0.3	0.0	0.0	16.4	0.0
Portable lighting towers	0.6	0.0	0.0	40.8	0.0
Tractor Trucks	82.9	3.8	1.6	5216.7	1.1
Transportation Operations and Management	3.3	0.2	0.1	207.3	0.0
Total	**310.7**	**14.4**	**5.9**	**19560.0**	**4.0**

Table 9: Emissions Inventory in Terminal 1 Port of Valparaíso – Vehicle Service

Scope 3 - (G) Transport vehicles Service					
Emission source	**NOx [Ton/Year]**	**PM2.5 [Ton/Year]**	**SO2 [Ton/Year]**	**CO2 [Ton/Year]**	**BC [Ton/Year]**
Crane Fork Ultraport	10.5	0.5	0.2	659.2	0.1
Crane Fork Marval	0.8	0.0	0.0	48.2	0.0
Crane Fork San Francisco	0.3	0.0	0.0	20.3	0.0
Total	**11.6**	**0.5**	**0.2**	**727.8**	**0.2**

- **Terminal 2:**

Table 10: Emissions Inventory in Terminal 1 Port of Valparaíso – Vehicle Service

Scope 3 - (G) Transport vehicles Service					
Emission source	**NOx [Ton/Year]**	**PM2.5 [Ton/Year]**	**SO2 [Ton/Year]**	**CO2 [Ton/Year]**	**BC [Ton/Year]**
Gas fork	4.938890657	0.22930564	0.094074108	310.9737224	0.064205579
Container Ship	2.556016767	0.11867221	0.048686034	160.93777	0.033228218
Diesel fork	0.400285296	0.01858467	0.007624482	25.20367776	0.005203709
Container stackers	0.136287613	0.13628761	0.055912867	184.8269702	0.038160532
Total	8.031480332	0.50285013	0.20629749	681.9421404	0.140798037

- **Zeal:**

Table 11: Emissions Inventory in Terminal 1 Port of Valparaíso - Mobile Sources

Scope 1 - (A) Mobile Sources					
Emission source	**NOx [Ton/Year]**	**PM2.5 [Ton/Year]**	**SO2 [Ton/Year]**	**CO2 [Ton/Year]**	**BC [Ton/Year]**
Crane Fork	0.213	0.010	0.004	13.426	0.003
Crane Fork	0.213	0.010	0.004	13.426	0.003
Crane Fork	0.213	0.010	0.004	13.426	0.003
Crane Fork	0.010	0.010	0.004	13.426	0.003
Crane Fork	0.006	0.006	0.003	8.391	0.002
Transfer truck	0.000	0.000	0.000	0.043	0.000
1 Grúa Reach Stacker PPM	0.063	0.063	0.026	85.727	0.018
Total	**0.719**	**0.109**	**0.045**	**147.865**	**0.031**

6. Vehicle Emissions

- Technology fleet: Trucks EURO II, and as inventories in international ports, Class 8b.

Figure 9: Trucks in Port of Valparaíso (www.cadch.cl)

- Types of containers terminal: Although information on the number of trucks loaded facilitated by type (Dry, Reefer, fractional), for estimating emissions no distinction was made by type of container transported.

- Kilometers year: Only local travel estimated 11 km from ZEAL and Terminal 1 and 2.

Figure 10: ZEAL location with respect to the port of Valparaíso

- Waiting times at terminals 1, 2 and ZEAL: time taken from "Inventory of Greenhouse Gas Emissions, Year 2012"

- Emission Factors:

For waiting times at terminals, they are considered emission rates published by the *California Air Resources Board* (CARB, 2013), expressed in g / hr. The Carb published two types of FFEE, "Idle low" and "high idle", the former are indicative of the status of truck waiting to load or unload a burden, which reflects the port activities. While the latter represents activities associated with truck stops, rest areas and distribution centers (Starcrest Consulting Group, LLC, 2013). In Table 122 emission rates are presented by year of truck models in this study were considered models rates for the years 1994-1997.

Table 12: Emission rates "Low Idle" for HDV.

	Emission Rate (g/hr)				
Model Year	HC	CO	NOx	PM	CO2
Pre 1987	18,65	28,4	42,50	3,43	4,27
1987-90	10,94	23,4	65,29	1,73	4,51
1991-93	8,71	21,5	72,91	1,28	4,61
1994-97	6,97	19,5	79,33	0,96	4,72
1998-02	5,23	17,8	85,65	0,66	4,85
2003-06	4,29	16,6	88,82	0,52	4,93
2007-09	4,29	16,6	27,9	0,06	4,93
2010+	4,29	16,6	27,9	0,06	4,93

In the case of emission estimates "en route", the emission factors HBEFA 3.1 were used for only one type of truck trailer 34 to 40 tons and with Euro II technology and in urban areas, distributor road traffic in a saturated condition.

Table 13: Emission Factors for HDV, HBEFA 3,1,

		Emission Factors (g/km)					
Truck	Traffic Situation	HC	NOx	PM	CO	CO2(tot)	FC
TT/AT >34-40t Euro-II	URB/Distr/50/Satur,	0,64	12,28	0,23	2,10	1068,13	339,09

Black Carbon emissions are calculated from the emissions of PM; nearly 75% of mobile source PM diesel is BC (Ramanathan, 2013),

Table 14: Information flow trucks Source / Target 2012 (EY, 2014)

Load Type	Transaction Type	Origin	Destination	Total trucks per year	Average stay Departure (Hours)	Distance From Shuttle (Km)	Average stay Destination (Hours)
Reefer	Exportación	ZEAL	Terminal2	3180	3,7	11	1,3
Reefer	Importación	Terminal2	ZEAL	0	0	11	0
Dry	Exportación	ZEAL	Terminal2	25663	2,35	11	0,61
Dry	Importación	Terminal2	ZEAL	18610	0,46	11	0,5
Fraccionada	Exportación	ZEAL	Terminal2	1125	1,28	11	0,6
Fraccionada	Importación	Terminal2	ZEAL	9832	1,13	11	0,34
Reefer	Exportación	ZEAL	Terminal1	19861	3,7	11	1,3
Reefer	Importación	Terminal1	ZEAL	0	0	11	0
Dry	Exportación	ZEAL	Terminal1	192467	2,35	11	0,61
Dry	Importación	Terminal1	ZEAL	142499	0,46	11	0,5
Fraccionada	Exportación	ZEAL	Terminal1	8457	1,28	11	0,6
Fraccionada	Importación	Terminal1	ZEAL	75011	1,13	11	0,34

Methodology:

$$Emision\ \left(\frac{Ton}{año}\right) = \frac{EEFF\ or\ Rate\ \left(\frac{g}{km}\ or\ \frac{g}{hr}\right) * Activity\ (km\ or\ hr) * HDV\ number}{1{,}000{,}000}$$

To determine the activity levels of the trucks in different areas of the port of Valparaiso, they were taken into account as stated in EY, 2013 Report; where for the calculation of emissions of greenhouse gases transaction type and origin / destination of the truck is so that when the transaction type corresponds to "export" it was considered the waiting time at the origin is assigned to ZEAL and the distance and time of transfer to the corresponding destination "Terminal"; and where appropriate to "import" the time of origin is assigned to the "Terminal" and on arrival time and distance of transfer to ZEAL.

Table 15: Emissions from truck traffic in the Port of Valparaíso

	Ton/Year			
	NOx	PM	CO2(tot)	BC
HDV i	151,05	2,24	5,841	1,68

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