PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS - 2006

THE PORT OF LOS ANGELES

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THE PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS FOR CALENDAR YEAR 2006

THE PORT OF LOS ANGELES

Prepared for:

THE PORT OF LOS ANGELES

Prepared by:

Starcrest Consulting Group, LLC
P.O. Box 434
Poulsbo, WA 98370

STARCREST CONSULTING GROUP, LLC
QUALITY ASSURANCE & ENVIRONMENTAL MANAGEMENT

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Authors:	Archana Agrawal, Consultant, Starcrest Guiselle Aldrete, Consultant, Starcrest Bruce Anderson, Principal, Starcrest Joseph Ray, Principal, Starcrest Mark Carlock, Consultant, Starcrest Sam Wells, Consultant, Starcrest
Contributors:	Steve Ettinger, Consultant, Starcrest Alycia Gilde, Consultant, Starcrest Joyce Kristiansson, Consultant, Starcrest Lars Kristiansson, Consultant, Starcrest Rose Muller, Consultant, Starcrest Jeff Reiter, Consultant, Starcrest
Document Preparation:	Denise Anderson, Consultant, Starcrest
Cover:	Melissa Silva, Principal, Starcrest

ACRONYMS AND ABBREVIATIONS

Act	Activity
AAPA	American Association of Port Authorities
ABS	American Bureau of Shipping
AMP	alternative maritime power
ANPRM	Advance Notice of Proposed Rulemaking
APL	American Presidents Line
APM	A. P. Moeller
AS	actual speed
ATB	articulated tug and barge
BACT	Best Available Control Technology
BAEI	Baseline Air Emissions Inventory
BNSF	Burlington Northern Santa Fe Railroad
BTH	Business Transportation and Housing Agency
BW	breakwater
CAAP	Clean Air Action Plan
Cal/EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CF	control factor
CHE	cargo handling equipment
CO	carbon monoxide
D	distance
DB	dynamic breaking
DF	deterioration factor
DMV	Department of Motor Vehicles
DMVT	daily vehicle miles of travel
DOC	diesel oxidation catalyst
DPF	diesel particulate filter
DPM	diesel particulate matter
DR	deterioration rate
DWT	deadweight tonnage
E	emissions
EEIA	Energy and Environmental Analysis
EF	emission factor
EI	emissions inventory
EMD	(GE) Electromotive Division
EPA	U.S. Environmental Protection Agency

ACRONYMS AND ABBREVIATIONS (CONT'D)

FCF	fuel correction factor
g/bhp-hr	grams per brake horsepower-hour
g/day	grams per day
g/hr	grams per hour
g/kW-hr	grams per kilowatt-hour
g/mi	grams per mile
GHG	greenhouse gas
GM	goods movement
GMP	Goods Movement Plan
GVWR	gross vehicle weight rating
HC	hydrocarbons
HDDV	heavy-duty diesel vehicle
HDV	heavy-duty vehicle
HFO	heavy fuel oil
hp	horsepower
hrs	hours
HVAC	heating/ventilation/air conditioning
ICTF	Intermodal Container Transfer Facility
IFO	intermediate fuel oil
IMO	International Maritime Organization
ITB	integrated tug and barge
kW	kilowatt
L.A.	Los Angeles
LAXT	Los Angeles Export Terminal
l/cyl	liters per cylinder
lbs/day	pounds per day
LF	load factor
LLA	low load adjustment
Lloyd's	Lloyd's Register of Ships
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LSI	large spark ignited (engine)
M&N	Moffatt & Nichol Engineers
MaRex	Marine Exchange of Southern California
MCR	maximum continuous rated
MDO	marine diesel oil

Acronyms and Abbreviations (cont'd)

MGO	marine gas oil
MMA	Meyer, Mohaddes Associates, Inc.
MMGT	million gross ton-miles
MOU	Memorandum of Understanding
mph	miles per hour
MS	maximum speed
MTC	Marine Terminals Corporation
MY	model year
N	north
NAAQS	National Ambient Air Quality Standards
nm	nautical miles
NO_x	oxides of nitrogen
NPRM	Notice of Proposed Rulemaking
NYK	Nippon Yusen Kaisha
OBD	on-board diagnostics
OGV	ocean-going vessel
PCEEI	Pleasure Craft Exhaust Emissions Inventory
PCST	Pacific Cruise Ship Terminals
PHL	Pacific Harbor Line
PM	particulate matter
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PMSA	Pacific Merchant Shipping Association
POLB	Port of Long Beach
ppm	parts per million
PZ	precautionary zone
Reefer	refrigerated vessel
RH	relative humidity
RIA	Regulatory Impact Analysis
RO	residual oil
ROG	reactive organic gases
Ro-Ro	roll-on/roll-off
rpm	revolutions per minute
RSD	Regulatory Support Document
RTG	rubber tired gantry crane
RTL	rich text language

ACRONYMS AND ABBREVIATIONS (CONT'D)

S	sulfur
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SFC	specific fuel consumption
SO_x	oxides of sulfur
SoCAB	Southern California Air Basin
SPB	San Pedro Bay
SSA	Stevedoring Services of America
SUV	sport utility vehicle
T&M	tampering and mal-maintenance
TEU	twenty-foot equivalent unit
TICTF	Terminal Island Container Transfer Facility
TOG	total organic gases
tpd	tons per day
tpy	tons per year
UDDS	Urban Dynamometer Driving Schedule
U.S.	United States
ULCC	ultra large crude carriers
ULSD	ultra low sulfur diesel
UP	Union Pacific Railroad
USCG	U.S Coast Guard
VBP	vessel boarding program
VLCC	very large crude carrier
VLCS	very large cargo ship
VMT	vehicle miles of travel
VOCs	volatile organic compounds
VSR	vessel speed reduction
VTS	vessel traffic service
W	west
ZH	zero hour
ZMR	zero mile rate

EXECUTIVE SUMMARY

The Port of Los Angeles (the Port) shares San Pedro Bay with the neighboring Port of Long Beach (POLB). Together, the San Pedro Bay Ports comprise a significant regional and national economic engine for California and the United States (U.S.), through which more than 40% of all U.S. containerized trade flows. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will more than double by the year 2020. The Ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts (and, in particular, air quality impacts) that result from such trade. Therefore, in November 2006, the San Pedro Bay Ports adopted their landmark, joint Clean Air Action Plan (CAAP) designed to reduce the air health risks and emissions associated with port-related operations, while allowing port development to continue. In order to track CAAP progress, the Port has committed to develop annual inventories starting with the 2005 Inventory of Air Emissions.

The Port released its first activity-based emissions inventory in 2004, documenting activity levels in the baseline year of 2001[1]. The 2001 baseline emissions inventory evaluated emissions for all Port terminals from five source categories: ocean-going vessels, harbor craft, off-road cargo handling equipment, railroad locomotives and on-road heavy-duty vehicles and evaluated operations at all Port terminals. In 2007, the Port released the 2005 Inventory of Air Emission which was the first update to the baseline inventory and also the first of the annual inventories to follow.

This study, the 2006 Inventory of Air Emissions, includes emissions estimates based on 2006 activity levels and annual comparisons for 2001, 2005, and 2006 emissions estimates to track progress. As in previous inventories, the following five source categories are included:

- Ocean-going vessels
- Harbor craft
- Cargo handling equipment
- Railroad locomotives
- Heavy-duty vehicles

[1] *Port of Los Angeles 2001 Baseline Air Emissions Inventory,* 2004.

This study also includes for the first time emission estimates for greenhouse gases (GHGs) for port-related tenant operational sources. Exhaust emissions of the following pollutants have been estimated:

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Total hydrocarbon (HC)
- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrogen oxide (N_2O)

Methodology Overview

Port tenants and shipping lines play an essential role in the development of an activity-based Emissions Inventory (EI) by providing the most accurate activity and operational information available. Emissions estimates are developed for each of the various source categories in a manner consistent with the latest estimating methodologies agreed upon by the Port and the participating regulatory agencies. The information gathered, analyzed, and presented in this 2006 EI continues to improve the understanding of the nature and magnitude of Port-related emission sources. Development of this inventory was coordinated with the U.S. Environmental Protection Agency - Region 9 (EPA), California Air Resources Board (CARB), and SCAQMD.

The geographical extent of the 2006 inventory is described in section 1 and in each source category section of the report. The geographical extent of the port-related emissions did not change from previous inventories and includes emissions from all source categories within the harbor district; emissions from rail locomotives and on-road trucks transporting cargo to or from the Port up to the cargo's first point of rest within the South Coast Air Basin (SoCAB) or up to the basin boundary, whichever comes first; and emissions from commercial marine vessels within the harbor and up to the study area boundary. Figure ES.1 shows the SoCAB boundary which is the gray shaded area.

Figure ES.1: South Coast Air Basin Boundary

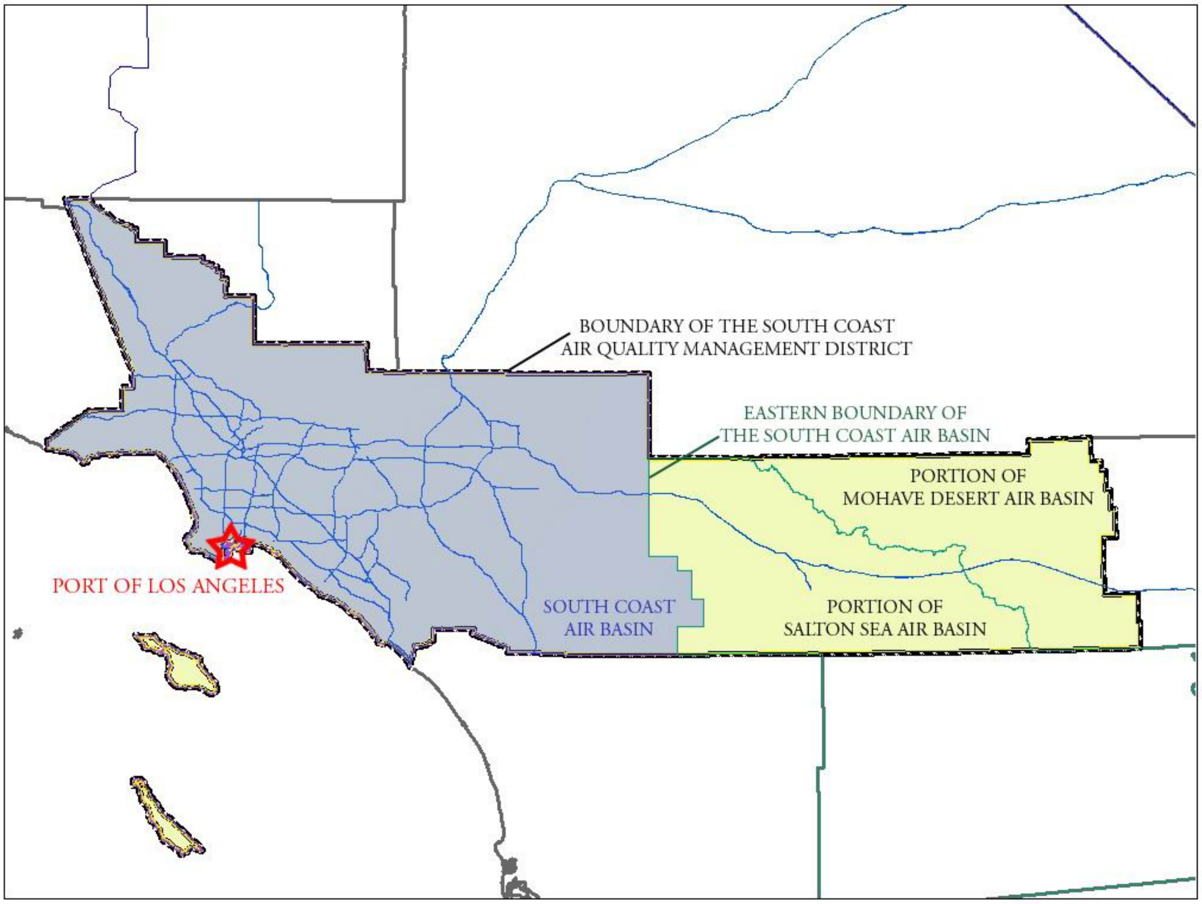


Figure ES.2 shows the geographical extent for the ocean-going vessels and harbor craft. The over-water boundary is bounded in the north by the southern Ventura County line at the coast and in the south with the southern Orange County line at the coast.

Figure ES.2: OGV Inventory Geographical Extent

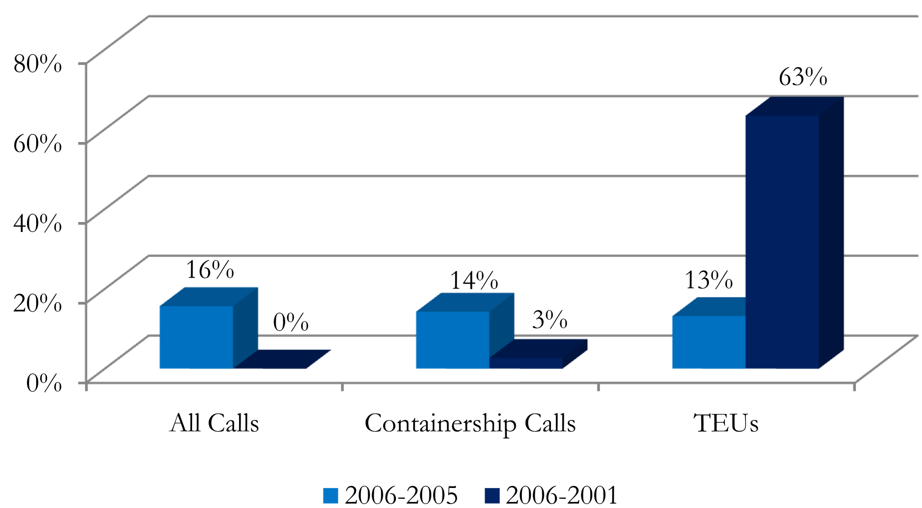
Findings

Table ES.1 and Figure ES.3 illustrate the differences in vessel calls and container cargo throughputs between 2001, 2005 and 2006. From 2005 to 2006, there was a 13% increase in TEU throughput, the number of total calls increased by 16%, and containership calls increased by 14%. From 2001 to 2006, although the number of calls stayed the same, the TEU throughput increased by 63%.

Table ES.1: TEUs and Vessel Call Comparison, %

EI Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2006	2,708	1,626	8,469,853	5,209
2005	2,341	1,423	7,484,625	5,260
2001	2,717	1,584	5,183,520	3,272
2006-2005	**16%**	**14%**	**13%**	**-1%**
2006-2001	**0%**	**3%**	**63%**	**59%**

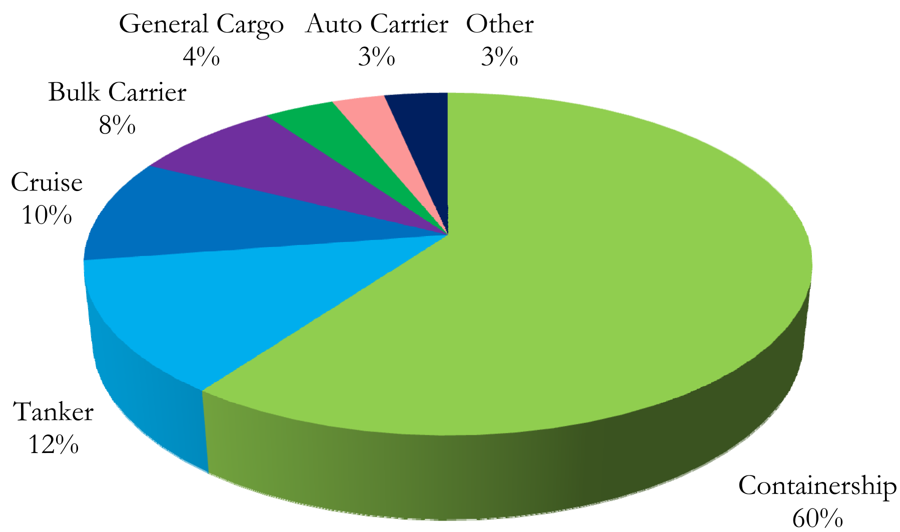
Figure ES.3: TEUs and Vessel Call Comparison, %



Ocean-going Vessels

Figure ES.4 shows that the majority of the vessels that called at the Port in 2006 are containerships (60%); followed by tankers (12%); cruise vessels (10%), bulk carriers (8%); general cargo (4%), and auto carriers (3%). The remaining 3% shown as others include reefers, RoRos, and miscellaneous vessels.

Figure ES.4: Distribution of Vessel Types by Inbound Calls



The various emission reduction strategies for ocean-going vessels are listed in Table ES.2 and summarized below:

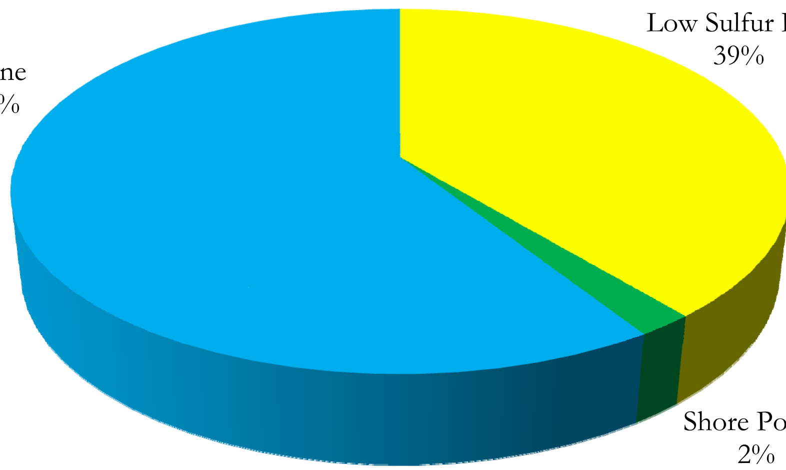
- The percent of calls with vessels that had fuel-efficient slide valves is 7% as compared to 4% in 2005.
- The percent of calls with IMO-compliant vessels (model year 2000 and newer) is 44% in 2006 as compared to 32% in 2005.
- Shore Power continued at berth 100 and the percent of total calls that Shore Powered was 2% for both 2006 and 2005.
- The percent of vessels that switched to a cleaner fuel for auxiliary engines at berth is 39% in 2006 as compared to 27% in 2005.
- The percentage of vessels that switched to a cleaner fuel for main engines during transit is 10% in 2006 as compared to 3% in 2005, and 0% in 2001.
- In 2006, approximately 84% of total vessel calls complied with the VSR program as compared to 64% in 2005 and 58% (for calls from Oct to Dec) in 2001.

Table ES.2: Emissions Reduction Strategies for OGVs

							Fuel Switch		
	Slide Valve		IMO-Compliant		Shore Power		Aux	Main	VSR
Year	# Vessels	# Calls	# Vessels	# Calls	# Vessels	# Calls	% of Calls	% of Calls	% of Calls
2006	29	191	432	1,183	23	61	39%	10%	84%
2205	22	100	271	740	17	40	27%	3%	64%

Figure ES.5 shows that in 2006, 41% of the vessel calls used a lower sulfur fuel (39%) or used shore power at berth (2%).

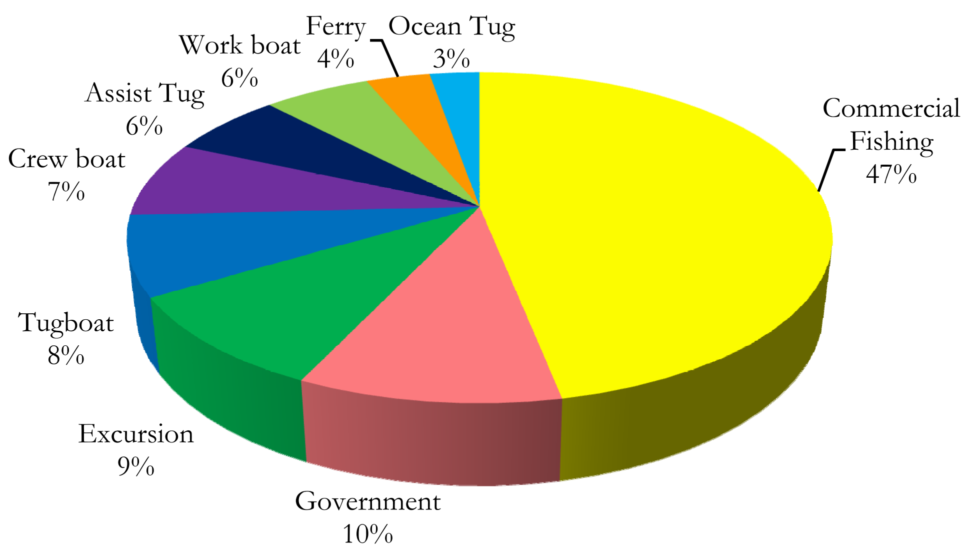
Figure ES.5: 2006 Distribution of Vessel Calls that Switch to Cleaner Fuel at Berth (Auxiliary Engines)



Harbor Craft

Figure ES.6 presents the distribution of the 256 commercial harbor craft inventoried for the Port of Los Angeles in 2006. The actual number of vessels did not change from 2005 to 2006. The vessel count did decrease by 35% since 2001 mainly due to the fact that half the commercial fishing vessels inventoried in 2001 are no longer at the Port in 2006.

Figure ES.6: 2006 Distribution of Commercial Harbor Craft



Approximately 27% of the main engines and 42% of the auxiliary engines have been replaced since 2001. Table ES.3 summarizes the percent distribution of engines based on engine standards. For this comparison, the following model years fall into the Tier 0, Tier 1 and Tier 2:

- Tier 0 are engines older than 1999
- Tier 1 engines' model year ranges from 2000 to 2003
- Tier 2 engines' model year are 2004+

Table ES.3: Harbor Craft Engine Standards Comparison by Tier

	Tier 0	Tier 1	Tier 2
CY 2006	61%	29%	10%
CY 2005	64%	30%	7%
CY 2001	100%	0%	0%

In 2001, model year was not known for all engines, but it can be assumed that close to 100% of the harbor craft had engines in the Tier 0 range since the engine model year was probably 1999 or older.

Between 2001 and 2005, many engines were replaced as a result of the Carl Moyer Program and Port-funded projects to reduce emissions in the harbor. In 2005, 64% of the engines were Tier 0 engines; 30% had Tier 1 engines and 7% had Tier 2 engines. In 2006, the percentage of Tier 0 engines was further reduced to 61% and the Tier 2 percentage increased to 10%.

Cargo Handling Equipment

Figure ES.7 presents the distribution of the 1,995 pieces of equipment inventoried at the Port for 2006. Out of all CHE inventoried at Port facilities for 2006, 48% were yard tractors, 28% were forklifts, seven percent were top handlers, five percent were RTG cranes, two percent were side handlers and ten percent were other equipment.

Figure ES.7: 2006 Distribution of Port CHE by Equipment Type

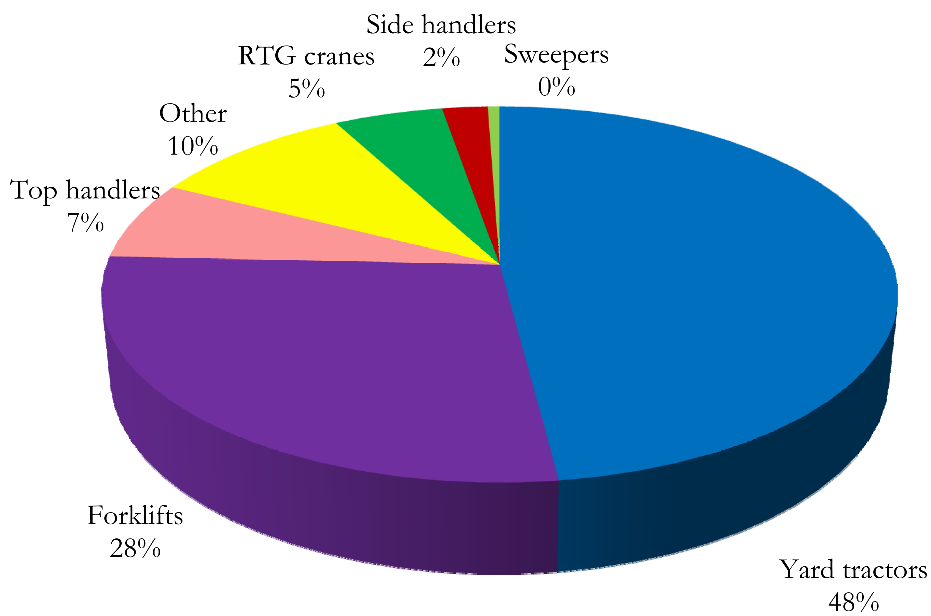


Table ES.4 summarizes the various engine power types for CHE, which include electric, liquefied natural gas (LNG), propane, gasoline, and diesel. Electric powered equipment has doubled and propane powered equipment has more than tripled at the port since 2001.

Table ES.4: CHE Engine Power Type Matrix

Equipment	Electric	LNG	Propane	Gasoline	Diesel
2006					
Forklifts	0	0	355	8	191
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	103
Side handlers	0	0	0	0	43
Top handlers	0	0	0	0	134
Yard tractors	0	2	58	0	897
Sweepers	0	0	0	2	10
Other	19	0	0	0	104
Total	**88**	**2**	**413**	**10**	**1,482**
2005					
Forklifts	0	0	263	8	151
Wharf gantry cranes	67	0	0	0	0
RTG cranes	0	0	0	0	98
Side handlers	0	0	0	0	41
Top handlers	0	0	0	0	127
Yard tractors	0	0	53	0	848
Sweepers	0	0	0	3	8
Other	12	0	0	0	103
Total	**79**	**0**	**316**	**11**	**1,376**
2001					
Forklifts	0	0	116	4	80
Wharf gantry cranes	44	0	0	0	0
RTG cranes	0	0	0	0	34
Side handlers	0	0	0	0	37
Top handlers	0	0	0	0	74
Yard tractors	0	0	0	0	590
Sweepers	0	0	0	1	3
Other	0	0	0	0	70
Total	**44**	**0**	**116**	**5**	**888**

Table ES.5 summarizes the various emissions controls for diesel powered CHE by equipment counts and by percent total diesel equipment (found in the total equipment count column). It should be noted that emission controls can be used in combination with each other, therefore they cannot be added across to come up with total equipment count (control equipment counts are greater than total equipment counts).

Table ES.5: Diesel Powered Equipment Emissions Control Matrix

	Control Equipment Counts				Total	Percent of Total Diesel Powered Equipment			
Equipment	DOC Installed	On-Road Engines	USLD Fuel	Emulsified Fuel	Equipment Count	DOC Installed	On-Road Engines	USLD Fuel	Emulsified Fuel
2006									
Forklifts	4	4	191	15	191	2%	2%	100%	8%
RTG cranes	10	0	103	28	103	10%	0%	100%	27%
Side handlers	13	0	43	10	43	30%	0%	100%	23%
Top handlers	54	0	134	42	134	40%	0%	100%	31%
Yard tractors	531	216	897	128	897	59%	24%	100%	14%
Sweepers	0	1	10	0	10	0%	10%	100%	0%
Other	0	5	104	0	104	0%	5%	100%	0%
Total	**612**	**226**	**1,482**	**223**	**1,482**	**41%**	**15%**	**100%**	**15%**
2005									
Forklifts	3	0	27	15	151	2%	0%	18%	10%
RTG cranes	0	0	36	28	98	0%	0%	37%	29%
Side handlers	14	0	16	10	41	34%	0%	39%	24%
Top handlers	48	0	79	36	127	38%	0%	62%	28%
Yard tractors	520	164	483	129	848	61%	19%	57%	15%
Sweepers	0	0	0	0	8	0%	0%	0%	0%
Other	0	1	65	0	103	0%	1%	63%	0%
Total	**585**	**165**	**706**	**218**	**1,376**	**43%**	**12%**	**51%**	**16%**
2001									
Forklifts	0	0	0	0	80	0%	0%	0%	0%
RTG cranes	0	0	0	0	34	0%	0%	0%	0%
Side handlers	0	0	0	0	37	0%	0%	0%	0%
Top handlers	0	0	0	0	74	0%	0%	0%	0%
Yard tractors	0	0	0	0	590	0%	0%	0%	0%
Sweepers	0	0	0	0	3	0%	0%	0%	0%
Other	0	0	0	0	70	0%	0%	0%	0%
Total	**0**	**0**	**0**	**0**	**888**	**0%**	**0%**	**0%**	**0%**

Rail Locomotives

Table ES.6 summarizes the rail TEU throughputs for total, on-dock, and near-dock rail activities. From 2005 to 2006, there was a 30% increase in total on-dock rail and an 18% increase in near-dock rail throughput. The off-dock rail emissions are not included in the Port's emissions inventory, but are shown in this table for completeness.

Table ES.6: Rail TEU Throughput Comparison

	2005	2006	% Change
Total Port Throughput	7,484,615	8,469,980	13%
Total On-Dock Rail	1,891,198	2,466,759	30%
% On-Dock of Total	25.3%	29.1%	
Near-Dock Rail(1)	555,694	653,321	18%
% Near-Dock of Total	7.4%	7.7%	
Off-Dock Rail(2)	868,416	858,960	-1%

(1) Intermodal Container Transfer Facility (ICTF) - Emissions from rail cargo movements to/from this location are included in the Port's emissions inventory.

(2) Rail cargo movements to/from these off-port rail yards are not included in the Port's emissions inventory.

Heavy-duty Vehicles

Table ES.7 shows a decrease in total idling time from 2005 to 2006. This is mainly do to three factors:

- The terminals modernized their gate system with optical character recognition (OCR) and added several queuing lines at the in and out gates which increased the efficiency at the gates and thus reduced idling time.
- Assembly Bill 2650 (known as the Lowenthal Bill), introduced in 2004, required that each marine terminal in California operate in a manner that does not cause the engines on trucks to idle or queue for more than 30 minutes while waiting to enter the gate into the marine terminal.
- Since July 2005, all marine terminals at the Ports of Long Beach and Los Angeles, offer off-peak shifts on nights and weekends. As part of the program, a Traffic Mitigation Fee is required for cargo movement through the ports during peak daytime hours. In 2006, the program diverted approximately 36% of the container moves at the two ports to off-peak hours.

Table ES.7: HDV Idling Time Comparison, hours

EI Year	Total Idling Hours
2006	2,962,463
2005	3,017,252
2001	4,404,847

Summary of 2006 Emission Estimates

The emission results for the Port of Los Angeles 2006 Inventory of Air Emissions are presented in this section. Table ES.8 summarizes the 2006 total port-related emissions in the South Coast Air Basin (SoCAB) by category in tons per year.

Table ES.8: 2006 Port-related Emissions by Category, tpy

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	644	515	546	6,614	5,711	601	279
Harbor craft	52	48	52	1,265	1	345	84
Cargo handling equipment	52	49	51	1,853	2	977	95
Rail locomotives	72	65	72	2,081	131	320	115
Heavy-duty vehicles	404	372	404	8,579	40	2,808	599
Total	**1,224**	**1,048**	**1,126**	**20,392**	**5,886**	**5,052**	**1,170**

DB ID457

The 2006 total port-related tenant greenhouse gas (GHG) emissions in SoCAB are summarized below. The GHG emissions summarized in Table ES.9 are in metric tons per year (2,200 lbs/ton) instead of the short tons per year (2,000 lbs/ton) used throughout the report. The CO_2 equivalent included is derived by multiplying the GHG emissions estimates by the following global warming potential (GWP)[2] values and then adding them together:

- CO_2 – 1
- CH_4 – 21
- N_2O – 310

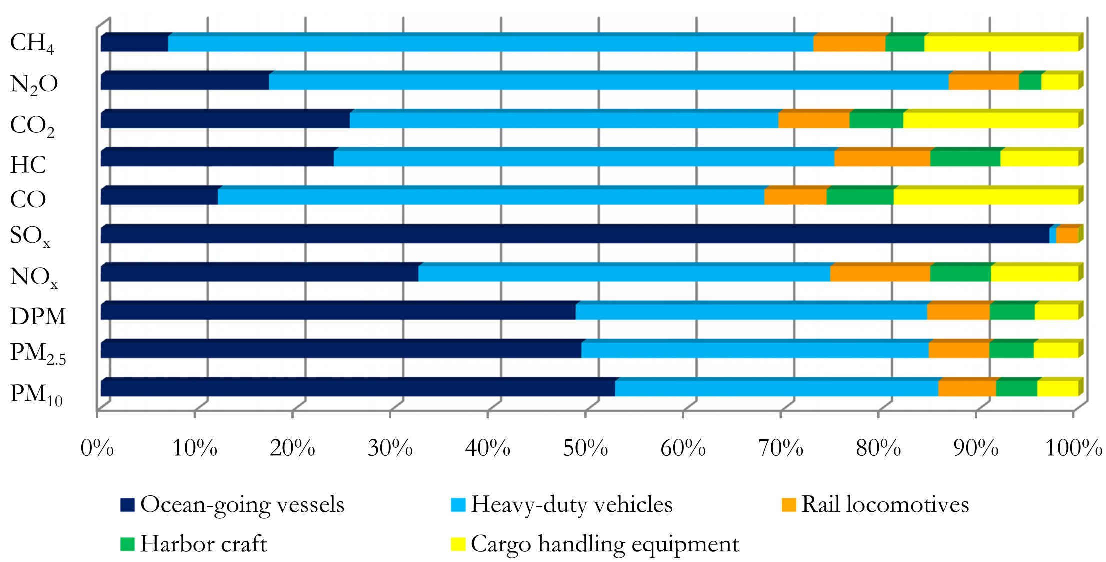
[2] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, 15 April 2008.

Table ES.9: 2006 Port-related GHG Emissions by Category, metric tons per year

Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	375,977	369,491	21	3
Harbor craft	80,659	79,770	3	2
Cargo handling equipment	261,276	259,735	5	6
Rail locomotives	108,394	105,645	9	3
Heavy-duty vehicles	662,276	635,751	84	25
Total	**1,488,581**	**1,450,391**	**121**	**38**

Figure ES.8 shows the distribution of the 2006 total port-related emissions for each pollutant and category. Ocean-going vessels (roughly 50%) and heavy-duty trucks (roughly 35%) have the highest percentage of particulate matter emissions among the port-related sources. Over 95% of the SO_x emissions are attributed to ocean-going vessels. Heavy-duty trucks account for the majority of NO_x emissions (43%), CO emissions (55%), and hydrocarbon emissions (52%).

Figure ES.8: 2006 Port-related Emissions by Category, %



In order to put the Port-related emissions into context, the following figures compare the Port's contributions to the other sources in the South Coast Air Basin. The 2006 SoCAB emissions used for this comparison were interpolated from the 2005 and 2008 emissions listed in the 2007 Air Quality Management Program (AQMP)[3].

[3] SCAQMD, *Final 2007 AQMP Appendix III, Base & Future Year Emissions Inventories*, June 2007.

In the South Coast Air Basin, 11% of diesel particulate matter emissions, 6% of NO_x emissions, and 27% of SO_x emissions are attributed to port-related emissions from Port of Los Angeles. The following three figures show the percentages of DPM, NO_x, and SO_x attributable to various sources within the SoCAB.

Figure ES.9: 2006 DPM Emissions in the South Coast Air Basin, %

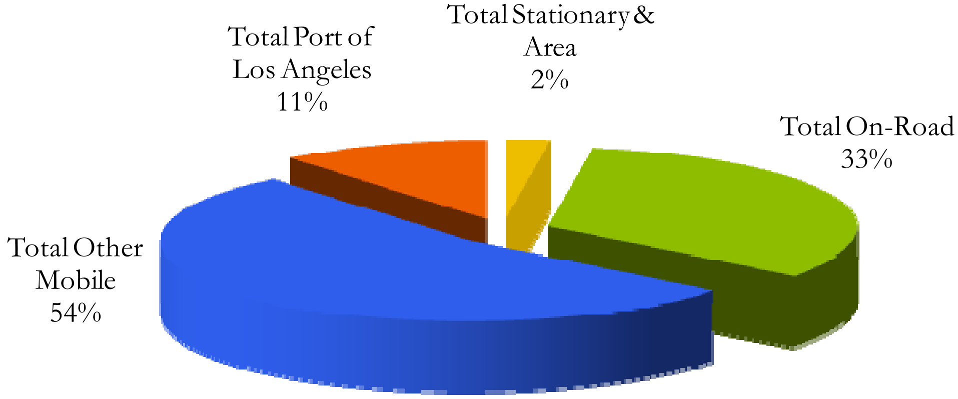


Figure ES.10: 2006 NO_x Emissions in the South Coast Air Basin, %

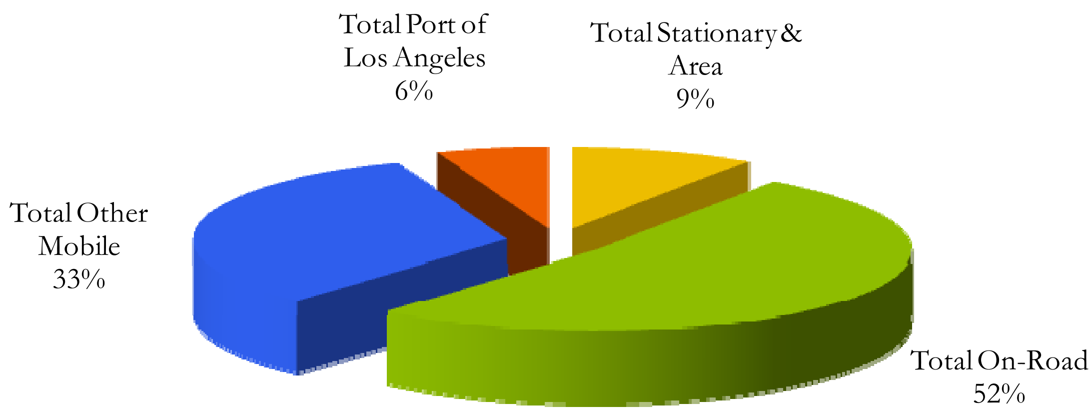


Figure ES.11: 2006 SO_x Emissions in the South Coast Air Basin, %

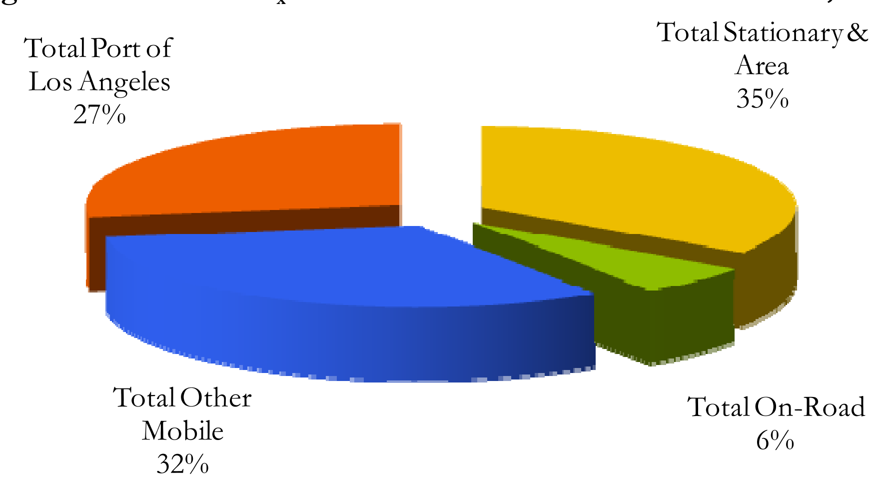


Table ES.10 present the total net change in emissions for all source categories in 2006 as compared to 2005 and 2001.

Table ES.10: Port-wide Emissions Comparison, tpy and % Change

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006 Total	1,224	1,048	1,126	20,392	5,886	5,052	1,170
2005 Total	1,139	973	1,056	18,245	5,767	4,340	1,030
2001 Total	954	809	na	15,543	5,975	3,499	806
2006-2005	**7%**	**8%**	**7%**	**12%**	**2%**	**16%**	**14%**
2006-2001	**28%**	**30%**	**na**	**31%**	**-1%**	**44%**	**45%**

Figure ES.12 presents the percent change in emissions between 2005 and 2006. From 2005 to 2006, emissions increased 7% to 8% for particulate matter, 12% for NO_x, 2% for SO_x, 16% for CO and 14% for HC. SO_x emissions increased only 2% in 2006 mainly due to diesel CHE and harbor craft using CARB diesel with 15 ppm sulfur in 2006.

Figure ES.12: Port-wide Emissions Comparison, 2006-2005, % Change

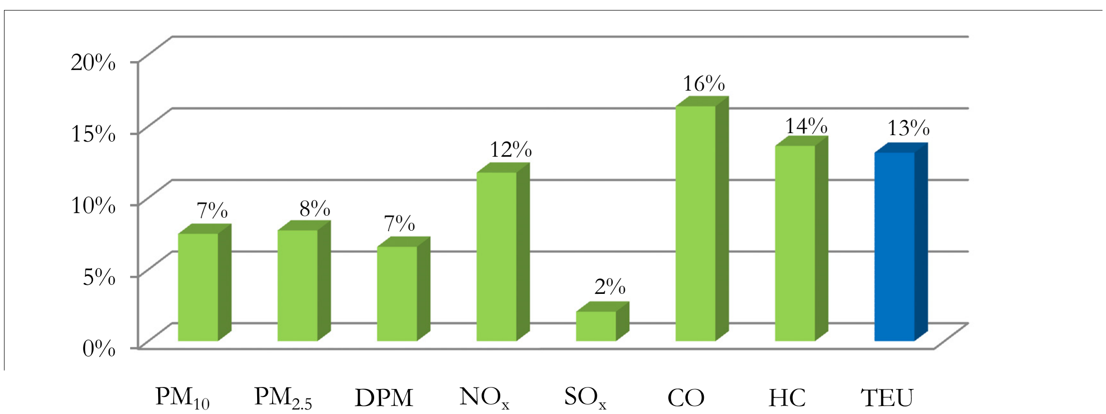


Figure ES.13 presents the percent change in emissions from between 2001 and 2006. From 2001 to 2006, emissions increased from 28% to 30% for PM, 31% for NO_x, 44% for CO, and 45% for HC. SO_x emissions decreased by 1% mainly due to diesel CHE and harbor craft using CARB diesel with 15 ppm sulfur in 2006.

Figure ES.13: Port-wide Emissions Comparison, 2006-2001, % Change

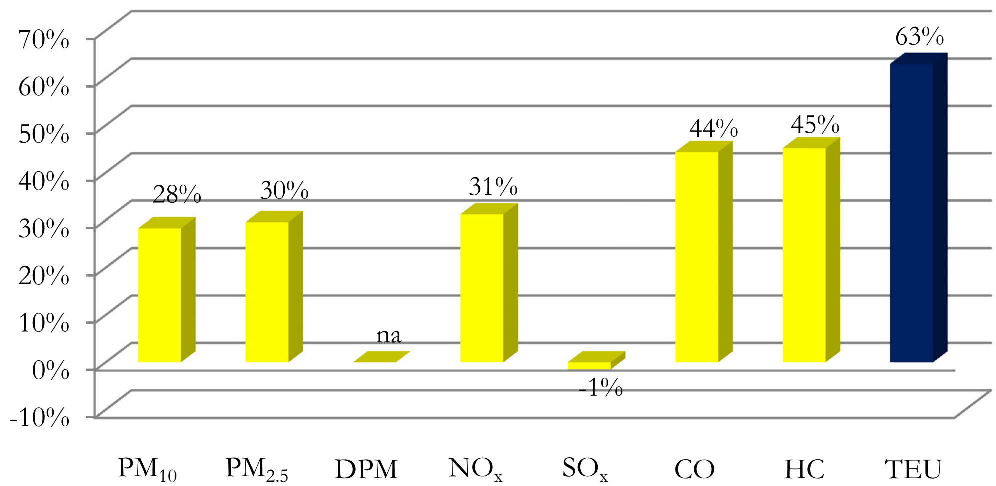


Table ES.11 summaries the annualized emissions efficiencies of all five source categories in tons of pollutant per 10,000 TEU moved. In 2006, the overall port efficiency improved by 20% for NO_x since 2001. CO and HC emission efficiencies have eroded between 2005 and 2006 due to fuel switch and new engine standards that can increase these pollutants.

Table ES.11: Emissions Efficiency Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	1.4	1.2	1.3	24.1	6.9	6.0	1.4
2005	1.5	1.3	1.4	24.4	7.7	5.8	1.4
2001	1.8	1.6	na	30.0	11.5	6.8	1.6
2006-2005	**-5%**	**-5%**	**-6%**	**-1%**	**-10%**	**3%**	**0%**
2006-2001	**-22%**	**-21%**	**na**	**-20%**	**-40%**	**-12%**	**-11%**

Figure ES.14 compares emissions efficiency changes between 2006 and 2005. Except for CO and HC, emissions efficiencies improved in 2006.

Figure ES.14: Emissions Efficiency Comparison, 2006-2005, % Change

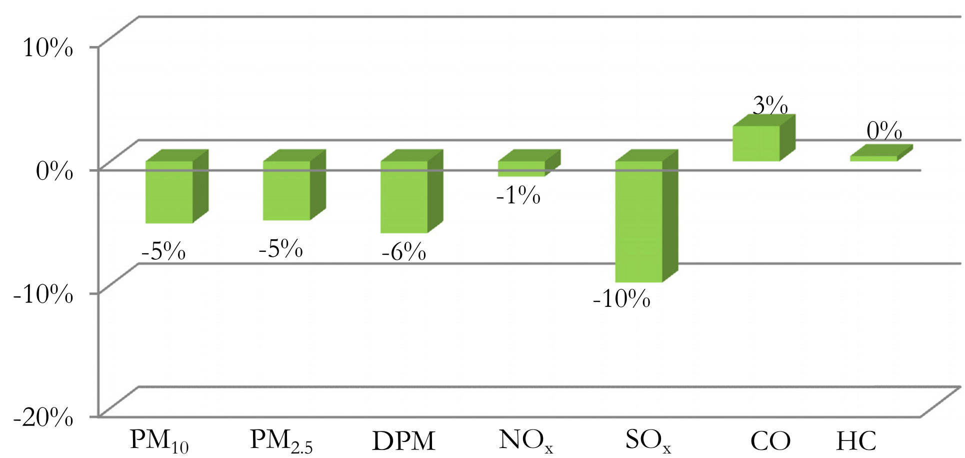
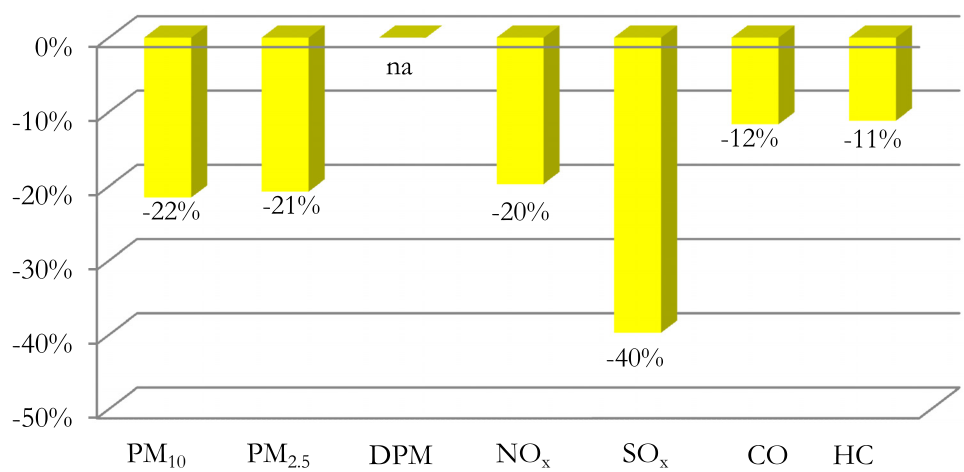


Figure ES.15 compares emissions efficiency changes between 2006 and 2001. Emissions efficiencies have substantially improved from 2001.

Figure ES.15: Emissions Efficiency Comparison, 2006-2001, % Change



Although port-wide emissions of all pollutants were higher in 2006 than in 2005, emissions efficiency continued to improve in 2006 compared to 2005 or 2001.

While the 2007 Emissions Inventory is still under preparation, it is expected that emissions from ocean-going vessels in calendar year 2007 will decrease because operators voluntarily complied with CARB's marine auxiliary engine fuel regulation throughout 2007 despite court appeals. In 2007, emissions from cargo handling equipment and harbor craft may have slight emission reductions due to equipment turnover (newer equipment with cleaner standards replacing older equipment). For rail, the 2007 on-port switching emissions are expected to be lower than in 2006 due to the new switching locomotives that replaced the old locomotives that have been in service at the Port in the past. Heavy-duty truck emissions are not expected to significantly change in 2007, but implementation of the truck program in 2008 and beyond will significantly reduce emissions from this component of Port operations.

SECTION 1 INTRODUCTION

The Port of Los Angeles (the Port) shares San Pedro Bay with the neighboring Port of Long Beach (POLB). Together, the San Pedro Bay Ports comprise a significant regional and national economic engine for California and the United States (U.S.), through which more than 40% of all U.S. containerized trade flows. The San Pedro Bay Ports customs district accounts for approximately $300 billion in annual trade. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will more than double by the year 2020. The economic benefits of the Ports are felt throughout the nation.

The Ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts (and, in particular, air quality impacts) that result from such trade. Therefore, in November 2006, the San Pedro Bay Ports adopted their landmark, joint Clean Air Action Plan (CAAP) designed to reduce the air health risks and emissions associated with port-related operations, while allowing port development to continue.

In order to track CAAP progress, the Port has committed to develop annual inventories starting with the 2005 Inventory of Air Emissions. The detailed annual activity-based inventory, with associated emissions estimates, is a critical and integral component to the success of the CAAP. Activity-based inventories based on detailed data collected on activities that occurred in a specific time period provide the most detailed inventory of air emissions for port-related sources. Activity-based inventories not only provide a greater understanding of the nature and magnitude of emissions, but also help track progress for the many emission reduction strategies that the Port, a landlord port, and its tenants have undertaken.

1.1 Reason for Study

The Port released its first activity-based emissions inventory in 2004, documenting activity levels in the baseline year of 2001[4]. The 2001 baseline emissions inventory evaluated emissions for all Port terminals from five source categories: ocean-going vessels, harbor craft, off-road cargo handling equipment, railroad locomotives and on-road heavy-duty vehicles and evaluated operations at all Port terminals. In 2007, the Port released the 2005 Inventory of Air Emissions[5] which was the first update to the baseline inventory and also the first of the annual inventories to follow.

[4] *Port of Los Angeles 2001 Baseline Air Emissions Inventory,* 2004.
[5] *Port of Los Angeles Inventory of Air Emissions 2005*, September, 2007.

This report represents the emissions inventory which includes emissions estimates based on 2006 activity levels and annual comparisons for 2001, 2005, and 2006 emissions estimates to track progress. The 2006 Inventory also includes for the first time emission estimates for greenhouse gases (GHGs) for port-related maritime mobile sources. The greenhouse gases are included to establish a baseline, to include in the forthcoming port-wide Climate Action Plan, and to track progress of this plan.

1.2 Goods Movement

Goods Movement (GM) has become a key issue associated with both growth of the California economy and the significant challenges to meeting the National Ambient Air Quality Standards (NAAQS) in the Southern California Air Basin (SoCAB). The Business, Transportation and Housing Agency (BTH) and the California Environmental Protection Agency (Cal/EPA) have recently updated their Goods Movement Action Plan (GMP)[6]. The GMP is intended to address GM related issues such as current and future infrastructure needs, impact on environment, adverse impact mitigation measures to protect public health and community concerns, public safety and security issues, and workforce development opportunities regarding goods movement. As stated in the GMP, it is the policy of this Administration to improve and expand California's goods movement industry and infrastructure in a manner which will:

- Generate jobs
- Increase mobility and relieve traffic congestion
- Improve air quality and protect public health
- Enhance public and port safety
- Improve California's quality of life

GMP is focused to address goods movement in California's four major "port-to-border" goods movement corridors:

- Los Angeles-Long Beach/Inland Empire
- Bay Area
- San Diego/Border
- Central Valley

[6] *Goods Movement Action Plan,* 11 January 2007. See: *http://www.arb.ca.gov/gmp/gmp.htm.*

Over decades, these corridors have been major routes for ship to rail, ship to truck, and truck to rail exchanges to move millions of containers per year to their ultimate destinations. As stated in the GMP, "to help develop order of magnitude estimates of how effort should be distributed among the corridors, the agencies compiled a series of indices to compare and contrast key indicators among the corridors. Items included:

- Value by customs district
- Maritime container volume
- Port of Entry tonnage
- Logistics jobs
- Daily vehicle hours of delay
- Mean average annual daily truck volume
- Total emissions per day
- Population

While the relative fractions or contributions of each of these factors vary by corridor, an un-weighted aggregate of the fractions indicate that the Los Angeles/Long Beach-Inland Empire corridor in southern California ranks first by a large margin with about 60 percent of the aggregate shares. The Bay Area, Central Valley, and San Diego corridors represent 19 percent, 13 percent, and 8 percent, respectively. More specific analysis will be necessary to determine the relative allocation of effort among the corridors to achieve simultaneous and continuous improvement."[7]

As a part of the GMP, the California Air Resources Board (CARB) is responsible for developing an emissions reduction plan based on international as well as domestic goods movement related future activities of the four corridors mentioned above. In April of 2006, CARB adopted the *Emissions Reduction Plan for Ports and Goods Movement in California*. The international goods movement category includes emissions from all on-port sources, including

- All ocean-going vessels up to 24 nautical miles,
- All harbor craft up to 24 nautical miles,
- All cargo handling equipment,
- All on-port trucks operation,
- All on-port rail operations,
- International goods movement portion of off-port truck operation, and
- International goods movement portion of off-port rail operation.

[7] CARB, Emissions Reduction Plan for Ports and Goods Movement 20 April 2006. (CARB 2006) See: *http://arb.ca.gov/planning/gmerp/gmerp.htm*.

According to the GMP, the State's five specific goals for addressing the air pollution associated with goods movement are:

A. Reduce total statewide international and domestic goods movement emissions to the greatest extent possible and at least back to 2002 levels by year 2010;

B. Reduce the statewide diesel particulate matter (PM) health risk from international and domestic goods movement 85 percent by year 2020;

C. Reduce NO_x emissions from international goods movement in the South Coast 30 percent from projected year 2015 levels, and 50 percent from projected year 2020 levels based on preliminary targets for attaining federal air quality standards;

D. Apply the emission reduction strategies for ports and goods movement statewide to aid all regions in attaining air quality standards; and

E. Make every feasible effort to reduce localized risk in communities adjacent to goods movement facilities as expeditiously as possible."[8]

This emissions inventory will be utilized by the stakeholders to track emissions from port-related sources and to document reductions from both regulatory and Port led reduction efforts.

1.3 Container Movements

Container terminals and their associated cargo movements are complex intermodal operations that are critical to international trade. Containerized cargo has significantly increased the efficiency and capacity of the transportation system over the prior general cargo/break bulk cargo models (which still exist for non-containerized cargo). Due to the inherent efficiencies of containerized cargo, the types of cargo shipped via containers are increasing yearly. To better understand the operations of the international transportation network associated with ports, this subsection describes overseas container transport, import cargo containers, export cargo containers, and how empty cargo containers are handled.

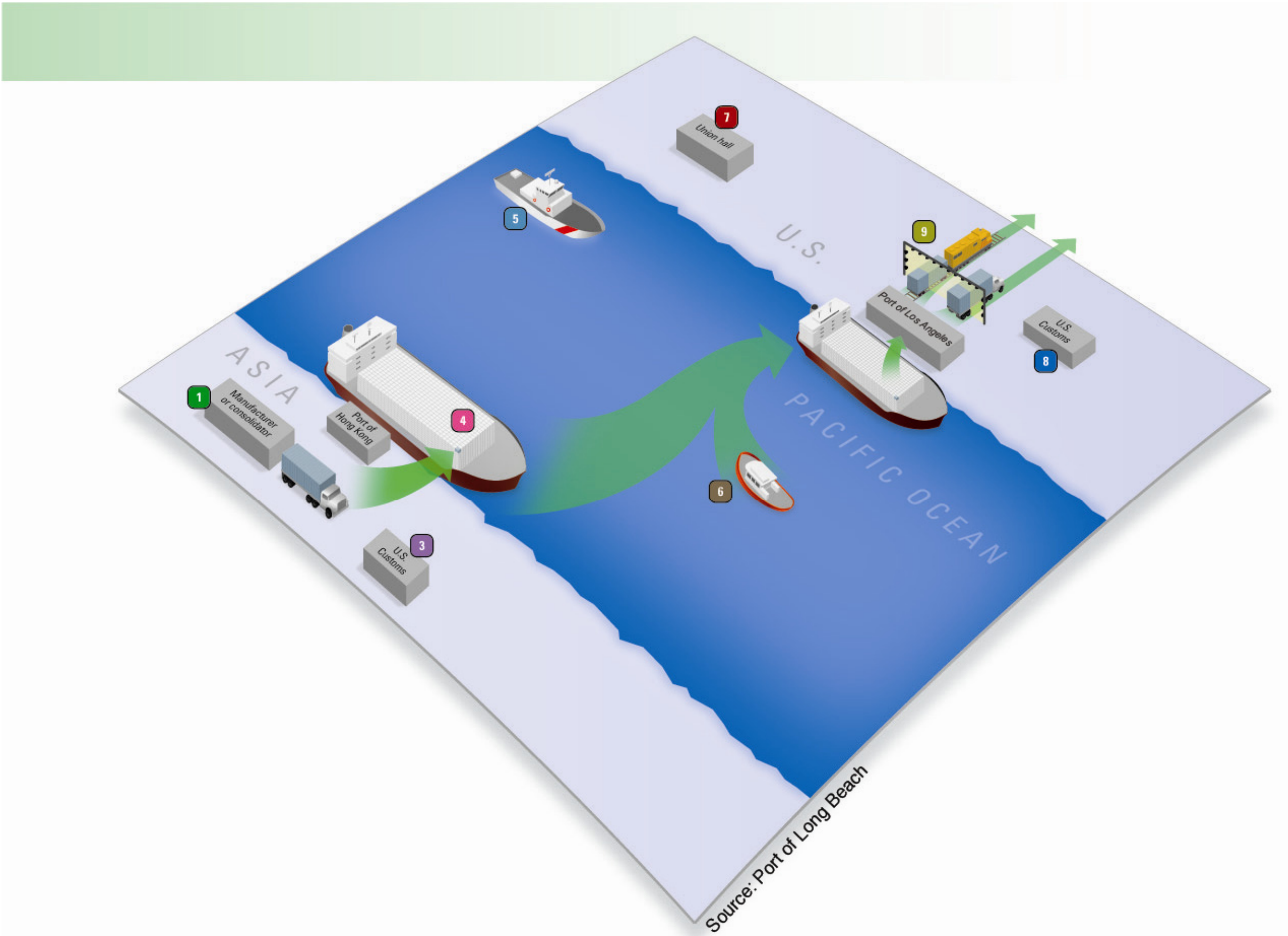
[8] CARB 2006.

1.3.1 Overseas Container Transport

Imported cargo generally starts at an overseas manufacturer, supplier, or consolidation facility, where items are boxed and placed inside metal shipping containers. Containers generally come in two common sizes 20-foot or 1 twenty-foot equivalent (TEU), or 40-foot or two TEUs. Other sizes such as 45-foot and 53-foot are also used. The U.S. buyer may contact an industry professional known as a "freight forwarder," or logistics company, to coordinate landside transportation of the cargo. The container is then transported to a foreign port, assessed for possible security risks, and placed on board containership, which is specifically designed to carry containerized cargo. Containerships calling at the San Pedro Bay ports range from 2,000 to over 8,000 TEUs per ship. The containerships transport the containerized cargo to the Port, where it is unloaded, and forwarded to local or national destinations. Figure 1.1 presents the steps that are associated with overseas cargo movements[9].

[9] Port of Long Beach, Cargo Movement In Focus, 2006.

Figure 1.1: Overseas Container Transport

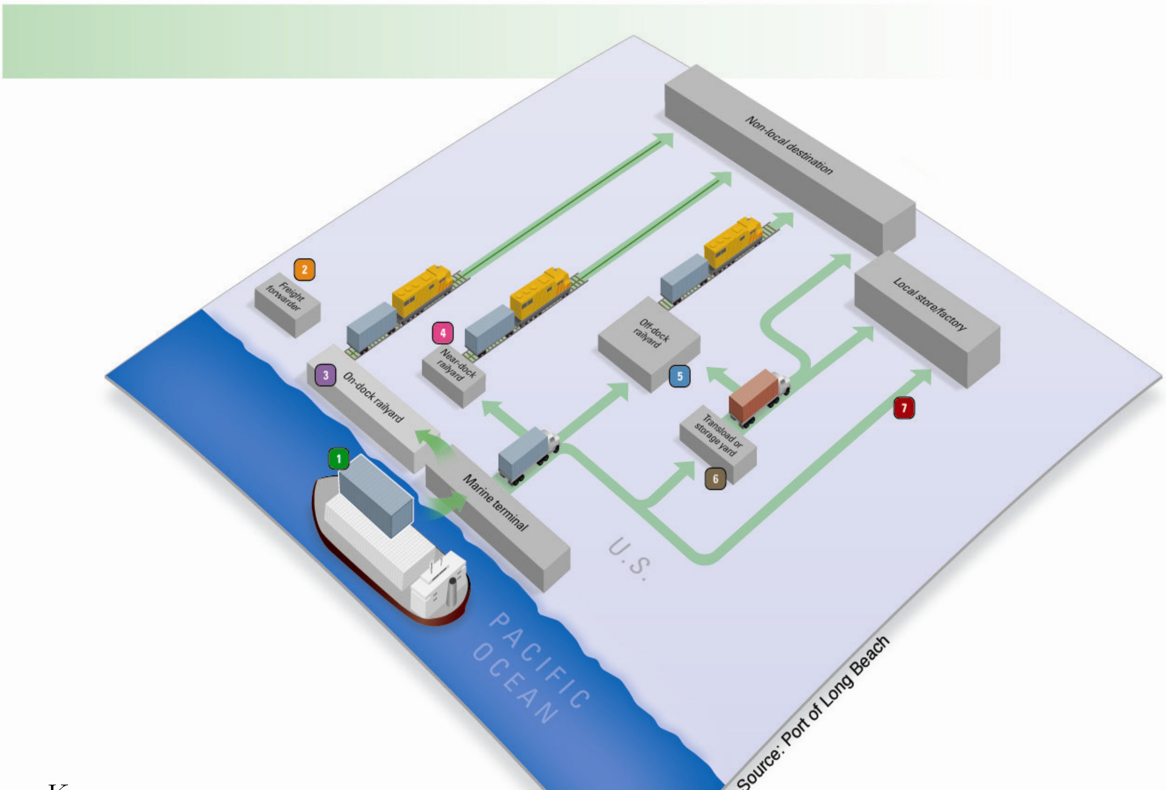


Key:
1) Product ordered
2) Container transported to foreign port (not shown)
3) Security check conducted by U.S. Customs agents based at foreign ports
4) Container loaded onboard containership
5) Coast Guard review conducted for ship, crew, and cargo manifests
6) Containership boarded and docked by a Port pilot
7) Ship unloaded by longshore workers (see Figure 1.2 for details)
8) Security check conducted by U.S. Customs agents
9) Container surveyed for radiation

1.3.2 Import Container Transport

Once the ship arrives at the Port, the imported containers are either transported by train or by truck to their final destination, or to one of several intermediate destinations such as a railyard, warehouse, distribution center, or "transload" facility (a sorting, routing, and short-term storage facility). A container's final destination will determine exactly what path it will take once it leaves the dock. Figure 1.2 presents the steps that are associated with imported container cargo movements[10].

Figure 1.2: Import Container Transport



Key:

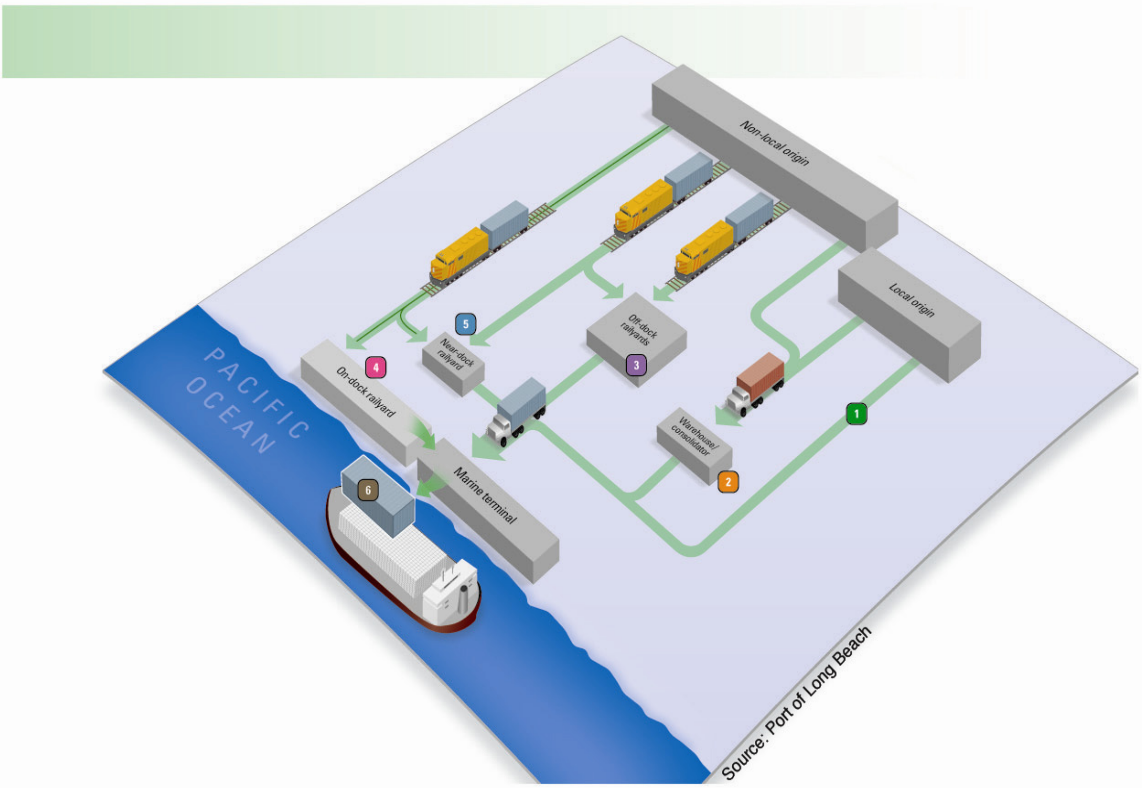
1) The marine terminal operator will arrange for unionized longshore workers to unload the ship. Containers are placed on trucks, rail, or terminal cargo handling equipment for storage on terminal.
2) Trucking company or train operator contacted by freight forwarder or logistics provider to move the container out of the terminal.
3) Cargo placed directly on rail using "on-dock" rail (as available).
4) Near-dock rail yards are used for terminals without on-dock rail or if additional rail capacity is needed. Trucks are used to "dray" containers from terminals to railyard.
5) Off-dock railyards are used to coordinate rail deliveries to national destinations. Containers are delivered by truck, then sorted and grouped by final destination. These railyards handle Port cargo as well as domestic cargo from other sources.
6) Shipping containers are often moved initially to a "transload" facility where cargo is unloaded, sorted, and repackaged into larger-sized truck trailers. The cargo is then delivered from the facility to regional distribution centers, local stores, or off-dock railyards.

[10] Port of Long Beach, Cargo Movement In Focus, 2006.

1.3.3 Export Container Transport

Export container cargo is similar to import containers; however, the flow is in the opposite direction. As with imported cargo, exported cargo may require multiple intermediate stops between its producer/manufacturer and the Port. Figure 1.3 presents the steps that are associated with exported container cargo movements[11].

Figure 1.3: Export Container Transport



Key:

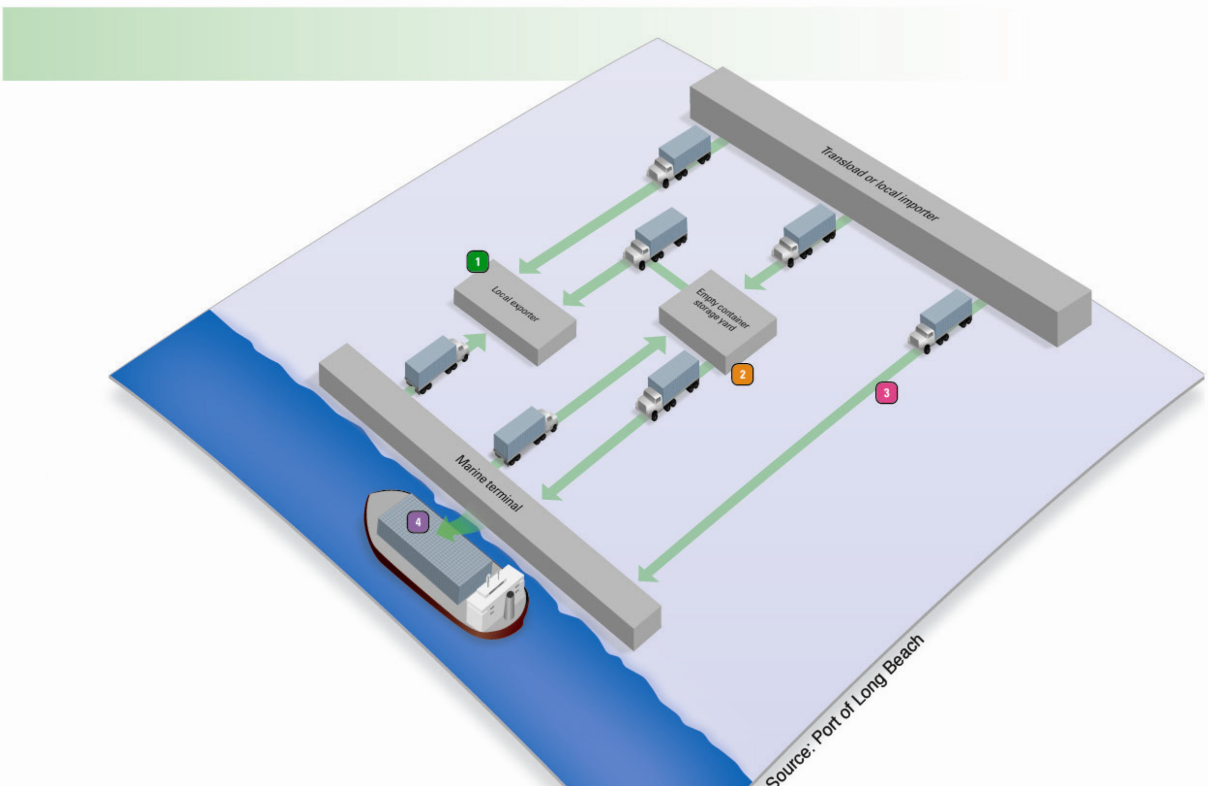
1) Local origin cargo delivered directly to the marine terminal from the producer, manufacturer, or exporting company.
2) Local or non-local origin cargo delivered to a warehouse/consolidator where the cargo may be temporarily stored with other cargo bound for export. Cargo may also be transferred from domestic truck trailers to marine shipping containers.
3) Some non-local origin cargo shipped by rail and delivered to off-dock railyards where the cargo is placed onto truck for final delivery to marine terminals.
4) Some non-local origin cargo shipped by rail directly to the marine terminal where it is loaded onto a ship or stored temporarily for the appropriate ship to arrive.
5) Some non-local origin cargo shipped by rail to near-dock railyards, where the cargo is picked up by truck for a short trip to the marine terminal.
6) Vessel loading of export cargo conducted after the ship has been unloaded of its import cargo.

[11] Port of Long Beach, Cargo Movement In Focus, 2006.

1.3.4 Empty Containers

Since the U.S. imports more goods than it exports, many empties are sent overseas to be reused or are used domestically for other purposes. Typically, about a third of the containers loaded onto a ship at the Port will be filled with cargo, while about two-thirds will be empty. The figure below diagrams the movement of empty containers after the delivery of full, imported containers to local businesses and/or transload facilities. Intermodal containers returning to the local area empty are not depicted; they would enter the system at the marine terminal or empty container storage yard.[12]

Figure 1.4: Empty Container Transport



Key

1) Empty container delivered to a local exporter to fill. Direct delivery of containers between importers and exporters is encouraged to reduce the number of truck trips a container takes in the South Coast.
2) Empty container delivered to container storage yard from a transload facility or local importer. From the storage yard, containers are moved by truck to the marine terminal for export or to a local exporter to be filled with cargo.
3) Empty container delivered directly from a transload facility or local importer to the marine terminal for export.
4) Empty container loaded onto a containership to be exported and reused overseas.

[12] Port of Long Beach, Cargo Movement In Focus, 2006.

1.4 Scope of Study

The scope of the study is described in terms of the year of activity used as the basis of emissions estimates, the pollutants quantified, the included and excluded source categories and the geographical extent. The purpose of the 2006 Inventory of Air Emissions (2006 EI) is to develop emission estimates based on activities that occurred in calendar year 2006.

1.4.1 Pollutants

Exhaust emissions of the following pollutants have been estimated:

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Total hydrocarbon (HC)
- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrogen oxide (N_2O)

Particulate matter

Particulate matter refers to tiny, discrete solid or aerosol particles in the air. Dust, dirt, soot, and smoke are considered particulate matter. Vehicle exhaust (cars, trucks, buses, among others) are the predominant source of fine particles. Fine particles are a concern because their very tiny size allows them to travel more deeply into lungs, increasing the potential for health risks.

Diesel particulate matter

Diesel particulate matter is a significant component of PM. Diesel exhaust also includes more than 40 substances that are listed as hazardous pollutants. DPM is considered a surrogate for the effects of both the PM and gaseous component of diesel exhaust. Sources of diesel emissions include diesel-powered trucks, buses, cars (on-road sources); and diesel-powered marine vessels, construction equipment and trains (off-road sources). DPM has been shown to contribute up to 80% of the carcinogenic health risk related to the portion of outdoor pollutants classified as "toxics."

Oxides of nitrogen

Oxides of nitrogen is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Most oxides of nitrogen are colorless and odorless. NO_x forms when fuel is burned at high temperatures, as in a combustion process. Oxides of nitrogen are precursors for ground level ozone formation. Ozone is formed by a reaction involving hydrocarbon and nitrogen oxides in the presence of sunlight. The primary manmade sources of NO_x are motor vehicles, electric utilities and other sources that burn fuels. Exposure to NO_x has been connected to a range of respiratory diseases and infections. Exposure to ozone can cause difficulty in breathing, lung damage and reduced cardiovascular functions.

Total hydrocarbon

Hydrocarbons are organic compounds composed of carbon and hydrogen. Most hydrocarbons serve as fuels for the various sources found at Ports. Some examples of hydrocarbon fuels are the components of gasoline, diesel, and natural gas. Hydrocarbon emissions are formed due to the incomplete fuel combustion and fuel evaporation. A number of hydrocarbons are considered toxics which can cause cancer or other health problems. Hydrocarbons are precursor to ground level ozone formation which leads to smog in the atmosphere.

Carbon monoxide

Carbon monoxide is a colorless, odorless, toxic gas commonly formed when carbon-containing fuel is not burned completely. Most vehicles are the predominant source of carbon monoxide. CO combines with hemoglobin in red blood cells and decreases the oxygen-carrying capacity of the blood. CO weakens hear contractions, reducing the amount of blood pumped through the body.

Greenhouse gases

Greenhouse gases contribute towards global warming. Global warming is a climate regulating phenomenon which occurs when certain gases in the atmosphere (naturally occurring or due to human activities) trap infrared radiation resulting into increase in global temperature. The first far reaching effort to reduce global warming was established in the form of Kyoto Protocol. Kyoto Protocol is a protocol to the United Nations Framework Connection on Climate Change (UNICCC) with the goal of reducing six green house gases (GHG). The six GHGs also referred to as the "six Kyoto gases" are: Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Sulfur Hexafluoride (SF_6), Hydroflurocarbons (HFCs), and Perflurocarbon (PFCs). Guidance to develop national GHG inventories is provided by Intergovernmental Panel on Climate Change (IPCC), the authoritative scientific body on climate change.

CO_2, CH_4, N_2O are emitted naturally or through human activities such as combustion of fossil fuels and deforestation. SF_6, HFCs and PFCs are synthetically produced for industrial purposes. This emissions inventory report includes estimates for CO_2, CH_4 and N_2O due to cargo handling equipment, harbor crafts, on-road heavy-duty trucks, rail locomotives and vessel operations at and near the port.

CO_2, CH_4 and N_2O have been included and estimated in this report based on emission factors presented in the corresponding source category sections and/or appendices. Each GHG differs in its ability to absorb heat in the atmosphere. Sometimes, estimates of greenhouse gas emissions are presented in units of carbon equivalents which weight each gas by its global warming potential (GWP) value. To normalize these values in a single greenhouse gas value, the GHG emissions estimates can be multiplied by the following values and then added together resulting in a single greenhouse gas value (CO_2 equivalent). The values are as follows[13]:

- CO_2 – 1
- CH_4 – 21
- N_2O - 310

1.4.2 Emission Sources

The scope includes the following five source categories:

- Ocean-going vessels
- Harbor crafts
- Cargo handling equipment
- Railroad locomotives
- Heavy-duty vehicles

Examples of the five sources include the containerships, tankers, and cruise ships that call the Port; the assist tugs and tugboats that assist vessels in the harbor; the cranes and forklifts that may move cargo within the terminals; the railroad locomotives that haul the cargo; and the on-road diesel trucks that visit the terminals. This inventory does not include stationary sources, as these are included in stationary source permitting programs administered by the South Coast Air Quality Management District.

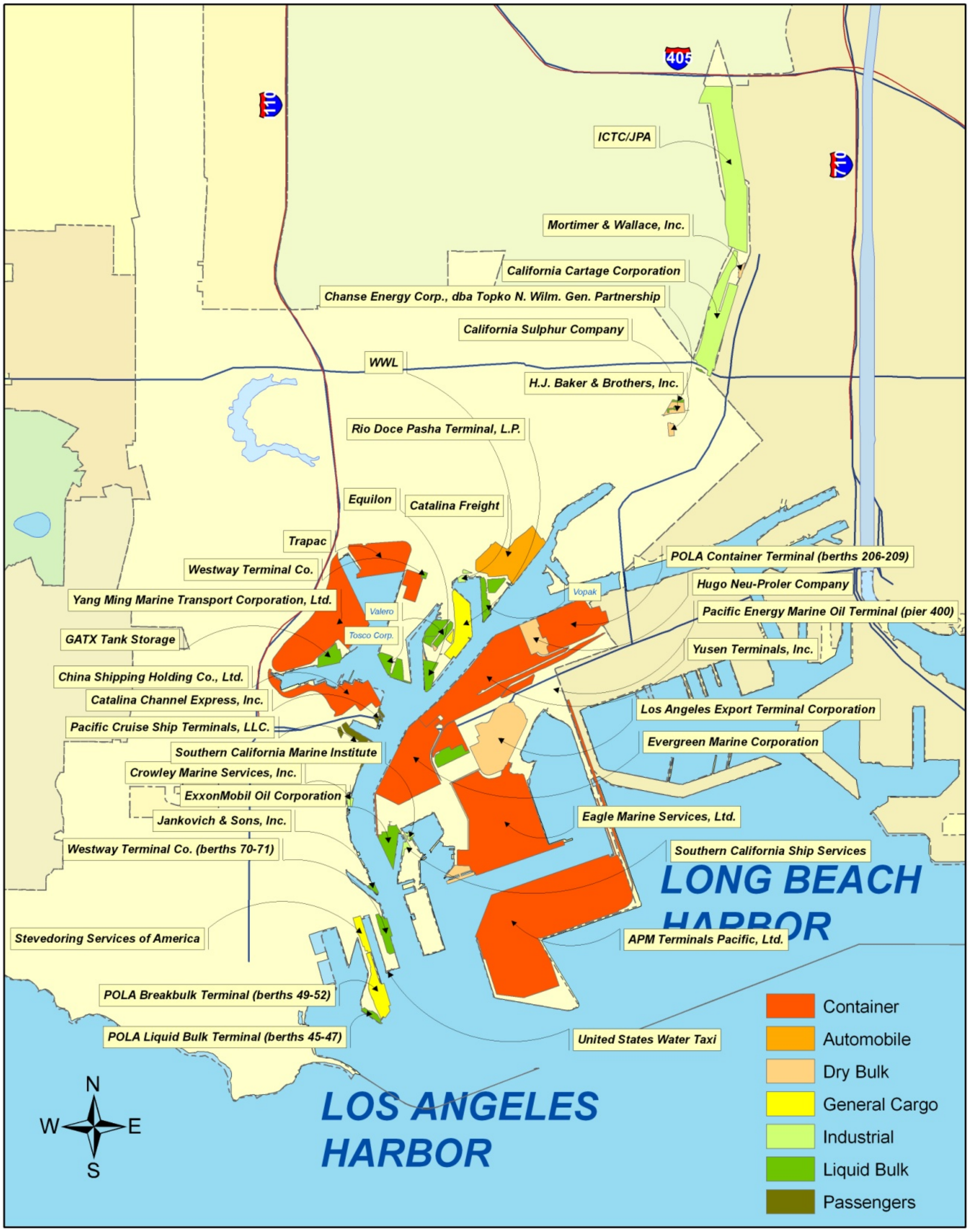
1.4.3 Geographical Extent

The 2006 EI includes tenant source category emissions that occur on Port-owned land within the Port boundary/district. An overview of the geographical extent is provided below for each of the source categories.

Figure 1.5 shows the land area of active Port terminals in 2006. The geographical scope for cargo handling equipment is the terminals and facilities on which they operate.

[13] *Inventory of Greenhouse Gas and Sinks: 1990-2006,* Annex 3; released by USEPA in April 2008.

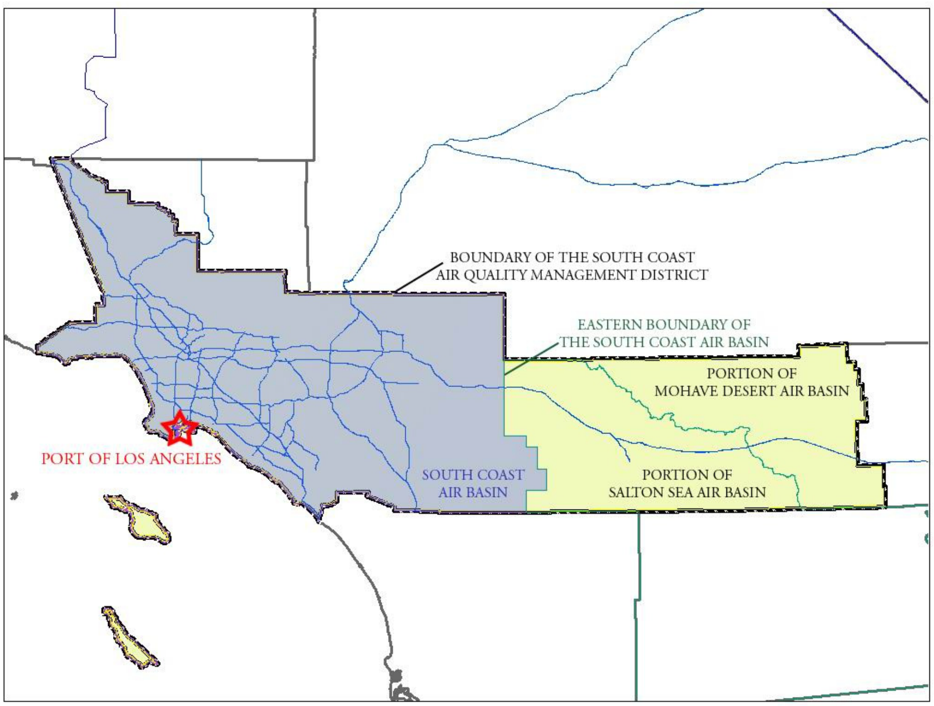
Figure 1.5: Port Boundary Area of Study



Emissions from switching and line haul railroad locomotives were estimated for on-dock rail yards, off-dock rail yards, intermodal yards, and the rail lines linking these facilities. For heavy-duty trucks related to the hauling of cargo, emissions from queuing at terminal entry gates, for travel and idling within the terminals, and for queuing at the terminal exit gates have been included. In addition to emissions that occur inside the Port facilities, emissions from locomotives and on-road trucks transporting Port cargo have been estimated for Port-related activity that occurs within the SoCAB boundaries. Emissions are estimated up to first point of rest within the SoCAB or up to the basin boundary.

Figure 1.6 shows the SoCAB boundary in grayish blue and the location of the Port. Since both the Port and the Port of Long Beach are interconnected with intermodal transportation linkages, every effort was made to only account for freight movements originating from or having a destination at the Port.

Figure 1.6: South Coast Air Basin Boundary



For marine vessels, OGVs and commercial harbor craft, the geographical extent of the EI is based on the same boundary that was used in previous marine vessel inventories developed for the SCAQMD and in the 2001 Baseline EI and 2005 Inventory. The northern and southern boundary is set by the South Coast county boundary which is continued over the water to the California water boundary to the west. The portion of the study area outside the Port's breakwater is four-sided, and geographically defined by the following coordinates:

- NW corner: 34°02'42.4" north (N) latitude by 118°56'41.2" west (W) longitude
- SW corner: 33°00'00.0" N latitude by 119°30'00.0" W longitude
- SE corner: 32°30'00.0" N latitude by 118°30'00.0" W longitude
- NE corner: 33°23'12.7" N latitude by 117°35'46.4" W longitude

Figure 1.7 shows the geographical extent of the study area for marine vessels (dark blue), the vessel traffic separation zone, and the main arrival and departure vessel flow for the northern and southern separation zones. The precautionary zone (PZ) will be further discussed in Section 3.2.

Figure 1.7: OGV Inventory Geographical Extent

1.5 General Emissions Estimate Methodology

The basic approach to developing an activity-based EI is through interviews and conversations with Port tenants, who own, operate and maintain equipment and own or charter vessels. Port tenants and shipping lines play an essential role in the development of an EI by providing the most accurate activity and operational information available. The activity and operational data collected is input into a database for storage. Emissions estimates are developed for each of the various source categories in a manner consistent with the latest estimating methodologies agreed upon by the Port and the participating regulatory agencies. The information gathered, analyzed, and presented in this EI continues to improve the understanding of the nature and magnitude of Port-related emission sources. Specific data collection and analytical approaches unique to each of the five source categories are summarized below along with a summary of the key updates.

In general, emissions estimates are quantified by multiplying units of activity (estimated using the activity and operational information described above) by an emission factor. Emission factors are standard values that express the mass of emissions in terms of a unit of activity. For example, some emission factors are expressed in terms of pounds of emissions (of a particular pollutant) per horsepower-hour. Horsepower-hours are the product of in-use horsepower times hours of operation. Emissions estimates can be calculated, then, by multiplying hours of operation per year (activity data) by in-use horsepower (operational information) by an emission factor (such as pounds per horsepower-hour) to provide a result of emissions in pounds of emissions per year. The actual calculations are often more complex than this example, because such parameters as in-use horsepower must be estimated as part of the calculations. In addition, the emission factors often vary depending on equipment-specific factors such as the model year and the accumulated hours of use, and fuel correction factors may need to be applied.

1.5.1 Ocean-Going Vessels

The basic methodology for estimating emissions from the various types of ocean-going vessels that call on the Port use local activity-based data to the greatest extent possible. This includes call records from the Marine Exchange of Southern California, which tracks and records the movement of all OGVs entering or departing San Pedro Bay. In addition, the Port has undertaken a Vessel Boarding Program (VBP) that focuses on gathering specific vessel characteristics and operational data from ships visiting the Port, to gain the most complete and detailed understanding of how the different types of OGVs arrive, depart, and transit San Pedro Bay and the harbor, as well as how they operate while at dock ("hotelling").

Additional ship-specific OGV data was obtained from Lloyd's Register of Ships (Lloyd's), a marine vessel data system that can provide vessel specific data for virtually every OGV in the world fleet. Lloyd's data was also used to develop profiles for parameters that are not known for every ship. The general vessel classifications include the following.

- Automobile carriers
- Bulk carriers
- Containerships
- Cruise ships
- General cargo ships
- Ocean-going tugboats
- Refrigerated vessels
- Roll-on roll-off ships
- Tankers

Emission factors were developed for different types of OGV engines by review of the literature and discussion/coordination with the regulatory agencies. Emissions were calculated by multiplying the emission factors by vessel-specific activity parameters such as in-use horsepower and hours of operation on a per engine basis. Numerous calculations were made for each port visit to adequately characterize the complicated activities of OGVs; (e.g., separate calculations were made for vessel transit, maneuvering, and hotelling activities for propulsion, auxiliary engines and auxiliary boilers). The results of all the calculations were summed to produce the overall emission estimates.

The emission estimates presented in the 2006 EI include the effects of the following emission reduction measures in place in 2006.

- The vessel speed reduction (VSR) program requiring 12 knots during transiting outside the harbor
- The use of alternative maritime power (AMP) at China Shipping's Berth 100
- Switching to a lower sulfur fuel near the coast or at berth on a voluntary basis by various shipping lines
- Newer vessels calling at the Port with cleaner and more fuel-efficient engines that meet or exceed standards set by the IMO
- New technologies added to vessels that reduce emissions such as fuel slide valves

1.5.2 Harbor Craft

Harbor craft operators whose vessels work within Port waters were interviewed to update the inventory of harbor craft. The harbor craft are separated into the following categories:

- Assist tugboat
- Towboats and push boats
- Ferries
- Excursion vessels
- Crew boats
- Work boats
- Government vessels
- Commercial fishing vessels

CARB emission factors were used in order to be consistent with CARB's latest methodology. Emissions were calculated by multiplying the emission factors by the appropriate measure of activity (such as annual hours of operation) on an engine by engine basis for each vessel included in the inventory.

1.5.3 Cargo Handling Equipment

Cargo handling equipment (CHE) consists of various types of equipment and vehicles that fall within the off-road designation and are used to move cargo within terminals and other off-road areas. The emission estimation methodology for this category followed CARB's CHE emissions estimation methodology which follows CARB's OFFROAD[14] model methodology plus additional modifications[15] made by CARB's staff for CHE. Equipment operators and owners were interviewed and asked to supply updated information such as activity hours, size and model year of all of their CHE used at the port.

1.5.4 Railroad Locomotives

Railroad operations are typically described in terms of two different types of operations, line haul and switching. Line haul operations involve long-distance transportation of a whole (unit) train between the Port and points across the country, whereas switching is the local movement of individual railcars or train segments to prepare them for line haul or to distribute them to destination terminals upon their arrival in port. Different companies conduct switching (Pacific Harbor Line) and line haul (Burlington Northern Santa Fe, Union Pacific) operations within the port. The line haul companies also operate switching locomotives at off-port rail yards.

[14] CARB, OFFROAD, 2003. See *http://www.arb.ca.gov/msei/off-road/off-road.htm.*
[15] CARB, Appendix B, Emissions Inventory Methodology. See *http://www.arb.ca.gov/react/cargo2005/cargo2005.htm.*

The on-port switching company operates a dedicated fleet of locomotives, while the line haul locomotives that service the Port are part of a nation-wide fleet, meaning that individual locomotives are not assigned specifically to port or South Coast Air basin service. Therefore, the types of information available for these two types of activity differs for the on-port switching locomotives, information on each locomotive and its activity (e.g., fuel use and throttle notch setting) can be used to estimate emissions; whereas for the line haul locomotives the information is more general (e.g., in terms of fuel use per ton of cargo and total tons of cargo carried).

The EPA has published emissions information for switching and line haul locomotive operations in both throttle notch and fuel consumption modes, so this information was used to estimate emissions and to cross-check between the estimating methods.

1.5.5 Heavy-Duty Vehicles

Heavy-duty on-road vehicles transport cargo between the port and off-port locations such as rail yards, warehouses, and distribution centers. To develop emission estimates, truck activities have been evaluated as having three components:

- On-terminal operations, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.
- Off-terminal Port operations, consisting of travel on public roads within the Port jurisdictional boundaries.
- On-road operations outside the Port boundaries but within the SoCAB. This includes travel within the boundaries of the adjacent Port of Long Beach, because the routes many trucks take run through both ports on the way to and from Port terminals.

For estimating on-road HDV emissions, activity information was developed by a traffic consultant using the trip generation and travel demand models that were used in the 2001 Baseline EI and in previous Port traffic studies.[16] For estimating on-terminal HDV emissions, terminal operators were interviewed with regards to on-terminal traffic patterns, including time spent waiting at the entry gate, time and distance on terminal while dropping off and/or picking up cargo, and time spent waiting at exit gates.

Emissions from HDVs were estimated by multiplying the speed-specific emission factor derived from CARB's emission factor model EMFAC 2007 by the distance parameters established for the terminals (on-terminal emissions) or road segments (on-road emissions). On-terminal idling emissions were estimated by multiplying the EMFAC idling emission factor by estimated idling times.

[16] Meyer, Mohaddes Associates, Inc., Ports of Long Beach/Los Angeles Transportation Study, June 2001; and Meyer, Moaddes Associates, Inc., Port of Los Angeles Baseline Transportation Study, April 2004.

1.6 Methodology Comparison

In order to make a meaningful comparison from year to year activities used in the annual inventories, the same methodology must be used for estimating emissions. The present calendar year's emissions are compared to past calendar year activity using the same methodology. For each specific source category, if there was a methodological change in 2006, then the 2005 and 2001 emissions were recalculated using 2005 and 2001 activity with the new 2006 methodology to provide a valid basis for comparison. If there was no change in methodology, then the emissions included in the 2005 Port Inventory of Air Emissions (2005 Port Inventory) were used for the comparison.

Methodological differences for 2006 vs. 2005:

OGV

- The methodology used in 2006 to estimate OGV emissions is the same as what was used in 2005 Inventory of Air Emissions (2005 Port Inventory)

Harbor Craft

- Emission factors changed (used EPA's EF in 2001 and 2005 Port Inventory, used CARB's EF in 2006)
- In 2005 Port Inventory, deterioration rates were not included in the calculations, but 2006 methodology includes deterioration rates
- The load factor for excursion vessels and ferries changed from 0.76 in 2005 to 0.42 in 2006

CHE

- The load factor for yard tractors changed from 0.65 in 2005 to 0.39 in 2006 based on a 2006 in-field study conducted by ports in consultation with CARB's staff

Rail

- The methodology used in 2006 to estimate rail emissions is the same as what was used in 2005 Port Inventory

HDV

- The methodology used in 2006 to estimate HDV emissions is the same as what was used in 2005 Port Inventory

Methodological differences for 2006 vs. 2001:

OGV

- The methodology used in 2006 to estimate OGV emissions is the same as what was used in 2005 Port Inventory therefore the adjusted 2001 OGV emissions used
- The adjusted 2001 OGV emissions found in 2005 Port Inventory were used for comparison

Harbor Craft

- Emission factors changed (used EPA's EF in 2005 and 2001 Port Inventory, used CARB's EF in 2006)
- In 2005 and 2001 Port Inventories, deterioration rates were not included in the calculations, but 2006 methodology includes deterioration rates

CHE

- The load factor for yard tractors changed from 0.57 in 2001 to 0.39 in 2006 based on a 2006 in-field study conducted by ports in consultation with CARB's staff

Rail

- The methodology used in 2006 to estimate rail emissions is the same as what was used in 2005 Port Inventory
- The adjusted 2001 rail emissions found in 2005 Port Inventory were used for comparison

HDV

- The methodology used in 2006 to estimate HDV emissions is the same as what was used in 2005 Port Inventory
- The adjusted 2001 HDV emissions found in 2005 Port Inventory were used for comparison

1.7 Report Organization

This report (Volume 1) presents the 2006 emissions and the methodologies used for each category in each of the following sections:

- Section 2 discusses regulatory and port measures
- Section 3 discusses ocean-going vessels
- Section 4 discusses harbor craft
- Section 5 discusses cargo handling equipment
- Section 6 discusses locomotives
- Section 7 discusses heavy-duty vehicles
- Section 8 discusses findings and results
- Section 9 compares 2006 emissions to adjusted 2005 and 2001 emissions

A separate volume (Volume 2) includes the following appendices:

- Appendix A ocean-going vessel data
- Appendix B harbor craft data and emission factors
- Appendix C cargo handling equipment data and emission factors
- Appendix D comparison excerpt from 2005 report

SECTION 2 REGULATORY AND SAN PEDRO BAY PORTS CLEAN AIR ACTION PLAN (CAAP) MEASURES

This section discusses the regulatory and port measures which address port-related activity. Almost all port-related emissions come from five diesel-fueled source categories: ocean-going vessels (OGVs), on-road heavy-duty vehicles (HDVs), cargo handling equipment (CHE), harbor craft and rail locomotives (RL). The responsibility for the emissions control of the majority of these sources falls under the jurisdiction of local (South Coast Air Quality Management District, SCAQMD), state (CARB) or federal (U.S. Environmental Protection Agency, EPA) agencies. The Ports of Long Beach and Los Angeles adopted the landmark San Pedro Bay Ports Clean Air Action Plan (CAAP) in November 2006 to curb port-related air pollution from trucks, ships, locomotives and other equipment by at least 45 percent in five years. A model for seaports around the world, the CAAP is the boldest air quality initiative by any seaport, consisting of wide-reaching measures to significantly reduce air emissions and health risks while allowing for the development of much-needed port efficiency projects. Below is a list of recently adopted and proposed regulatory measures in addition to the CAAP measures that will reduce emissions from the ports over the next five years and beyond.

2.1 Ocean-Going Vessels

EPA's Final Regulation – Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters Per Cylinder (EPA 2008)[17]

This regulation, adopted 14 March 2008, applies to all remanufactured and new-built auxiliary engines used on U.S. flagged ocean-going vessels. Engines covered are category 1 and 2 engines with greater than 800 horsepower (hp) rating less than 30 liter per cylinder (l/cyl) displacement. This is a three part regulation as follows:

1. Remanufactured engines – establishes more stringent emissions standards on existing engines when they are remanufactured. Depending upon the availability, these standards are applicable as early as 2008.
2. Tier 3 – more stringent emissions standards for new engines with phase-in starting in 2009. Tier 3 standards target PM and NO_x emissions based on currently available on-road and Tier 4 non-road technologies.
3. Tier 4 – most stringent emissions standards for new engines with phase-in starting in 2014. Tier 4 standards are based on highly efficient after-treatment catalyst technologies along with the use of ultra low sulfur fuel.

[17] See: http://*www.epa.gov/otaq/regs/nonroad/420f08004.htm#exhaust.* (EPA 2008).

Emission Standards for Marine Diesel Engines Above 30 l/cyl (Category 3 Engines)
EPA is pursuing two parallel, related actions for emission standards for Category 3 marine diesel engines. On one track, EPA is a member of the U.S. delegation that is participating in negotiations at the International Maritime Organization (IMO) with regard to amendments to MARPOL Annex VI[18] that consider additional NO_x limits for new engines; additional sulfur content limits for marine fuel; methods to reduce PM emissions; potential NO_x and PM limits for existing engines; and potential volatile organic compounds (VOCs) limits for tankers. On second track, EPA is planning to develop new national standards for Category 3 marine diesel engines over the next few years, taking into consideration the state of technology that may permit emission reductions and the status of international action for more stringent standards.

CAAP Measure- SPBP-OGV5; OGV Main &Auxiliary Engine Emissions Improvements
This measure provides for main and auxiliary engine emissions reductions that are validated through the Technology Advancement Program. The goal of this measure is to reduce main and auxiliary engine DPM, NO_x, and SO_x emissions by 90%. The first engine emissions reduction technology identified for this measure is the use of MAN B&W slide valves for main engines. The implementation mechanism for this measure is the terminal lease renewal.

CARB's Regulation to Reduce Emissions from Diesel Auxiliary Engines on Ocean going vessels While at Berth at a California Port[19]
On 6 December 2007, CARB's board approved a regulation that requires operators of containerships, passenger ships and refrigerated cargo ships to shut off their diesel auxiliary-powered engines for most of the time during their stay at a California port. It is anticipated that the OGV operators while at berth will either utilize electrical power from the shore or clean emissions control technologies that will reduce PM and NO_x emissions by 50% in 2014 and 80% in 2020. The phase-in requirement starts on 1 January 2010.

Emissions Standard for Marine Propulsion Engines
The IMO adopted limits for NO_x in MARPOL Annex VI in 1997. These NO_x limits apply to marine engines over 130 kilowatts (kW) installed on vessels built on or after 2000. The NO_x standards are from 17.0 grams per kilowatt hour (g/kW-hr) (for < 130 revolutions per minute (rpm) to 9.8 g/kW-hr for <2000 rpm, depending upon the engine speed). The required number of countries ratified the Annex in May 2004 and it went into force for those countries in May 2005. The Annex has not yet been ratified by the U.S. Engine manufacturers have been certifying engines to the Annex VI NO_x limits since 2000 as the standards are retroactive.

[18] IMO, International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). See: http://www.imo.org/
[19] See: *http://www.arb.ca.gov/regact/2007/shorepwr07/shorepwr07.htm.*

Vessel Speed Reduction (VSR) Program

In May 2001, a Memorandum of Understanding (MOU) between the Port, the Port of Long Beach, EPA Region 9, CARB, SCAQMD, the Pacific Merchant Shipping Association (PMSA), and the Marine Exchange of Southern California was signed. This MOU called for OGVs to voluntarily reduce speed to 12 knots at a distance of 20 nautical miles (nm) from Point Fermin. The term of this MOU expired in 2004; however, currently a significant number (roughly 80% in 2006) of the OGVs operating at the Port are abiding by VSR speeds within 20 nm from Point Fermin.

CAAP Measure – SPBP-OGV1; Vessel Speed Reduction (VSR) Program

The San Pedro Bay Ports Clean Air Action Plan adopted by the Ports of Los Angeles and Long Beach require 90% VSR compliance for OGVs that come to terminals which are due for lease renewal. Reduction in speed demands less power on the main engine, which in turn reduces NO_x emissions and fuel usage.

Low Sulfur Fuel for Marine Auxiliary Engines

In December 2005, CARB adopted low sulfur fuel requirements for marine auxiliary engines within 24 nm of the California coastline. As of January 2007, the regulation required use of marine diesel oil (MDO) or marine gas oil (MGO) with sulfur content of equal or less than 0.5% sulfur by weight, followed by use of MGO with sulfur content of equal or less than 0.1 % sulfur in 2010. The use of low sulfur fuel will reduce emissions of NO_x, DPM and SO_x. The vessel operators have voluntarily complied with the regulation throughout 2007 and early part of 2008. The PMSA filed for a court injunction and the ninth circuit court ruled in favor of the PMSA on 27 February 2008. The ninth circuit court also made it clear that Air Resources Board may start enforcing this upon CARB's receipt of authorization from USEPA. At this time CARB has suspended the enforcement of this regulation and plan to submit a request for authorization from USEPA and while the request for authorization to USEPA is being submitted, CARB is developing a new fuel regulation for ship auxiliary engines that will address the issues raised by PMSA. CARB staff plans to propose this new regulation to the Board in July of 2008.

Low Sulfur Fuel for Marine Propulsion Engines and Boilers[20]

Currently CARB is developing a regulation that will require use of low sulfur fuel in main and auxiliary boilers of all U.S. and foreign-flagged OGVs within 24 nm of the California coast. CARB is proposing a two step requirement as follows:

1. Starting 1 July 2009 – use of MGO or MDO with sulfur content limit of 0.5%.
2. Starting 1 January 2012 – use of MGO or MDO with sulfur content of 0.1% to 0.2%.

Steamships that use boilers as a primary source of propulsion are excluded from this proposed regulation.

[20] See: *http://www.arb.ca.gov/ports/marinevess/presentations/030508/030508regpres.pdf.*

CAAP Measures- SPBP-OGV3 and 4; OGV Main & Auxiliary Engine Fuel Standards
This measure is designed to require the use of lower sulfur distillate fuels in the auxiliary and Main engines of OGVs within 40 nm of Point Fermin and while at berth. Upon lease renewal, this measure requires the use of distillate fuels that have a sulfur content of ≤0.2% S MGO. The Ports are focusing this measure and SPBP-OGV4 (Main Engine Fuel Standards) to target fuel quality with the goal of synchronizing both the auxiliary and main engine fuels.

Low-Sulfur Vessel Main Engine Fuel Incentive Program
To quickly reduce emissions from Ocean-going Vessels, the ports of Long Beach and Los Angeles have adopted an incentive program to encourage vessel operators to discontinue the use of highly polluting bunker fuel in favor of clean, 0.2 percent low sulfur distillate fuel. The program will pay eligible shipping lines the difference between the cost of bunker fuel and the more expensive low-sulfur distillate when used in main engines within the terms of the program. It encourages the use of cleaner fuels among ocean-going vessels prior to the implementation of lease-based low-sulfur fuel agreements and prior to the start of international treaties, U.S. Environmental Protection Agency, or California Air Resources Board regulations requiring low-sulfur fuel use. This program will end on June 30, 2009, upon the expected implementation of statewide low sulfur fuel regulations.

ARB's Regulation Related to Ocean-going Vessel Onboard Incineration
This regulation was adopted by CARB's board in 2005 and amended in 2006. As of November 2007, it prohibits all cruise ships and ocean-going vessels of 300 registered gross tons or more from conducting on-board incineration within three nautical miles of California coast. Enactment of this regulation will reduce toxics air contaminants such as dioxins and toxics metals exposure to the public. It will also reduce PM and hydrocarbon emissions generated during incineration.

2.2 Harbor Craft

EPA's Emission Standards for Harbor Craft Engines – adopted on 14 March 2008
EPA's final regulation, – Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters per Cylinder, described in Section 2.1, applies to harbor craft as well. EPA established new engine standards for new Category 1 and 2 diesel engines – engines rated over 50 hp used for propulsion in most harbor craft. These standards are to be phased in between 2004 and 2007 and limit NO_x, hydrocarbon, CO and DPM, but the emissions reductions achieved are modest in the next five years. EPA expects 24% reduction in NO_x and 12% reduction in DPM in 2030 when the harbor craft engine fleet is fully turned over to these new engines.

CARB's Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft – Adopted in November 2007[21]

As a part of Diesel Risk Reduction Plan and Goods Movement Plan, CARB adopted a regulation that will reduce DPM and NO_x emissions from new and in-use commercial harbor crafts. Under CARB's definition, commercial harbor craft includes tugboats, towboats, ferries, excursion vessels, work boats, crew boats, and fishing vessels. This regulation requires stringent emissions limits for auxiliary as well as propulsion engines installed in commercial harbor crafts. All in-use, new purchases or replacement engines have to meet EPA's most stringent emissions standards per a compliance schedule set by CARB for in-use engines, and at the time of purchase for new engines. The in-use requirement only applies to tugboats, towboats, ferries, work boats, and crew boats. The compliance schedule for in-use engine replacement starts in 2009.

Low Sulfur Fuel Requirement for Harbor Craft

In 2004, CARB adopted a low sulfur fuel requirement for harbor craft. As of 1 January 2006 (in SoCAB) harbor craft operating in SoCAB are required to use on-road diesel fuel (e.g., ultra-low sulfur diesel, ULSD), which has a sulfur content limit of 15 parts per million (ppm) sulfur, and lower aromatic content. Use of lower sulfur and aromatic fuel will result in NO_x and DPM reduction benefits. In addition, use of low sulfur fuel will facilitate retrofitting of harbor craft with emissions control devices such as diesel particulate filters (DPFs) that have potential to reduce PM by 85%.

2.3 Cargo Handling Equipment

Emissions Standards for Non-Road Diesel Powered Equipment

The EPA's and CARB's Tier 1, Tier 2, Tier 3, and Tier 4 (interim Tier 4 and final) emissions standards for non-road diesel engines require compliance with progressively more stringent standards for hydrocarbon, CO, DPM, and NO_x. Tier 4 standards for non-road diesel-powered equipment complement the latest 2007+ on-road heavy-duty engine standards requiring 90 percent reduction in DPM and NO_x when compared against the current level. To meet these standards, engine manufacturers will produce new engines with advanced emissions control technologies similar to those already expected for on-road heavy-duty diesel vehicles. These standards for new engines were phased in with smaller engines in 2008 until all but the very largest diesel engines meet NO_x and PM standards in 2015. Currently, the interim Tier 4 standard includes 90% reduction for PM and a 60% reduction in NO_x.

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[21] See: *http://www.arb.ca.gov/regact/2007/chc07/isor.pd.f*

CARB's Cargo Handling Equipment Regulation
In December of 2005 CARB adopted a regulation to reduce emissions from CHE such as yard tractors and forklifts starting in 2007. The regulation calls for the replacement or retrofit of existing engines with engines that use the Best Available Control Technology (BACT). As of 1 January 2007 the regulation requires that newly purchased, leased, or rented CHE be equipped with either a 2007 or later on-road engine, a Tier 4 off-road engine or the cleanest verified diesel PM emissions control system which reduces DPM by 90% and NO_x by at least 70% for yard tractors. For cargo handling equipment other than yard tractors, currently verified technologies reduce PM by 85%.

CAAP Measures- SPBP-CHE1- Performance Standards for CHE
This measure calls for further CHE improvements at the time of terminal lease renewal. Beginning 2007, all CHE purchases will meet one of the following performance standards: Cleanest available NO_x alternative-fueled engine meeting 0.01 g/bhp-hr PM, available at time of purchase; or cleanest available NO_x diesel-fueled engine meeting 0.01 g/bhp-hr PM, available at time of purchase. If there are no engines available that meet 0.01 g/bhp-hr PM, then must purchase cleanest available engine (either fuel type) and install cleanest VDEC available.

By the end of 2010, all yard tractors operating at the San Pedro Bay Ports will meet at a minimum the EPA 2007 on-road or Tier IV engine standards.

By the end of 2012, all pre-2007 on-road or pre Tier IV off-road top picks, forklifts, reach stackers, RTGs, and straddle carriers <750 hp will meet at a minimum the EPA 2007 onroad engine standards or Tier IV off-road engine standards.

By end of 2014, all CHE with engines >750 hp will meet at a minimum the EPA Tier IV off-road engine standards. Starting 2007 (until equipment is replaced with Tier IV), all CHE with engines >750 hp will be equipped with the cleanest available VDEC verified by CARB.

2.4 Railroad Locomotives

Emissions Standards for New and Remanufactured Locomotives and Locomotive Engines- Latest Regulation Finalized on 14 March 2008[22]
In 1998, EPA adopted Tier 0 (1973-2001), Tier 1 (2002-2004), and Tier 2 (2005+) emissions standards applicable to newly manufactured and remanufactured railroad locomotives and locomotive engines. These standards require compliance with progressively more stringent standards for emissions of hydrocarbon, CO, NO_x, and DPM. Although the most stringent standard, Tier 2, results in over 40% reduction in NO_x and 60% reduction in DPM compared to Tier 0, full potential of these reductions will not be realized in the next five years because of the long life of diesel locomotive engines. Further, EPA has published its

[22] See: *http://www.epa.gov/otaq/regs/nonroad/420f08004.htm.*

final regulation – "Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters per Cylinder – Signed 14 March 2008."[23] This regulation applies to all remanufactured and new-built locomotive engines installed on line haul, switch and passenger locomotives, as described in Section 2.1.

EPA Advance Notice of Proposed Rulemaking (ANPRM) for Locomotives
According to the ANPRM, EPA is considering standards modeled after the 2007/2010 highway and Tier 4 non-road diesel engine programs, with an emphasis on achieving large PM emission reductions as soon as possible through the use of advanced emission control technology starting as early as 2011. This technology, based on high-efficiency catalytic after treatment, is enabled by the availability of clean diesel fuel with sulfur content capped at 15 ppm. EPA is currently developing the NPRM for this program.

Low Sulfur Fuel Requirement for Intrastate Locomotives
In 2004, CARB adopted a low sulfur fuel requirement for intrastate locomotives. Intrastate locomotives are defined as those locomotives that operate at least 90 percent of the time within borders of the state, based on hours of operation, miles traveled, or fuel consumption. Mostly applicable to switchers, as of 1 January 2006, statewide, intrastate locomotives are required to use CARB off-road diesel fuel which has a sulfur content limit of 15 ppm sulfur and a lower aromatic content. Use of fuel with lower sulfur and lower aromatics will result in NO_x and DPM reductions. In addition, use of low sulfur fuel will facilitate retrofitting of locomotives with emissions control devices such as DPFs that have potential to reduce DPM by 85%.

Statewide 2005 Memorandum of Understanding
In order to accelerate the implementation of Tier 2 engines in SoCAB, CARB and EPA Region 9 entered into an enforceable MOU in 1998 with two major Class 1 freight railroads [Union Pacific (UP) and Burlington Northern Santa Fe (BNSF)] in California. This MOU requires UP and BNSF to concentrate introduction of the Tier 2 locomotives in the SoCAB, which will achieve a 65% reduction in NO_x by 2010.

In 2005, CARB entered into another MOU with UP and BNSF whereby these two railroads have agreed to phase out non-essential idling and install idling reduction devices, identify and expeditiously repair locomotives that smoke excessively and maximize the use of 15 ppm sulfur fuel.

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[23] EPA 2008.

2.5 Heavy-Duty Vehicles

Emission Standards for New 2007+ On-Road Heavy-Duty Vehicles
In 2001, CARB adopted EPA's stringent emission standards for 2007 and late model HDV, which will ultimately result in 90% reductions in emissions of NO_x and PM. According to this regulation, HDV engine manufacturers will be meeting a PM standard of 0.01 g/bhp-hr in 2007, which is 90% lower than the 2004 PM standard of 0.1 g/bhp-hr. The NO_x standard requires a phase-in of the 0.2 g/bhp-hr NO_x standards between 2007 and 2010. By 2010, all engines have to meet the 0.2 g/bhp-hr NO_x standard, which is over 90% lower than the 2004 NO_x standard of 2.4 g/bhp-hr. It is expected that between 2007 and 2010, on average, manufacturers will be producing HDV engines meeting the PM standard of 0.01 g/bhp-hr and a NO_x standard of 1.2 g/bhp-hr. This latter standard is referred to as the 2007 interim standard.

Heavy-Duty Vehicle On-Board Diagnostics (OBD) Requirement
In 2005, CARB adopted a comprehensive HDV OBD regulation, which ensures that the increasingly stringent HDV emissions standards being phased in are maintained during each vehicle's useful life. The OBD regulation requires manufacturers to install a system in HDVs to monitor virtually every emissions related component of the vehicle.

Ultra-Low Sulfur Diesel (ULSD) Fuel Requirement
In 2003, CARB adopted a regulation requiring that diesel fuel produced or offered for sale in California for use in any on-road or non-road vehicular diesel engine (with the exception of locomotive and marine diesel engines) contain no more than 15 ppm of sulfur by weight, as of June 2006 statewide. ULSD fuel is needed in order for retrofit technologies, such as DPF, to work successfully.

CARB's Regulation for Reducing Emissions from On-Road Heavy-Duty Diesel Trucks Dedicated to Goods Movement at California Ports
As a part of CARB's emissions reduction plan for ports and goods movement in California, in December 2007, CARB adopted a regulation to modernize the drayage truck fleet that operates at California ports. This goal is achieved in two phases as follows:

1. By 31 December 2009, all trucks operating at California Ports have to meet 1994 – 2003 on-road heavy duty truck engine standards plus be retrofitted with CARB's level 3 verified emissions control technologies that reduce PM at least by 85%; or meet 2004 and later on-road heavy-duty truck engine standards.
2. By 31 December 2013, all trucks operating at California Ports have to meet 2007 and beyond on-road heavy duty truck engine standards.

CAAP Measures- SPBP-HDV1- Performance Standards for On-Road Heavy-Duty Vehicles
Per the stated goals of the CAAP, the Ports of Los Angeles and Long Beach approved a tariff plan which progressively bans older trucks from operating at the two ports. The ban is implemented in three phases as follows:

1. By 1 October 2008 – All pre-1989 trucks are banned from ports services.
2. By 1 January 2010 – All 1989-1993 trucks along with un-retrofitted 1994-2003 trucks are banned from ports services.
3. By 1 January 2012 – All trucks that do not meet 2007and later on-road heavy duty engine standards are banned from ports services.

The recently adopted CARB regulations, anticipated CARB rulemakings, and the measures in the CAAP will provide a vital and complementary combination of measures that support the overall effort to meet both State and San Pedro Bay Ports air quality improvement goals.

One non-regulatory program that is also helping to significantly reduce emissions from sources including those associated with ports is the Carl Moyer Program. This program is a CARB-administered grant program implemented in partnership with local air districts to fund the replacement of older, "dirty" engines or to cover the incremental cost of purchasing cleaner-than-required engines and vehicles. Under this program, owners/operators of mobile emissions sources can apply for incremental funding to reduce emissions. The program is also being expanded to include a fleet modernization component. Emissions source categories at the Ports that have been successful in obtaining Carl Moyer funding include: heavy-duty vehicles, cargo handling equipment, harbor craft, and rail locomotives. It is important to note that only emission reductions that are surplus to regulatory requirements are eligible for Carl Moyer funding. As regulations are developed which require retrofit or replacement of specific equipment and/or vehicles, those projects will no longer be eligible for funding.

2.6 Greenhouse Gases

In California, assembly bill AB 32[24], signed by the governor in September 2006, created a comprehensive, multi-year program to reduce statewide GHG emissions. It gives CARB the authority to develop strategies to achieve an overall goal of restoring emissions to 1990 levels by the year 2020, which is an approximate 25% reduction in GHG emissions. In addition, AB 1803, passed in January 2007, mandates CARB to adopt a regulation to require the reporting and verification of statewide GHGs beginning with the source or category that contributes the most to the statewide emissions.

[24] See: *http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf*.

In December 2007, CARB staff presented to their board, California's 1990 GHG emissions (six Kyoto gases) inventory[25] for major sectors such as transportation, electric power, industry, petroleum refining, agriculture, and forestry. These are statewide estimates and each major sector has its own sub categories. Following the mandate of AB 1803[26], CARB's board has also adopted a mandatory reporting regulation that requires annual GHG reporting from largest commercial and industrial stationary sources in California. Transportation sources are not currently covered by this regulation.

[25] See: *http://www.arb.ca.gov/cc/inventory/inventory.htm*.
[26] See: *http://www.arb.ca.gov/cc/reporting/ghg-rep/ghg-rep.htm*.

SECTION 3 OCEAN-GOING VESSELS

This section presents emissions estimates for the ocean-going vessels source category, including source description (3.1), geographical delineation (3.2), data and information acquisition (3.3), operational profiles (3.4), emissions estimation methodology (3.5), and the emission estimates (3.6).

3.1 Source Description

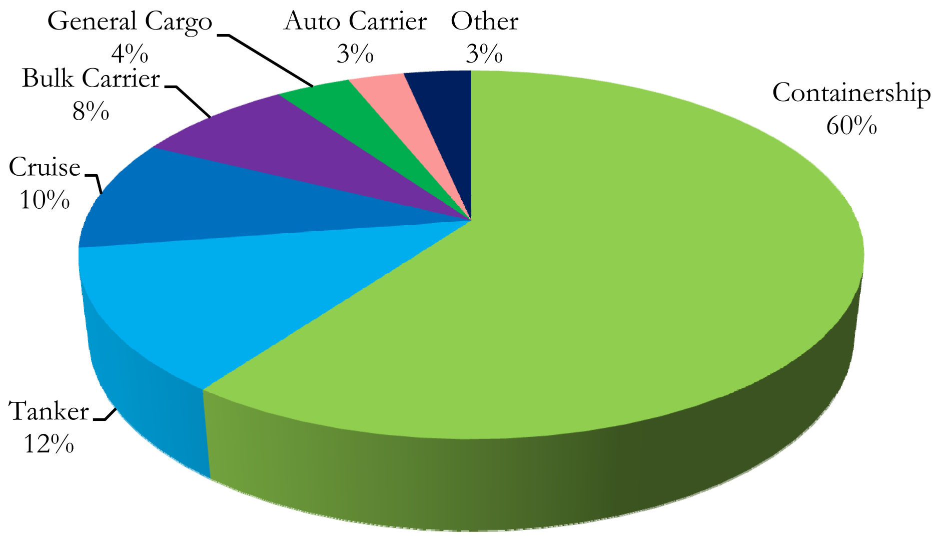
OGV's calling at the Port in 2006, whether inbound from the open ocean or transiting from neighboring POLB, are included. OGV's calling only at POLB or bypassing both ports without physically stopping at a Port dock have not been included. Harbor craft, including tugboats, excursion vessels, and other workboats, are discussed in Section 4.

Ocean-going vessels are categorized by the following main vessel types for purposes of this EI:

- Auto carrier
- Bulk carrier
- Containership
- Passenger cruise vessel
- General cargo
- Ocean-going tugboat
- Miscellaneous vessel
- Refrigerated vessel (Reefer)
- Roll-on roll-off vessel (RoRo)
- Tanker

Based on 2006 Marine Exchange data, there were 2,708 inbound calls to the port in 2006. Figure 3.1 shows that the majority of the vessels that called at the Port in 2006 are containerships (60%); followed by tankers (12%); cruise vessels (10%), bulk carriers (8%); general cargo (4%), and auto carriers (3%). The remaining 3% shown as others include reefers, RoRos, and miscellaneous vessels.

Figure 3.1: Distribution of Vessel Types by Inbound Calls



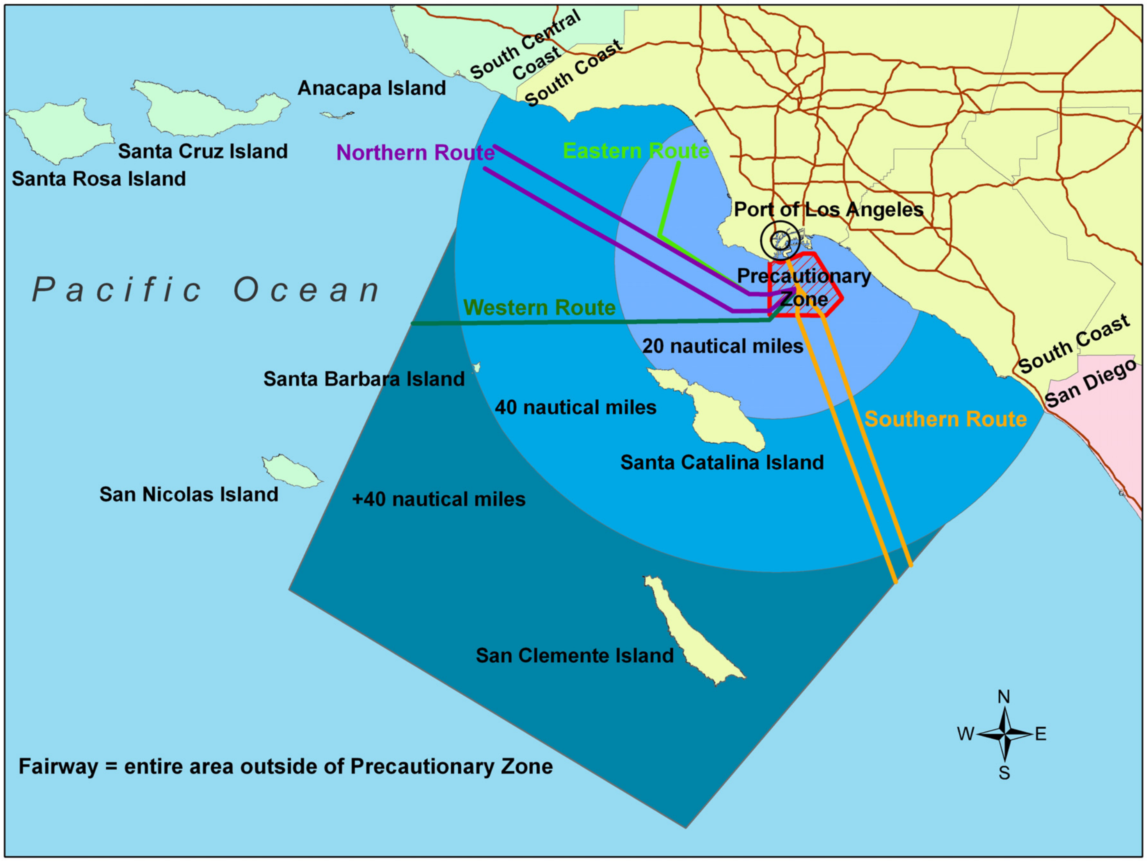
3.2 Geographical Delineation

The geographical extent of the emissions inventory for commercial marine vessels is the boundary for SoCAB. Figure 3.2 shows this portion of the study area as well as the major shipping routes. The Marine Exchange of Southern California (MarEx) ship routes were used along with their estimates of travel distances offshore from Point Fermin. These trip segments were organized into four routes (each comprised of both inbound and outbound traffic) reflecting north, east (El Segundo), west, and south routes, as designated by the MarEx.[27]

- North: The predominant trade route for OGVs in terms of ship calls, involving coastwise trade to the U.S. continental ports as far as Seattle (Straits of San Juan de Fuca) but also to Alaska and the Far East (Great Circle Route).
- South: The second most traveled direction for ship calls, serving not only Mexico and other ports but also traffic through the Panama Canal.
- West: Mainly involved with travel to Hawaii, but may include some towboat trips to the Channel Islands.
- East: This is a short trip between the Port and El Segundo, the location of a petrochemical complex to the north.

[27] Marine Exchange of California Vessel Tracking Service. See: *http://www.mxsocal.org/vessel-traffic-service.aspx*.

Figure 3.2: Geographical Extent, Fairway and Major Shipping Routes



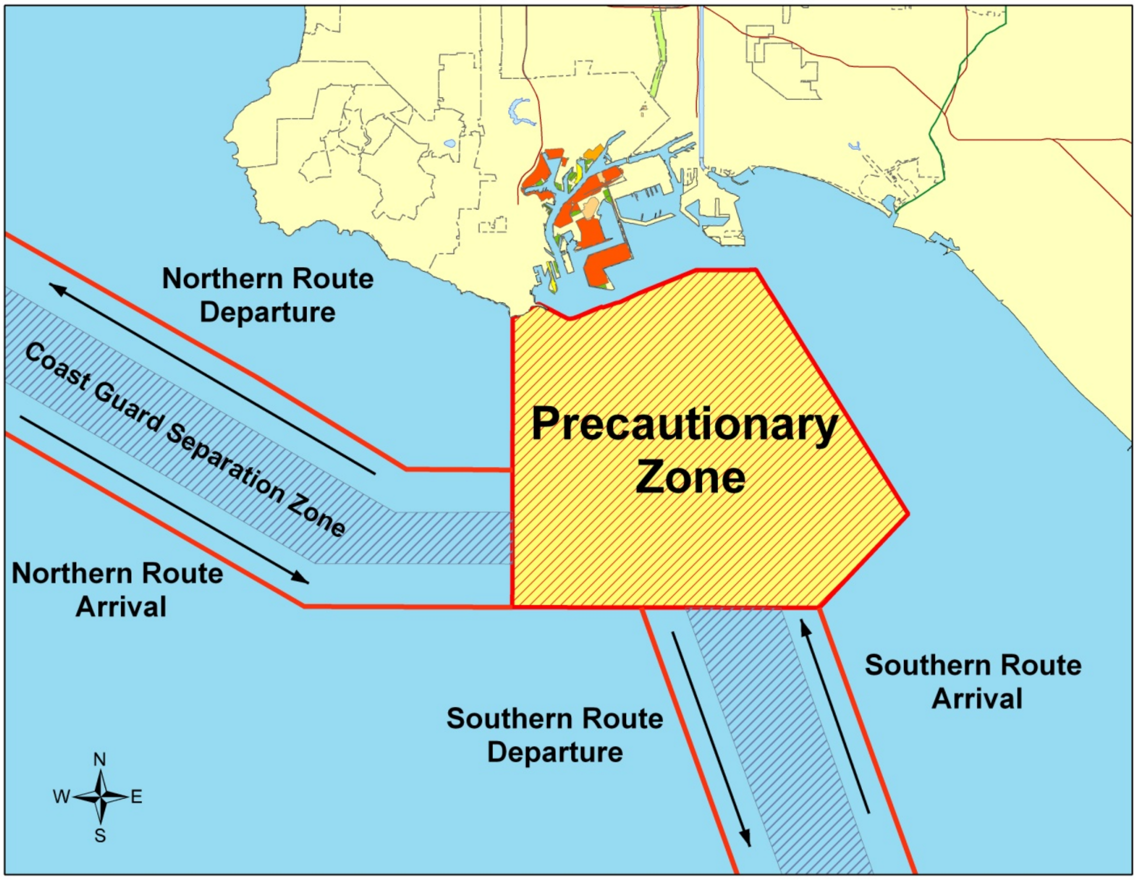
The distances in nautical miles (nm) for the various routes are listed in Table 3.1. The distances shown are from the precautionary zone (PZ) to the basin boundary and from the breakwater (BW) to the PZ.

Table 3.1: Route Distances, nm

Route	PZ to Boundary Distance, nm		BW to PZ Distance, nm	
	Inbound	Outbound	Inbound	Outbound
North	40	39	7.5	5.0
East	23.5	21.5	7.5	5.0
South	34	38	8.5	8.3
West	43.5	43.5	7.5	5.0

The PZ is a designated area where ships are preparing to enter or exit a port. In this zone the pilots are picked up or dropped off. Figure 3.3 shows the precautionary zone.

Figure 3.3: Precautionary Zone



The harbor is located within the breakwater and is characterized by the slowest vessel speeds. In the harbor, the vessels may be maneuvering to dock or undock or they may be hotelling while the cargo is loaded and/or unloaded.

3.3 Data and Information Acquisition

Various sources of data and operational knowledge about the Port's marine activities were used to compile the data necessary to prepare emission estimates. These sources included:

- Marine Exchange of Southern California
- Vessel Speed Reduction Program speed data
- Los Angeles Pilot Service
- Lloyd's Register of Ships
- Port Vessel Boarding Program data
- Nautical charts and maps

Each data source is detailed in the following subsections.

3.3.1 Marine Exchange of Southern California

MarEx operates the Vessel Traffic Service (VTS) in cooperation with the U.S. Coast Guard (USCG), the Ports of Los Angeles and Long Beach, and the State of California. The VTS was established in 1994 to provide traffic safety, traffic monitoring and security functions for the two ports, and is the first private/public VTS partnership in the country that is funded by industry. MarEx requires ships to report their activities to the VTS upon arrival and departure and tracks ship route taken.

The MarEx data that was evaluated in developing the emission estimates includes vessel names, arrival and departure dates and times, transit speeds and directions, berth of destination, and other information. This data source was the primary basis for establishing:

- vessel types
- calculated hotelling time
- distribution of arrival and departure travel directions by route
- number of ship calls
- names of vessels
- vessel origination and destination

3.3.2 Vessel Speed Reduction Program Data

MarEx monitors OGV speeds over the four routes into and out of the Port as part of a VSR program that was started in May 2001. For the 2006 EI, the actual speeds in the fairway are used and thus the full effect of the VSR program is taken into consideration for the fairway speeds.

3.3.3 Los Angeles Pilot Service

The Los Angeles Pilot Service maintains an automated database which documents the time when the pilot took control of the ship's bridge and when the pilot relinquished control back to the ship's officers. The date and time data was used to estimate transit time profiles for maneuvering from berth to precautionary zone for the following modes:

- Inbound from sea
- Outbound to sea
- Anchorage shifts
- Other shifts (e.g., inter-port and intra-port shifts)

For the majority of the movements (roughly 75%), the maneuvering times were matched for each movement. For those movements that could not be matched, defaults were used for each mode, ship type and terminal based on average trip times. There were over 300 defaults for each of these modes, since ship type and terminal were also taken into consideration. The various modes are discussed in greater detail in Section 2.4.

3.3.4 Lloyd's Register of Ships

Lloyd's[28] is considered to be the leading resource for obtaining ship characteristics such as tonnage, speed, engine power plant configuration, age, and other parameters. The company is known as a classification society for the purpose of insuring many of the vessels on an international basis; for the vessels classified by Lloyd's the data are quite complete, however, for other ships using a different insurance certification authority, the data are less complete and/or accurate. Lloyd's was used for obtaining information such as main and auxiliary engine power and vessel speed ratings because it is the best available source of such information. The survey results from the Port of Los Angeles Vessel Boarding Program suggest that the current Lloyd's data are fairly accurate for propulsion horsepower and vessel speed.

The company Fairplay has the rights to Lloyd's ship data and sells the software containing information on commercial marine vessels, which include ocean-going vessels. Lloyd's data used in this report was obtained in April 2007. The worldwide fleet of OGVs was assembled in a common database and a query was completed to match with the MarEx vessel data. There was nearly a 100% match between the Lloyd's data and MarEx data (some integrated and articulated tug barges were not found in Lloyd's).

[28] Lloyd's – Fairplay, Ltd., *Lloyd's Register of Ships*. See: *http://www.lr.org/code/home.htm.*

Another source of ship data that was used only for the ocean tugs which are integrated and articulated tug barges (ITB and ATB), was the American Bureau of Shipping (ABS), a major classification society. Data obtained included engine information for the ocean-going tugboats such as horsepower.

3.3.5 Vessel Boarding Program Survey Data

The best source of local activity data and ship parameters is from the individuals who own and/or operate the vessels. The Vessel Boarding Program (VBP) was an in-depth survey of OGVs during which Starcrest consultants actually rode on the ship and interviewed the ship's executive and engineering staff, usually the Captain and Chief Engineer.

Building on previous boardings conducted by the Port of Los Angeles, Port of Long Beach and Starcrest, the 2006 inventory includes the information from previous boardings, new data received from companies and new boardings conducted since the last inventory. Figure 3.4 presents the percent of vessels by vessel type for the vessels boarded at the Port of Los Angeles between 2003 and 2007.

Figure 3.4: Percent by Vessel Type of Vessels Boarded in 2003-2007

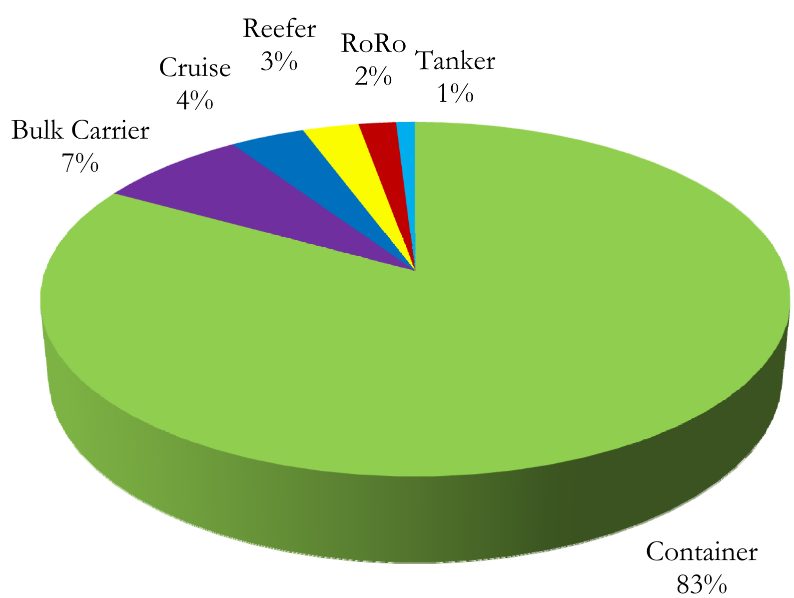


Table 3.2 summarizes the Port of Los Angeles VBP statistics.

Table 3.2: Port of Los Angeles Vessel Boarding Program Statistics

Count	Type
181	Boardings
43	Arrivals
91	At berth
47	Departures
25	Shipping lines
106	Vessels

Table 3.3 summarizes the statistics for the various data collected from other ports or provided by shipping lines without boarding the vessel.

Table 3.3: Vessel Boarding Program Statistics

Number of Vessels	Program
106	Port of Los Angeles
41	Port of Long Beach
32	Puget Sound
239	Data provided without boarding
418	**Vessels Total**

The following VBP survey data was used specifically for emission estimation methodology in this study:

- Main engine power
- Auxiliary engine power
- Auxiliary engine load
- Boiler fuel consumption
- Vessels that switched fuels
- Emission reduction technologies such as slide valves

The specific values used for emission estimation methodology are discussed in Section 3.5. Other data collected and findings are summarized in Section 3.7. For main engine data, the match with Lloyd's and ABS data was 100%, so defaults for main engine power were not required

Auxiliary Engine Data

Due to the fact that auxiliary engine information is usually not provided to Lloyd's by vessel owners, since it is not required by IMO or the classification societies, Lloyd's contains minimal auxiliary engine information. For the 2006 vessels that called at the Port, 12% of the discrete vessels had matching auxiliary engine information found in Lloyd's data and an additional 16% of the data came from the information gathered by vessel boardings and sister ships. Table 3.4 provides a summary of the count of auxiliary engine data used by vessel type, with the containerships broken down by container capacity. See section 3.5.9 for auxiliary engine default discussion.

Table 3.4: Auxiliary Engine Information from VBP and Lloyd's Data

Port	Vessel Type	VBP	Sister Ships	Lloyds	Default	Total
LA	Auto Carrier	1	0	1	33	35
LA	Bulk - General	0	0	16	165	181
LA	Bulk Wood Chips	0	0	0	2	2
LA	Container - 1000	3	0	0	33	36
LA	Container - 2000	4	2	1	28	35
LA	Container - 3000	11	3	2	27	43
LA	Container - 4000	28	21	15	48	112
LA	Container - 5000	19	19	0	27	65
LA	Container - 6000	4	2	13	9	28
LA	Container - 7000	10	4	0	2	16
LA	Container - 8000	0	0	3		3
LA	Cruise	0	0	13	15	28
LA	General Cargo	3	0	7	55	65
LA	Ocean Tugs	3	0	0	4	7
LA	Miscellaneous	0	0	1	3	4
LA	Reefer	0	0	3	21	24
LA	RoRo	0	0	0	3	3
LA	Tanker - General	0	0	11	59	70
LA	Tanker - Chemical	1	0	2	29	32
LA	Tanker - Crude - Aframax	0	0	2	2	4
LA	Tanker - Crude - Handyboat	0	0	0	7	7
LA	Tanker - Crude - Panamax	1	0	5	6	12
LA	Tanker - Crude - Suezmax	0	0	0	1	1
LA	Tanker - Oil Products	5	0	12	56	73
LA	**Total**	93	51	107	635	886
LA	**Percentage of total**	**10%**	**6%**	**12%**	**72%**	**100%**

DB ID477

3.4 Operational Profiles

Vessel activity is defined as the number of ship trips by trip type and segment. Trip segments are used for the at-sea portion of the ship trip between the open ocean and the precautionary zone. These trips are then processed so as to define time in mode, where a mode is an engine type, and geographical segment. The purpose of this step is to estimate power demand for that mode of operation and multiply it by the amount of time spent in that particular mode, which estimates available energy expressed as power per unit of time (e.g., kilowatt-hours, kW-hrs). A vessel-by-vessel analysis was conducted, as in the case of the 2005 EI. The only need for average power or time-in-mode was for vessels that lacked data for those fields. Vessel activity was drawn from three sources:

- MarEx trip tables which define arrivals, departures, and shifts
- MarEx speed tables which define speeds for the VSR Program at 10, 15 and 20 nautical miles
- Los Angeles Pilot Services data which provide transit times for harbor maneuvering

Before processing the data, the column headings were checked and date/time stamps were put into a standard format. Pre-processing also involved creation of a new MarEx variable to calculate elapsed time for the purposes of calculating hotelling time. The calculation involved subtracting departure time from arrival time while at berth or anchorage. Ship movements are tracked by MarEx as to:

- Arrivals (inbound trip)
- Departures (outbound trip)
- Shifts (inter-port, intra-port, and anchorage shifts)
- Total movements (sum of all the above)

Arrivals
For this study, arrivals include inbound trips from the sea to a berth and inbound trips from the sea to an anchorage. An inbound trip from the sea to an anchorage is assigned to the port if the next port of call is a berth at the port.

Departures
For this study, departures include outbound trips from a berth or anchorage to the sea.

Shifts
While many vessels make only one arrival and departure at a time, some vessels make multiple stops within a port. To assist with preparation of the marine emissions inventory, all shifts were grouped together, since they do not have an "at-sea" component as with arrivals and departures. When a vessel shifts from one berth to another or from an anchorage to a berth, the emissions associated with that shift (transit emissions from/to berth) are allocated to the "to berth" or "arriving berth".

There are three broad categories of shifts:

- Intra-port shifts – movements within a port from one berth to another.
- Inter-port shifts – movements between adjacent ports. This is a common occurrence in co-located ports such as Los Angeles and Long Beach.
- Anchorage shifts – movements between a terminal and anchorage. For example, a vessel receives a partial load, goes to anchorage, and then returns to the terminal to complete loading.

Table 3.5 presents the arrivals, departures, shifts and total movements for vessels at the Port in 2006. Arrivals and departures do not match because the activity is based on a calendar year.

Table 3.5: Total OGV Movements for 2006

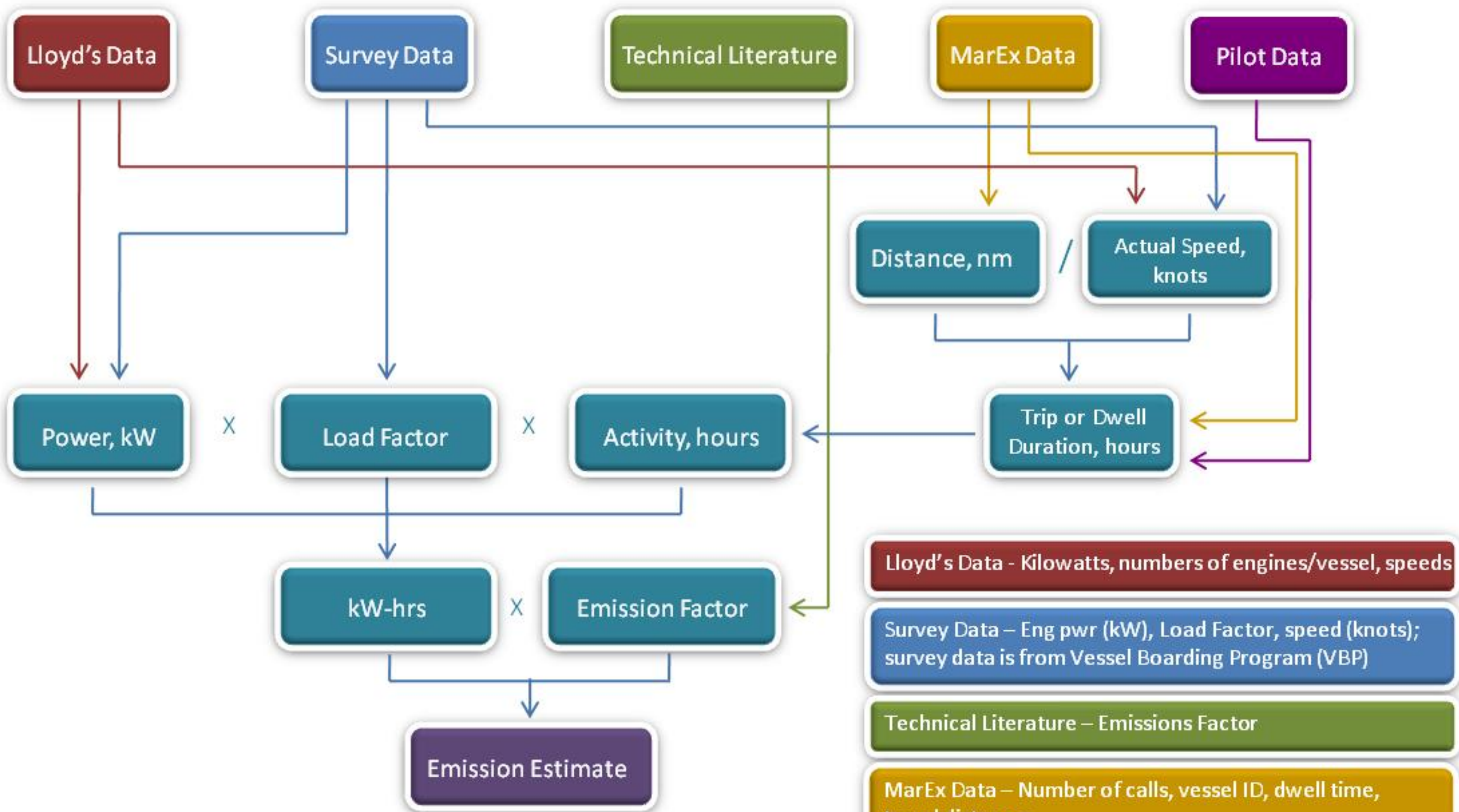
OGV Type	Arrival	Departure	Shift	Total
Auto Carrier	72	72	10	154
Bulk - General	211	171	216	598
Bulk Wood Chips	2	1	3	6
Container - 1000	213	209	46	468
Container - 2000	149	148	20	317
Container - 3000	201	197	30	428
Container - 4000	514	505	82	1101
Container - 5000	289	277	23	589
Container - 6000	181	179	19	379
Container - 7000	78	78	3	159
Container - 8000	1	2	2	5
Cruise	263	263	0	526
General Cargo	100	89	115	304
Ocean Tugs	53	43	58	154
Miscellaneous	4	3	4	11
Reefer	33	36	48	117
RoRo	3	2	1	6
Tanker - General	122	86	195	403
Tanker - Chemical	43	32	46	121
Tanker - Crude - Aframax	4	3	10	17
Tanker - Crude - Handyboat	11	6	20	37
Tanker - Crude - Panamax	13	5	24	42
Tanker - Oil Products	148	104	231	483
Total	**2,708**	**2,511**	**1,206**	**6,425**

DB ID451

3.5 Methodology

Emissions are estimated as a function of vessel power demand (energy expressed in kW-hrs) multiplied by an emission factor, where the emission factor is expressed in terms of grams per kilowatt-hour (g/kW-hr). Emission factors and emission factor adjustments for low propulsion engine load are then applied to the various activity data. The process for estimating emissions from propulsion engines is illustrated as a process flow diagram in Figure 3.5. This diagram indicates the sources of information discussed in the previous subsection and how they are used to develop the components of the emission calculations, described below.

Figure 3.5: Propulsion Engine Emission Estimation Flow Diagram



Equations 3.1 and 3.2 report the basic equations used in estimating emissions.

$$E = Energy \times EF \qquad \text{Equation 3.1}$$

Where:

E = Emissions from the engine(s) that are included in the "Energy" term discussed below, usually calculated as grams of emissions per unit of time (e.g., per year), but converted to tons of emissions by dividing by 453.6 grams per pound and 2,000 pounds per ton.

Energy = Energy demand, in kW-hrs, calculated using Equation 2.2 below as the energy output of the engine (or engines) over the period of time covered by the estimate.

EF = Emission factor, usually expressed in terms of g/kW-hr, discussed in more detail below.

The 'Energy' term of the equation is where most of the location-specific information is used. Energy is calculated using Equation 3.2:

$$Energy = MCR \times LF \times Act \qquad \text{Equation 3.2}$$

Where:

MCR = maximum continuous rated engine power, kW
LF = load factor (unitless)
Act = activity, hours

The emissions estimation methodology section discusses methodology used for propulsion engines (subsections 3.5.1 to 3.5.7), auxiliary engines (subsections 3.5.8 and 3.5.9) and auxiliary boilers (subsections 3.5.10). Propulsion engines are also referred to as main engines.

Incinerators are not included in the emissions estimates because incinerators are not used within the study area. Interviews with the vessel operators and marine industry, in general, report that vessels do not use their incinerators while at berth or near coastal waters.

3.5.1 Propulsion Engine Maximum Continuous Rated Power

MCR power is defined as the manufacturer's tested engine power; for this study, it is assumed that the Lloyd's 'Power' value is the best surrogate for MCR power. The international specification is to report MCR in kilowatts, and it is related to the highest power available from a ship engine during average cargo and sea conditions. However, operating a vessel at 100% of its MCR power is very costly from a fuel consumption and engine maintenance perspective, so most operators limit their maximum power to about 80% of MCR.

3.5.2 Propulsion Engine Load Factor

Load factor is expressed as the ratio of a vessel's power output at a given speed to the vessel's MCR power. As suggested above, at normal service speed, a ship probably has a load factor of close to 80%. For intermediate speeds, the Propeller Law is used to estimate ship propulsion engine loads, based on the theory that propulsion power varies by the cube of speed.

$$LF = (AS / MS)^3 \qquad \text{Equation 3.3}$$

Where:

LF = load factor, percent
AS = actual speed, knots
MS = maximum speed, knots

3.5.3 Propulsion Engine Activity

Activity is measured in hours of operation. Actual in-harbor maneuvering and transit times were taken from Pilot data. The VSR program requests vessels to travel at or below 12 knots when the vessel is 20 nm out. Vessel speeds are recorded by the Marine Exchange for zones called 10, 15 and 20. The zones are estimated by radius distance from Point Fermin, so the distances are in the 10, 15 and 20 nm range made by the concentric circles, but the actual distance is not exactly 10, 15, and 20. The VSR speed data is used instead of averages for the fairway extending to approximately 20 miles. For the at-sea portion not covered by VSR actual speed data, transit times were estimated by dividing distance traveled by ship speed.

$$Act = D/AS \qquad \text{Equation 3.4}$$

Where:

Act = activity, hours
D = distance, nautical miles
AS = actual ship speed, knots

The PZ uses assigned speeds based on VBP data, as found in Table 3.6.

Table 3.6: Precautionary Zone Speed, knots

Vessel Type	Class	Speed
Auto Carrier	Fast	11.0
Bulk	Slow	9.0
Containership	Fast	11.0
Cruise	Fast	11.0
General Cargo	Slow	9.0
Miscellaneous	Slow	9.0
Ocean tug	Slow	9.0
Reefer	Slow	9.0
RoRo	Slow	9.0
Tanker	Slow	9.0

DB ID472

3.5.4 Propulsion Engine Emission Factors

The main engine emission factors used in this study were reported in a 2002 ENTEC study,[29] except for PM emission factors which were provided by CARB. The greenhouse gas emission factors for CO_2, CH_4 and N_2O were reported in an IVL 2004 study.[30] Vessels are assumed to operate their main engines on residual oil (RO) which is intermediate fuel oil (IFO 380) or one with similar specifications, with an average sulfur content of 2.7%. This is supported by information collected during the VBP and 2005 CARB survey; exceptions are made for those vessels that use a different fuel other than residual fuel. The two predominant propulsion engine types are:

- Slow speed diesel engines, having maximum engine speeds less than 130 rpm based on the EPA definition for ship engines as described in a 1999 Regulatory Impact Analysis.[31]
- Medium speed diesel engines, having maximum engine speeds over 130 rpm (and typically greater than 400 rpm).

The emission factors for propulsion power using residual fuel are listed below. Table 3.8 includes emission factors for the greenhouse gases carbon dioxide, methane, and nitrogen dioxide.

[29] ENTEC, *Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community, Final Report*, July 2002. Prepared for the European Commission.(ENTEC 2002).

[30] IVL, *Methodology for Calculating Emissions from Ships: Update on Emission Factors".* Prepared by IVL Swedish Environmental Research Institute for the Swedish Environmental Protection Agency.

[31] EPA, *Control of Emissions from Marine Diesel Engines, Regulatory Impact Analysis*, November 1999. EPA 420-R-99-026.

Table 3.7: Emission Factors for OGV Propulsion Power using Residual Oil, g/kW-hr

Engine	Model Year	PM_{10}	$PM_{2.5}$	DPM	NO	SO	CO	HC
Slow speed diesel	<= 1999	1.5	1.2	1.5	18.1	10.5	1.4	0.6
Medium speed diesel	<= 1999	1.5	1.2	1.5	14.0	11.5	1.1	0.5
Slow speed diesel	2000 +	1.5	1.2	1.5	17.0	10.5	1.4	0.6
Medium speed diesel	2000 +	1.5	1.2	1.5	13.0	11.5	1.1	0.5
Gas turbine	all	0.05	0.04	0.0	6.1	16.5	0.2	0.1
Steamship	all	0.8	0.6	0.0	2.1	16.5	0.2	0.1

DB ID454

Table 3.8: GHG Emission Factors for OGV Propulsion Power using Residual Oil, g/kW-hr

Engine	Model Year	CO_2	CH_4	N_2O
Slow speed diesel	<= 1999	620	0.012	0.031
Medium speed diesel	<= 1999	683	0.010	0.031
Slow speed diesel	2000 +	620	0.012	0.031
Medium speed diesel	2000 +	683	0.010	0.031
Gas turbine	all	970	0.002	0.08
Steamship	all	970	0.002	0.08

DB ID453

3.5.5 Propulsion Engines Low Load Emission Factors

In general terms, diesel-cycle engines are not as efficient when operated at low loads. An EPA study[32] prepared by Energy and Environmental Analysis, Inc. (EEIA) established a formula for calculating emission factors for low engine load conditions such as those encountered during harbor maneuvering and when traveling slowly at sea such as in the reduced speed zone. While mass emissions (e.g., pounds per hour) tend to go down as vessel speeds and engine loads decrease, the emission factors (e.g., g/kW-hr) increase. This is based on observations that compression-cycle combustion engines are less efficient at low loads. Low load emission factor equations were developed from EPA emission factors for marine vessels at full load. These equations work well to describe the low-load effect where emission rates can increase, based on a limited set of data from Lloyd's Maritime Program and the U.S.

[32] EEIA for Sierra Research, for EPA, *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data,* February 2000. Sierra Research work assignment No. 1-10. EPA420-R-002.

Coast Guard. The low load effect was first described in a study conducted for the EPA in 2002.[33] The equation is based on the variables provided in Table 3.9.

Table 3.9: Low-Load Emission Factor Regression Equation Variables as Modified

Pollutant	Exponent	Intercept (b)	Coefficient (a)
PM	1.5	0.25	0.0059
NO_x	1.5	10.45	0.1255
CO	1.0	0.15	0.8378
HC	1.5	0.39	0.0667

DB ID476

The equation was used to generate emission factors for the entire range of load factors from 2% to 20% for each pollutant, as follows:

$$\mathbf{y = a(fractional\ load)^{-x} + b} \qquad \text{Equation 3.5}$$

Where:

y = emissions in g/kW-hr
a = coefficient
b = intercept
x = exponent (negative)
fractional load = derived by the Propeller Law

Each of the 20 EEIA factors was divided by the emission factor at 20% EEAI load. This resulted in positive numbers, since emissions increased as load decreased. At 20% load, the value was exactly 1.0 since it was divided into itself. These numbers are called low-load adjustment factors (LLA) and are listed in Table 3.10. The LLA multipliers are then applied to any at sea emission factor. The database then computes the resulting emission factor for each pollutant.

[33] EPA, *Commercial Marine Inventory Development,* July 2002. EPA 420-R-02-019. (IVL 2004).

Table 3.10: Low Load Adjustment Multipliers for Emission Factors

Load	PM	NO_x	SO_x	CO	HC	CO_2	CH_4	N_2O
2%	7.29	4.63	1.00	10.00	31.62	1.00	31.62	4.63
3%	4.33	2.92	1.00	6.67	17.21	1.00	17.21	2.92
4%	3.09	2.21	1.00	5.00	11.18	1.00	11.18	2.21
5%	2.44	1.83	1.00	4.00	8.00	1.00	8.00	1.83
6%	2.04	1.60	1.00	3.33	6.09	1.00	6.09	1.60
7%	1.79	1.45	1.00	2.86	4.83	1.00	4.83	1.45
8%	1.61	1.35	1.00	2.50	3.95	1.00	3.95	1.35
9%	1.48	1.27	1.00	2.22	3.31	1.00	3.31	1.27
10%	1.38	1.22	1.00	2.00	2.83	1.00	2.83	1.22
11%	1.30	1.17	1.00	1.82	2.45	1.00	2.45	1.17
12%	1.24	1.14	1.00	1.67	2.15	1.00	2.15	1.14
13%	1.19	1.11	1.00	1.54	1.91	1.00	1.91	1.11
14%	1.15	1.08	1.00	1.43	1.71	1.00	1.71	1.08
15%	1.11	1.06	1.00	1.33	1.54	1.00	1.54	1.06
16%	1.08	1.05	1.00	1.25	1.40	1.00	1.40	1.05
17%	1.06	1.03	1.00	1.18	1.28	1.00	1.28	1.03
18%	1.04	1.02	1.00	1.11	1.17	1.00	1.17	1.02
19%	1.02	1.01	1.00	1.05	1.08	1.00	1.08	1.01
20%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

DB ID475

Low load emission factors are not applied to steamships or ships having gas turbines because the EPA study only observed rise in factors for diesel engines.

3.5.6 Propulsion Engine Harbor Maneuvering Loads

Main engine loads within a harbor tend to be very light, especially when coasting on the way into port. During docking, when the ship is being positioned against the wharf, the assist tugboats do most of the work. Estimation of main engine maneuvering loads is the composite of several factors, such as:

- 2% load during docking
- 15 minute docking duration (based on VBP observations)
- variable loads with inbound and outbound speeds
- docking and harbor transit loads combined by percent time-in-mode

Docking and harbor transits are two subsets of what is called "maneuvering." The docking aspect is fairly routine, with the exception that some ships require extra backing and turning, either on entry or exit. The port pilot data and VBP support these generalities, although maneuvering times vary by port, terminal, and ship type. Thus docking is about 2% load, but the harbor transit load has to be calculated by the Propeller Law.

Harbor transit speeds within the breakwater were profiled from VBP information as follows:

- inbound fast ships (auto, container, cruise ships) at 7 knots
- inbound slow ships (any other vessel type) at 5 knots
- outbound traffic for all vessels at 8 knots

Results are then weighted together by percentage of time in docking and harbor transit modes. Results of that operation are shown in Table 3.11. The departure load is typically higher than the arrival load because the engine power is used to leave the dock, while the vessel usually coasts in on arrival.

Table 3.11: Composite Harbor Maneuvering Loads

Vessel Type	Max. Rated Speed	Arrival Load	Departure Load
Auto Carrier	19	4.4%	5.7%
Bulk	14	3.7%	11.6%
Container – 1000	19	4.1%	5.0%
Container – 2000	21	3.3%	4.3%
Container – 3000	22	2.9%	3.9%
Container - 4000	24	2.3%	3.1%
Container – 5000	25	2.1%	2.8%
Container – 6000	25	2.1%	2.8%
Container – 7000	25	2.1%	2.8%
Container – 8000	25	2.2%	2.9%
Cruise	22	3.1%	3.9%
General Cargo	16	3.0%	9.6%
Ocean tug	14	4.1%	13.3%
Miscellaneous	16	3.0%	9.4%
Reefer	19	2.8%	4.8%
RoRo	21	2.3%	4.4%
Tanker	15	3.4%	11.4%

DB ID478

3.5.7 Propulsion Engine Defaults

All the vessels that called the Port in 2006 were able to be matched for main engine power using the most current Lloyd's data, along with ABS data and VBP information for ocean tugs. Therefore, no defaults were used for main engine power.

3.5.8 Auxiliary Engine Emission Factors

The ENTEC auxiliary engine emission factors used in this study are presented in Table 3.12. For medium speed engines built after the year 2000, the 13.0 g/kW-hr NO_X emission factor is used.

Table 3.12: Emission Factors for Auxiliary Engines using Residual Oil, g/kW-hr

Engine	MY	PM_{10}	$PM_{2.5}$	DPM	NO_X	SO_x	CO[34]	HC
Medium speed	<= 1999	1.5	1.2	1.5	14.7	12.3	1.1	0.4
Medium speed	2000+	1.5	1.2	1.5	13.0	12.3	1.1	0.4

DB ID456

Table 3.13: GHG Emission Factors for Auxiliary Engines using Residual Oil, g/kW-hr

Engine	MY	CO_2	CH_4	N_2O
Medium speed	<= 1999	683	0.008	0.031
Medium speed	2000+	683	0.008	0.031

3.5.9 Auxiliary Engine Defaults

Auxiliary engine information is usually not provided to Lloyd's by vessel owners since it is not required by IMO or the classification societies, thus Lloyd's data contains minimal auxiliary engine information. Therefore, auxiliary engine data gathered from the VBP and Lloyd's data on ships making local calls to both San Pedro Bay ports (Los Angeles and Long Beach) was used to generate profiles or defaults for the purpose of "gap filling" when there was missing data.

In addition to maximum power demand, loads were profiled as well. Vessels do not use the total auxiliary engine installed power when at sea, during hotelling and during maneuvering. For each mode and vessel type, a different number of engines may be used and at varying loads depending on several factors, such as weather and number of reefers onboard. Hotelling load is primarily what is needed to meet the power needs of the lights, heating/ventilation/air conditioning (HVAC) systems, communications, computers, ship cranes, pumps, reefer load, and various other power demands while the vessel is at dock. Maneuvering is generally the highest auxiliary load mode for OGVs as the bow thrusters need to be available and used in spurts. The fairway or open sea is generally where the lowest auxiliary loads are found as additional auxiliary power is not required for maneuvering and many vessels

[34] IVL 2004.

have shaft generators and exhaust turbine generators that help provide power to the ship in an effort to reduce operating costs through lower fuel consumption.

From the inception of the VBP, the average or typical number of auxiliary engines used and the corresponding load at sea, during maneuvering and at berth has been studied to gain a better understanding of how the auxiliary engines are used in relation to the total power installed. The load default in kilowatts is based on the percent load which takes into account the average number of actual engines used and their load. Another way to view auxiliary engine load is to see it as the kilowatts used from the total power available. Table 3.14 summarizes the total power and load defaults used for this study by vessel subtype. Cruise ships do not have default values available since each cruise ship is different.

Table 3.14: Auxiliary Engine Power and Load Defaults

Vessel Type	Total Aux Eng Power (kW)	Auxiliary Engines Load Defaults (kW)		
		Sea	Maneuvering	Hotelling
Auto Carrier	2,491	374	1,121	648
Bulk - General	2,028	345	913	446
Bulk Wood Chips	2,850	485	1,283	627
Container - 1000	2,753	358	1,377	496
Container - 2000	4,870	633	2,435	877
Container - 3000	4,697	611	2,348	845
Container - 4000	7,434	966	3,717	1,338
Container - 5000	8,361	1,087	4,180	1,505
Container - 6000	13,226	1,719	6,613	2,381
Container - 7000	13,645	1,774	6,823	2,456
Container - 8000	11,939	1,552	5,970	2,149
Cruise	11,513	na	na	na
General Cargo	2,110	359	949	470
Ocean Tug	600	102	270	134
Miscellaneous	1,505	256	677	336
Reefer	3,480	592	1,566	1,114
Ro/Ro	6,899	1,035	3,104	1,794
Tanker - General	3,049	732	1,006	793
Tanker -Chemical	3,572	857	1,179	929
Tanker - Crude - Aframax	2,364	567	780	615
Tanker - Crude - Handyboat	2,155	517	711	560
Tanker - Crude - Panamax	2,798	671	923	727
Tanker - Crude - Suezmax	2,689	645	887	699
Tanker - Crude - ULCC	4,236	1,017	1,398	1,101
Tanker - Crude - VLCC	4,604	1,105	1,519	1,197
Tanker - Oil Products	2,231	535	736	580
Tankers (Diesel/Electric)	1,985	476	655	516

DB ID471

3.5.10 Auxiliary Boilers

In addition to the auxiliary engines that are used to generate electricity for on-board uses, most OGVs have one or more boilers used for fuel heating and for producing hot water. Boilers are typically not used during transit at sea since many vessels are equipped with an exhaust gas recovery system or "economizer" that uses exhaust for heating purposes and therefore the boilers are not needed when the main engines are used. Boilers are only assumed to be used at reduced speeds, such as during maneuvering and when the vessel is at Port and the main engines are shut down.

Table 3.15 and 3.16 shows the emission factors used for the steam boilers based on ENTEC's emission factors for steam boilers (ENTEC 2002).

Table 3.15: Emission Factors for OGV Auxiliary Boilers using Residual Oil, g/kW-hr

Engine	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Steam boilers	0.8	0.6	0.0	2.1	16.5	0.2	0.1

Table 3.16: GHG Emission Factors for OGV Auxiliary Boilers using Residual Oil, g/kW-hr

Engine	CO_2	CH_4	N_2O
Steam boilers	970	0.002	0.08

The boiler fuel consumption collected from vessels during the VBP was converted to equivalent kilowatts using Specific Fuel Consumption (SFC) factors found in the ENTEC report. The average SFC value for using residual fuel is 305 grams of fuel per kW-hour. Using the following equation, the average kW for auxiliary boilers was calculated.

$$\textbf{Average kW} = ((\textbf{daily fuel}/24) \times 1{,}000{,}000)/305 \qquad \text{Equation 3.6}$$

Auxiliary boiler energy defaults in kilowatts used for each vessel type are presented in Table 3.17. The cruise ships and tankers (except for diesel electric tankers) have much higher auxiliary boiler usage rates than the other vessel types. Cruise ships have higher boiler usage due to the number of passengers and need for hot water. Tankers provide steam for steam-powered liquid pumps, inert gas in fuel tanks, and to heat fuel for pumping. Ocean tugboats do not have boilers; therefore their boiler energy default is zero. As mentioned earlier, boilers are not typically used at sea; therefore the boiler energy default at sea is zero.

Table 3.17: Auxiliary Boiler Energy Defaults

Vessel Type	Boiler Energy Defaults (kW)		
	Sea	Maneuvering	Hotelling
Auto Carrier	0	371	371
Bulk - General	0	109	109
Bulk - Heavy Load	0	109	109
Bulk Wood Chips	0	109	109
Container - 1000	0	506	506
Container - 2000	0	506	506
Container - 3000	0	506	506
Container - 4000	0	506	506
Container - 5000	0	506	506
Container - 6000	0	506	506
Container - 7000	0	506	506
Container - 8000	0	506	506
Cruise	0	1,000	1,000
General Cargo	0	106	106
Ocean Tug	0	0	0
Miscellaneous	0	371	371
Reefer	0	464	464
Ro/Ro	0	109	109
Tanker - General	0	371	3,000
Tanker -Chemical	0	371	3,000
Tanker - Crude - Aframax	0	371	3,000
Tanker - Crude - Handyboat	0	371	3,000
Tanker - Crude - Panamax	0	371	3,000
Tanker - Oil Products	0	371	3,000
Tankers (Diesel/Electric)	0	346	346

DB ID470

3.5.11 Fuel Correction Factors

Fuel correction factors are used to adjust the emission rates from the fuel. As discussed earlier, emission factors were given for engines using residual fuel with an average 2.7% sulfur content and marine diesel oil with an average 1.5% sulfur content. Table 3.18 lists the fuel correction factors as used in the San Pedro Bay Clean Air Action Plan.[35]

[35] See *http://www.cleanairactionplan.org.*

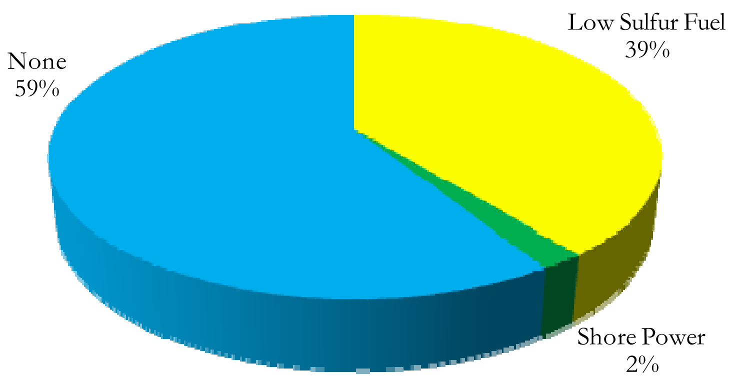
Table 3.18: Fuel Correction Factors

Actual Fuel	Sulfur Content	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
HFO	1.5%	0.82	1	0.56	1	1	1	1	1
MDO	1.5%	0.47	0.90	0.56	1	1	1	0.90	1
MGO	0.5%	0.39	0.90	0.18	1	1	1	0.90	1
MGO	0.2%	0.36	0.90	0.07	1	1	1	0.90	1
MGO	0.1%	0.35	0.90	0.04	1	1	1	0.90	1

DB ID455

In 2006, vessels burned a lower sulfur fuel (39%) or used shore power (2%) at berth for 41% of the vessel calls. Containerships were the vessels that overwhelmingly switched to a lower sulfur fuel and used shore power as compared to other vessel types that called the Port. For the majority of the vessels that switched fuels, the fuel used was marine diesel oil with less than 0.5% sulfur.

Figure 3.6: Vessels Using Low Sulfur Fuel or Shore Power at Berth, % of Vessel Calls



3.5.12 Emission Reduction Technologies

Control factors can also be used for emission reduction technologies that the vessel may have. In 2006, fuel slide valves were used by 29 known vessels that made almost 200 calls to the Port. This new type of fuel valve leads to better combustion process, less smoke, and lower fuel consumption which results in reduced overall emissions for NO_x (30% reduction) and PM (25% reduction). Some new engines, specifically those manufactured by MAN B&W, may have this type of fuel valve. Some companies are retrofitting vessels with MAN B&W main engines in their fleet with the fuel slide valve. Since the slide valves are on a vessel by vessel basis, the inventory may not have captured all the vessels with slide valves that called at the Port in 2006. The emission reductions used for the slide valves are based on MAN B&W Diesel A/S emission measurements of marine vessel *Sine Maersk*.

3.6 Emission Estimates

A summary of the ocean-going vessel emission estimates by vessel type for all pollutants for the year 2006 is presented in Tables 3.19 and 3.20. Ocean-going vessel data is presented in Appendix A.

Table 3.19: 2006 Ocean-Going Vessel Emissions by Vessel Type, tpy

Vessel Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto Carrier	**6.7**	**5.3**	**6.2**	**73.3**	**52.3**	**6.3**	**2.9**
Bulk	34.1	27.3	31.7	328.0	292.3	26.6	11.0
Bulk - Heavy Load	0.7	0.5	0.5	5.5	7.2	0.4	0.2
Bulk - Self Discharging	0.1	0.1	0.1	1.3	1.0	0.1	0.0
Bulk Wood Chips	0.3	0.2	0.3	2.9	2.6	0.2	0.1
Bulk	**35.2**	**28.2**	**32.6**	**337.7**	**303.0**	**27.4**	**11.3**
Container - 1000	30.0	24.0	22.0	268.2	322.8	22.4	9.5
Container - 2000	23.2	18.5	19.0	240.8	204.1	20.9	9.6
Container - 3000	38.2	30.6	33.9	424.4	306.4	37.0	18.1
Container - 4000	127.3	101.8	117.2	1,419.7	950.3	133.0	65.1
Container - 5000	89.4	71.5	80.7	969.5	701.1	96.2	47.4
Container - 6000	57.2	45.8	52.1	810.8	359.4	79.8	38.0
Container - 7000	21.4	17.1	19.1	327.5	142.1	35.1	16.4
Container - 8000	1.0	0.8	0.9	8.7	7.6	0.8	0.4
Containership	**387.6**	**310.1**	**344.9**	**4,469.5**	**2,993.8**	**425.3**	**204.6**
Cruise	**85.8**	**68.6**	**82.3**	**789.3**	**750.8**	**64.0**	**26.4**
General Cargo	**17.5**	**14.0**	**14.5**	**157.3**	**171.4**	**12.7**	**5.4**
Ocean Tugboat	**1.0**	**0.8**	**1.0**	**23.6**	**0.8**	**2.2**	**1.0**
Miscellaneous	**0.2**	**0.1**	**0.1**	**1.5**	**2.0**	**0.1**	**0.1**
Reefer	**7.9**	**6.4**	**6.9**	**72.4**	**75.4**	**5.7**	**2.4**
RoRo	**0.6**	**0.5**	**0.6**	**6.6**	**3.9**	**0.5**	**0.2**
Tanker - General	35.3	28.2	19.2	232.6	480.3	19.5	8.3
Tanker - Chemical	8.9	7.1	5.3	62.1	114.7	5.2	2.2
Tanker - Crude - Aframax	2.2	1.8	1.6	16.8	25.6	1.4	0.6
Tanker - Crude - Handyboat	3.7	3.0	2.1	24.1	48.9	2.1	0.9
Tanker - Crude - Panamax	5.7	4.6	4.0	41.2	67.6	3.6	1.5
Tanker - Oil Products	45.2	36.2	25.2	305.5	621.1	25.5	10.9
Tanker	**101.0**	**80.8**	**57.4**	**682.2**	**1,358.0**	**57.2**	**24.4**
Total	**643.5**	**514.8**	**546.4**	**6,613.6**	**5,711.4**	**601.5**	**278.6**

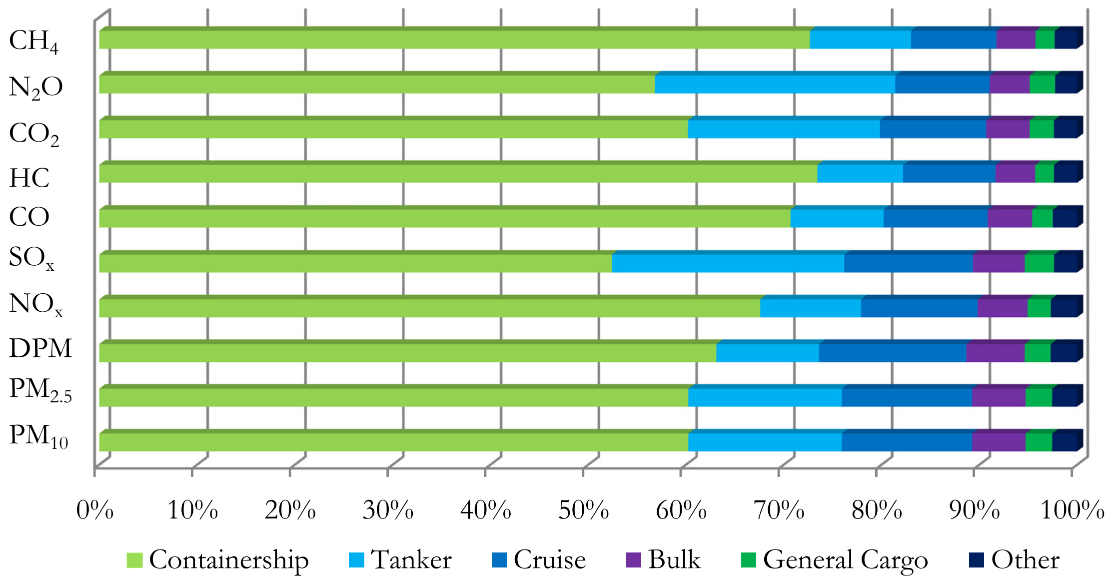
DB ID121

Table 3.20: Summary of 2006 Ocean-Going Vessel GHG Emissions by Vessel Type, tpy

Vessel Type	CO_2	N_2O	CH_4
Auto Carrier	**3,462.1**	**0.2**	**0.0**
Bulk	17,419.8	0.9	0.1
Bulk - Heavy Load	424.4	0.0	0.0
Bulk - Self Discharging	56.5	0.0	0.0
Bulk Wood Chips	151.4	0.0	0.0
Bulk	**18,052.1**	**0.9**	**0.1**
Container - 1000	20,686.7	1.3	0.1
Container - 2000	14,732.6	0.9	0.1
Container - 3000	21,362.5	1.2	0.2
Container - 4000	70,511.8	3.7	0.7
Container - 5000	53,186.5	2.8	0.5
Container - 6000	43,984.1	2.2	0.4
Container - 7000	19,786.2	0.9	0.2
Container - 8000	445.6	0.0	0.0
Containership	**244,695.9**	**13.0**	**2.1**
Cruise	**44,133.4**	**2.2**	**0.3**
General Cargo	**10,079.6**	**0.6**	**0.1**
Ocean Tugboat	**1,294.9**	**0.1**	**0.0**
Miscellaneous	**118.0**	**0.0**	**0.0**
Reefer	**4,432.9**	**0.2**	**0.0**
RoRo	**335.6**	**0.0**	**0.0**
Tanker - General	28,235.5	2.0	0.1
Tanker - Chemical	6,741.1	0.5	0.0
Tanker - Crude - Aframax	1,504.3	0.1	0.0
Tanker - Crude - Handyboat	2,871.7	0.2	0.0
Tanker - Crude - Panamax	3,971.2	0.3	0.0
Tanker - Oil Products	36,512.0	2.6	0.1
Tanker	**79,835.7**	**5.6**	**0.3**
Total	**406,440.1**	**22.8**	**2.9**

Figure 3.7 shows percentage of emissions by vessel type for each pollutant. Containerships have the highest percentage of the emissions (approximately 50 to 70%) for the vessels, followed by tankers (10 to 20%), cruise ships (10 to 12%), bulk and general cargo. The "other" category includes general cargo, ocean-going tugboats and miscellaneous vessels.

Figure 3.7: 2006 Ocean-Going Vessel Emissions by Vessel Type, %



3.6.1 Emission Estimates by Engine Type

Tables 3.21 and 3.22 present summaries of emission estimates by engine type in tons per year.

Table 3.21: 2006 Ocean-Going Vessel Emissions by Engine Type, tpy

Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auxiliary Engine	255.8	204.6	255.8	3,068.4	1,793.6	256.3	93.2
Auxiliary Boiler	92.8	74.2	0.0	243.8	1,909.9	23.2	11.6
Main Engine	295.0	236.0	290.6	3,301.4	2,007.9	321.9	173.8
Total	**643.5**	**514.8**	**546.4**	**6,613.6**	**5,711.4**	**601.5**	**278.6**

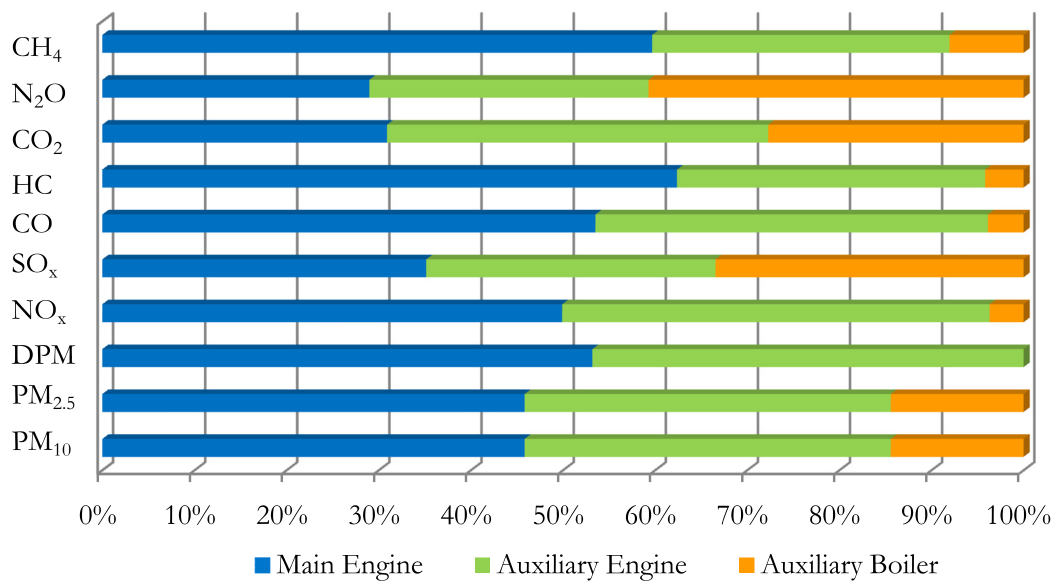
DB ID118

Table 3.22: 2006 Ocean-Going Vessel GHG Emissions by Engine Type, tpy

Engine Type	CO_2	N_2O	CH_4
Auxiliary Engine	168,224.5	6.9	0.9
Auxiliary Boiler	112,620.1	9.3	0.2
Main Engine	125,595.5	6.6	1.7
Total	**406,440.1**	**22.8**	**2.9**

Figure 3.8 shows results in percentages for emission estimates by engine type. The auxiliary boilers generally have lower NO_x emission rates and higher SO_x emission rates than diesel engines which may explain the higher SO_x emissions percentage for auxiliary boilers.

Figure 3.8: 2006 Ocean-Going Vessel Emissions by Engine Type, %



3.6.2 Emission Estimates by Mode

Tables 3.23 and 3.24 present summaries of emission estimates by the various modes in tons per year. For each mode, the engine type emissions are also listed. Hotelling at terminal berth and at anchorage are listed separately. Transit and harbor maneuvering emissions include both berth and anchorage calls.

Figure 3.9: 2006 Ocean-Going Vessel Emissions by Mode

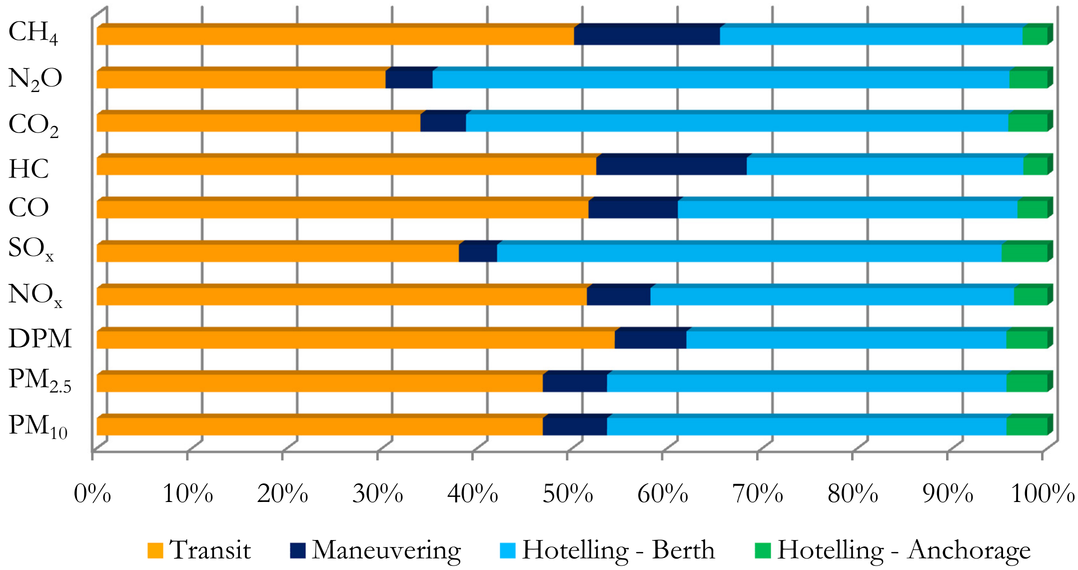


Table 3.23: 2006 Ocean-Going Vessel Emissions by Mode, tpy

Mode	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Transit	Aux	28.5	22.8	28.5	301.1	216.9	24.7	9.0
Transit	Auxiliary Boiler	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transit	Main	273.5	218.8	269.3	3,109.4	1,959.4	286.5	137.4
Total Transit		**302.0**	**241.6**	**297.8**	**3,410.5**	**2,176.2**	**311.2**	**146.4**
Maneuvering	Aux	19.8	15.9	19.8	244.3	136.0	20.5	7.5
Maneuvering	Auxiliary Boiler	2.2	1.7	0.0	5.7	44.8	0.5	0.3
Maneuvering	Main	21.5	17.2	21.4	192.0	48.6	35.4	36.4
Total Maneuvering		**43.5**	**34.8**	**41.2**	**442.1**	**229.4**	**56.5**	**44.1**
Hotelling - Berth	Aux	183.9	147.1	183.9	2,301.3	1,249.9	193.2	70.2
Hotelling - Berth	Auxiliary Boiler	86.5	69.2	0.0	227.4	1,781.0	21.7	10.8
Hotelling - Berth	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling - Berth		**270.4**	**216.3**	**183.9**	**2,528.7**	**3,030.9**	**214.8**	**81.1**
Hotelling - Anchorage	Aux	23.6	18.9	23.6	221.6	190.8	17.9	6.5
Hotelling - Anchorage	Auxiliary Boiler	4.1	3.3	0.0	10.7	84.1	1.0	0.5
Hotelling - Anchorage	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling - Anchorage		**27.7**	**22.1**	**23.6**	**232.3**	**274.9**	**19.0**	**7.0**
Total		**643.5**	**514.8**	**546.4**	**6,613.6**	**5,711.4**	**601.5**	**278.6**

Table 3.24: 2006 Ocean-Going Vessel Greenhouse Gas Emissions by Mode, tpy

Mode	Engine Type	CO_2	N_2O	CH_4
Transit	Aux	16,195.0	0.7	0.1
Transit	Auxiliary Boiler	0.0	0.0	0.0
Transit	Main	122,237.0	6.3	1.4
Total Transit		**138,432.0**	**6.9**	**1.4**
Maneuvering	Aux	13,474.6	0.6	0.1
Maneuvering	Auxiliary Boiler	2,650.8	0.2	0.0
Maneuvering	Main	3,358.5	0.4	0.4
Total Maneuvering		**19,483.9**	**1.1**	**0.4**
Hotelling - Berth	Aux	126,782.5	5.2	0.7
Hotelling - Berth	Auxiliary Boiler	105,021.8	8.7	0.2
Hotelling - Berth	Main	0.0	0.0	0.0
Total Hotelling - Berth		**231,804.3**	**13.8**	**0.9**
Hotelling - Anchorage	Aux	11,772.5	0.5	0.1
Hotelling - Anchorage	Auxiliary Boiler	4,947.4	0.4	0.0
Hotelling - Anchorage	Main	0.0	0.0	0.0
Total Hotelling - Anchorage		**16,720.0**	**0.9**	**0.1**
Total		**406,440.1**	**22.8**	**2.9**

3.7 Facts and Findings

Information gathered during the data collection process, but not necessarily used for emissions calculations, is summarized in this subsection. Table 3.25 summarizes the number of calls and total TEUs handled by the Port in 2001, 2005 and 2006. It was another record year with about 8.5 million total TEUs handled at the Port in 2006.

Table 3.25: TEUs per vessel call in 2006, 2005 and 2001

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2001	2,717	1,584	5,183,520	3,272
2005	2,341	1,423	7,484,625	5,260
2006	2,708	1,626	8,469,853	5,209

DB ID452

3.7.1 Flags of Convenience

Most OGVs are foreign flagged ships, whereas harbor vessels are almost exclusively domestic. Over 94% of the OGVs that visited the Port of Los Angeles in 2006 were registered outside the U.S. Although only 6% of the individual OGVs are registered in the U.S., they comprise 14% of all calls. This is most likely because the U.S. flagged OGVs make shorter, more frequent stops along the west coast.

Figures 3.10 and 3.11 shows the breakdown of the ships' registered country (i.e., flag of registry) for discrete vessels and by the number of calls, respectively. Approximately 30 other flags of registry were not included in the pie charts separately and are included together as "other" category.

Figure 3.10: Flag of Registry, Discrete Vessel

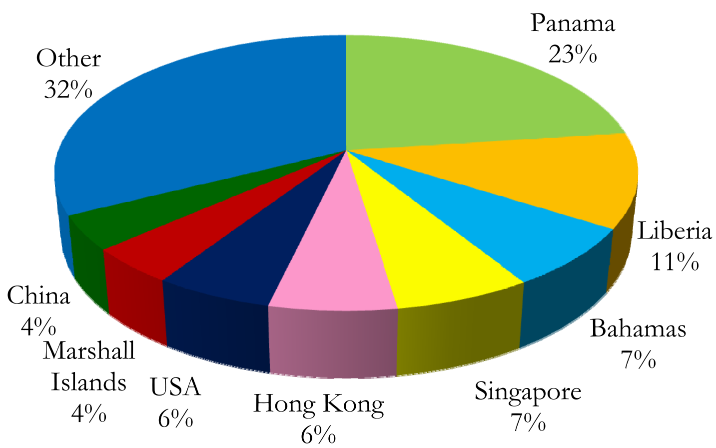
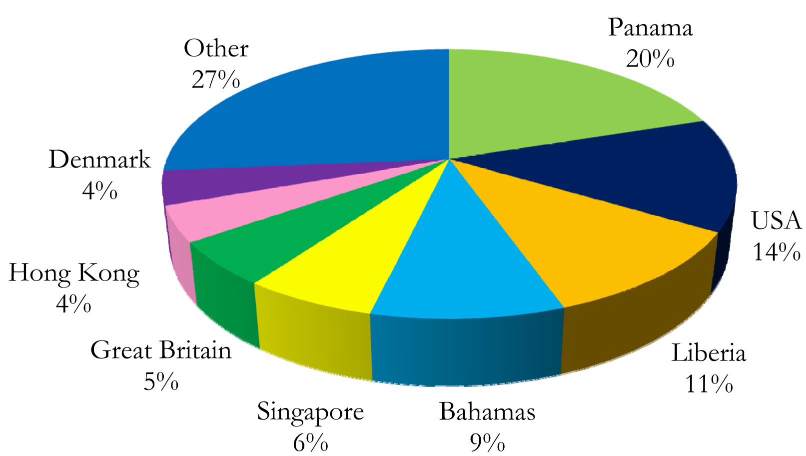


Figure 3.11: Flag of Registry, Vessel Call



3.7.2 Next and Last Port of Call

Figures 3.12 and 3.13 summarize the next (to) port and last (from) port, respectively, for vessels that called in 2006. The other category contains about 200 ports that had less than 3% each.

Figure 3.12: Next (To) Port

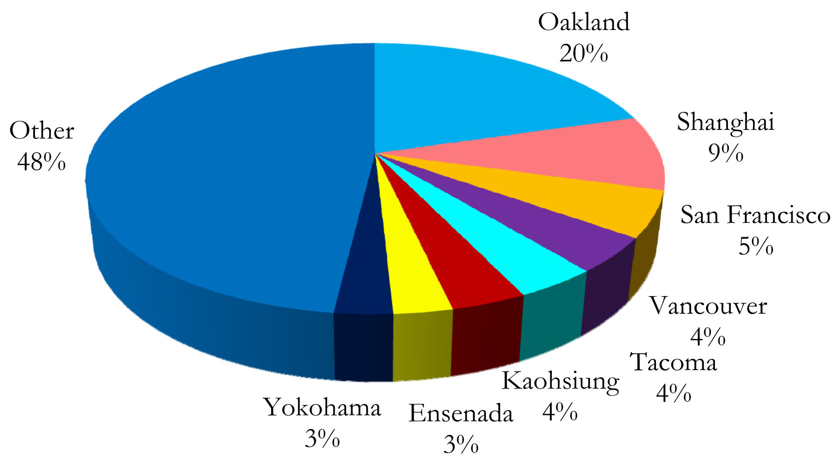
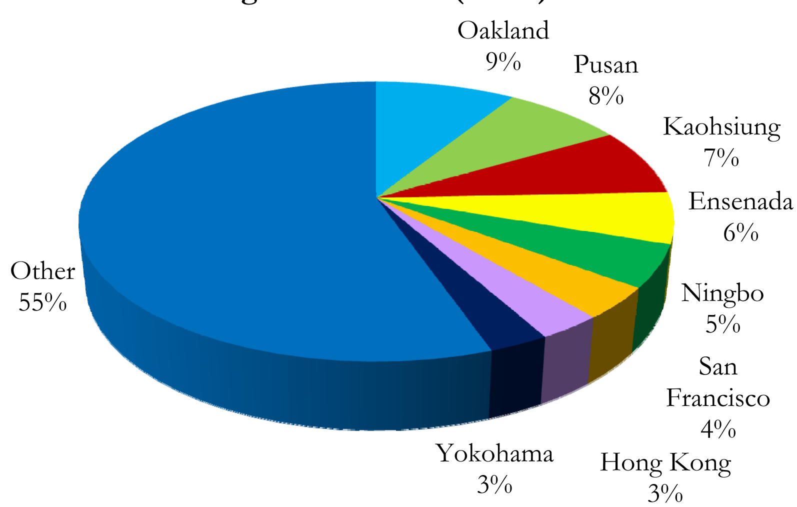


Figure 3.13: Last (From) Port



3.7.3 Vessel Characteristics

Table 3.26 summarizes the vessel and engine characteristics by vessel type. The year built, deadweight (Dwt), speed, and main engine power are based on the specific vessels that called at the Port. Due to the large number of containerships and tankers that call at the Port and their variety, the vessels were divided by vessel types.

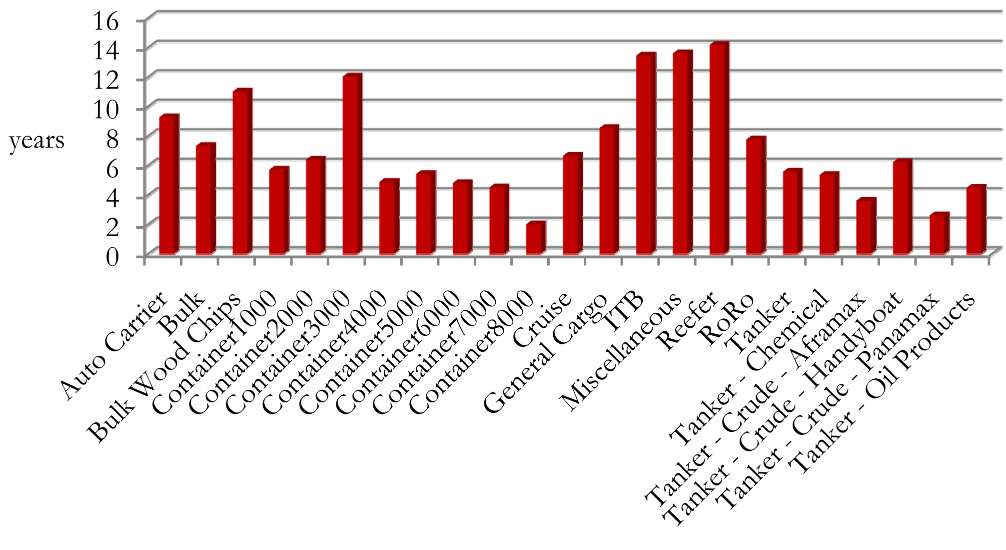
Table 3.26: Vessel Type Characteristics for Vessels that Called the Port in 2006

Vessel Type	Year Built	Average Age (Years)	Average DWT (tons)	Average Speed (knots)	Average Main Eng (kW)	Average Aux Eng (kW)
Auto Carrier	1997	9	17,092	18.9	10,773	2,478
Bulk	1999	7	43,259	14.4	7,782	2,053
Bulk Wood Chips	1995	11	38,296	14.8	5,994	2,028
Container - 1000	2000	6	18,591	19.3	12,806	2,595
Container - 2000	2000	6	32,872	21.6	21,598	4,923
Container - 3000	1994	12	45,625	22.1	27,680	4,665
Container - 4000	2001	5	57,159	24.1	41,934	7,693
Container - 5000	2001	5	66,539	25.2	51,529	8,291
Container - 6000	2001	5	81,220	24.9	58,210	13,086
Container - 7000	2002	5	95,709	25.1	56,255	13,707
Container - 8000	2004	2	101,691	25.2	68,490	11,878
Cruise	1999	7	8,547	21.5	33,716	8,429
General Cargo	1997	9	39,969	15.5	9,481	2,071
ITB	1993	13	48,257	14.2	13,386	650
MISC	1992	14	37,597	14.8	9,973	1,524
Reefer	1992	14	12,193	19.5	9,120	3,444
RoRo	1998	8	11,680	16.2	10,418	6,899
Tanker	2000	6	39,843	15.0	9,222	3,051
Tanker - Chemical	2001	5	30,071	14.9	7,457	3,098
Tanker - Crude - Aframax	2002	4	107,874	14.8	15,187	2,530
Tanker - Crude - Handyboat	2000	6	49,911	14.8	7,665	3,049
Tanker - Crude - Panamax	2003	3	70,762	14.9	11,183	3,087
Tanker - Oil Products	2002	4	48,631	14.6	8,952	2,980

DB ID460

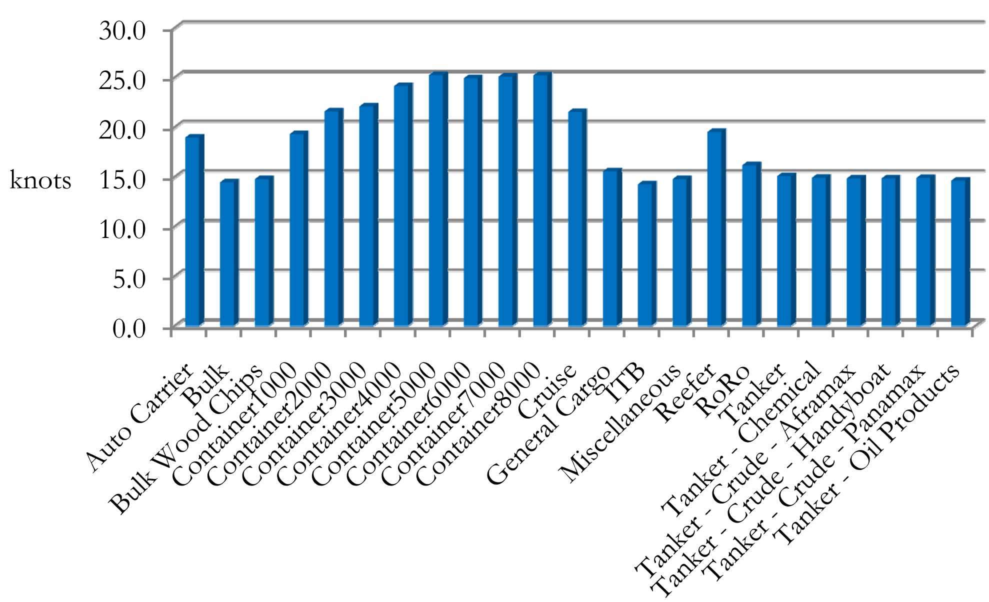
The larger containerships and tankers (Aframax and Panamax) that called the Port have newer vessels.

Figure 3.14: Average Age of Vessels that Called the Port of Los Angeles in 2006, years



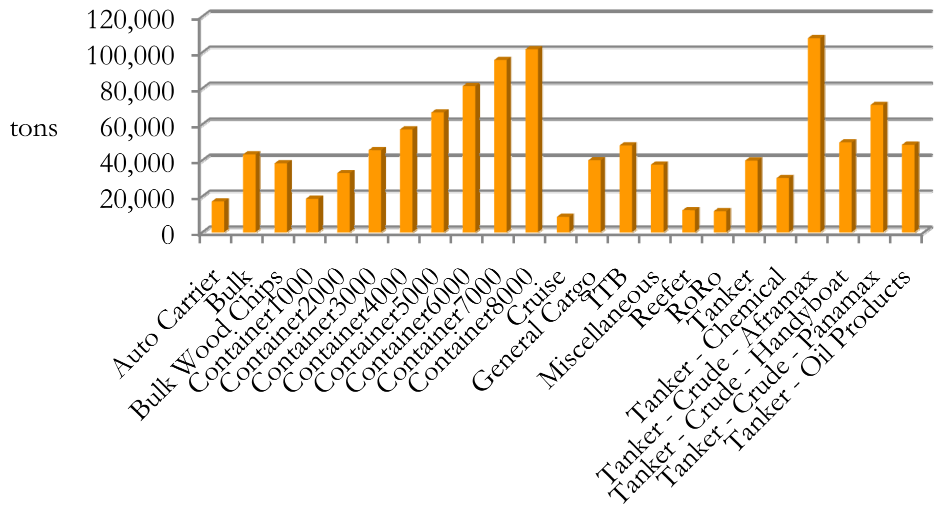
Containerships and cruise ships have the highest maximum rated speeds.

Figure 3.15: Average Maximum Rated Sea Speed of Vessels that Called the Port in 2006, knots



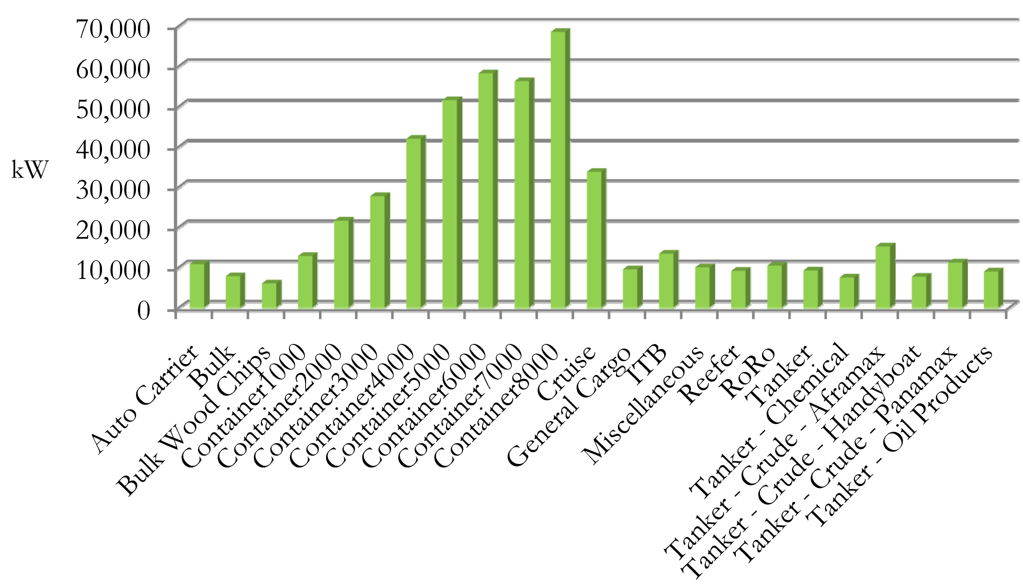
The largest containerships (7000+TEU) and the Aframax Tankers have the largest average deadweight tonnage among the various vessel types, while cruise ships, reefer, and RoRos weigh the least.

Figure 3.16: Average Deadweight of Vessels that Called the Port in 2006, tons



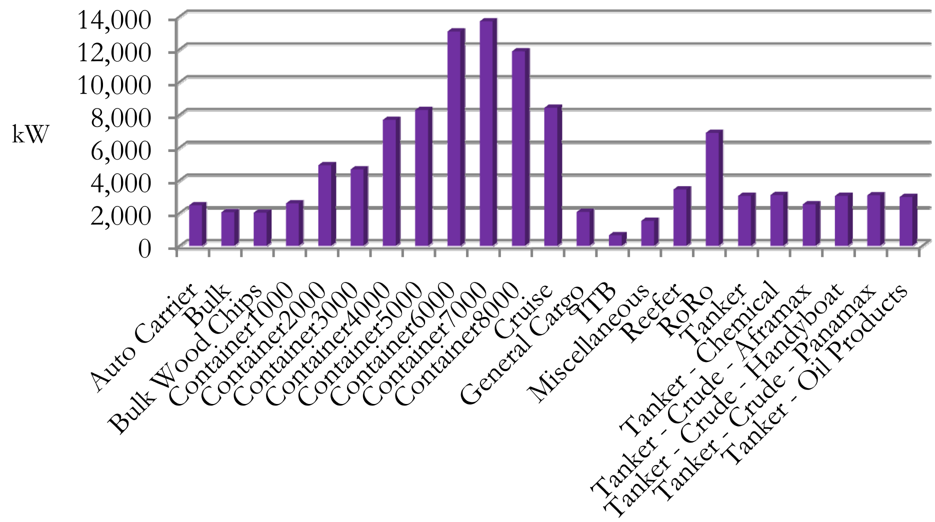
Containerships have the highest main engine total installed power, followed by cruise ships.

Figure 3.17: Average Main Engine Total Installed Power of Vessels that Called the Port in 2006, kilowatts



The 6000+ TEU containerships and cruise ships have the highest auxiliary engine total installed power.

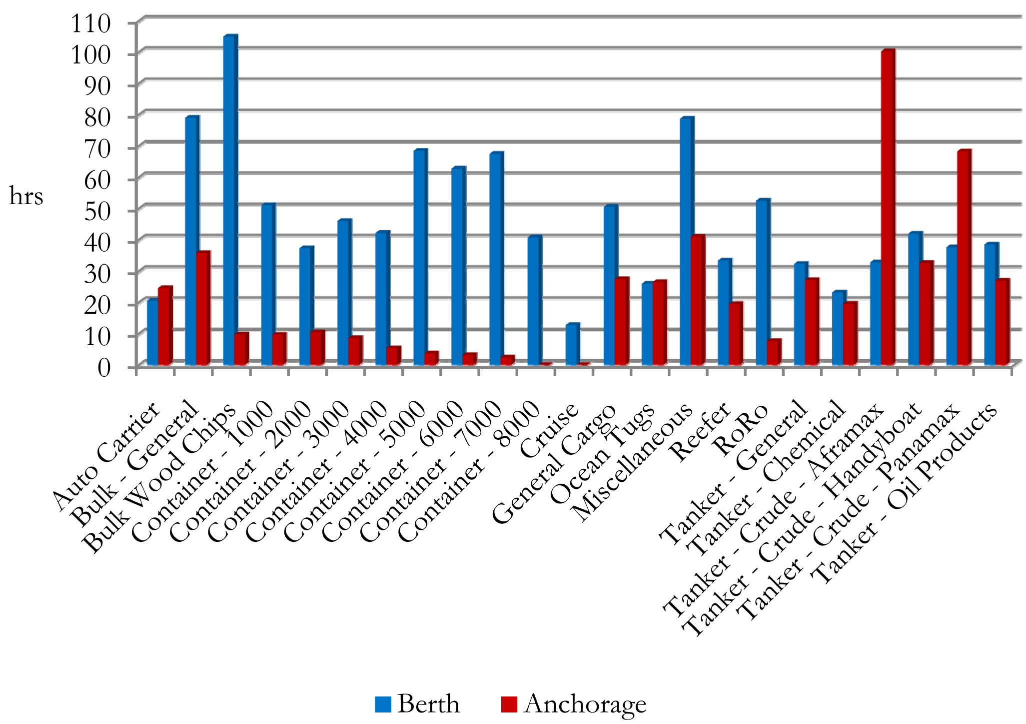
Figure 3.18: Average Auxiliary Engine Total Installed Power of Vessels that Called the Port in 2006, kilowatts



3.7.4 Hotelling Time at Berth and Anchorage

Figure 3.19 shows the average hotelling times at berth and anchorage by vessel type for vessels that called the Port in 2006. The figure shows cruise ships and larger containerships spend little to no time at anchorage. Tankers, especially the Aframax and Panamax crude tankers spend more time at anchorage than berth.

Figure 3.19: Average Hotelling Time at Berth and Anchorage, hours



Tables 3.27 and 3.28 summarize the berth and anchorage hotelling times, respectively. A containership shows a maximum berth hotelling time of 2,924 hours. This is not a routine berth call and the vessel may have had a malfunction that kept it at berth. Cruise ships stayed the least amount of time at berth followed by auto carriers. Average hotelling times are not used in emissions calculation, this table is intended for illustrative purposes.

Table 3.27: Hotelling Times at Berth for Vessels that Called the Port in 2006 by Vessel Type

	Berth Hotelling Time, hours		
Vessel Type	**Min**	**Max**	**Avg**
Auto Carrier	8.3	43.8	20.5
Bulk - General	10.9	302.2	79.0
Bulk Wood Chips	71.3	138.7	105.0
Container - 1000	10.6	2,924.0	51.1
Container - 2000	10.8	84.8	37.3
Container - 3000	12.3	86.8	46.0
Container - 4000	2.8	189.8	42.2
Container - 5000	13.4	123.1	68.4
Container - 6000	11.9	134.3	62.8
Container - 7000	50.0	99.5	67.5
Container - 8000	35.8	48.8	40.8
Cruise	3.2	40.3	12.8
General Cargo	9.3	189.6	50.6
Ocean Tugs	8.4	45.9	26.0
Miscellaneous	24.4	144.8	78.7
Reefer	4.0	212.8	33.4
RoRo	16.7	111.7	52.5
Tanker - General	8.2	186.3	32.3
Tanker - Chemical	8.9	71.4	23.2
Tanker - Crude - Aframax	18.3	47.3	32.8
Tanker - Crude - Handyboat	17.3	70.8	42.0
Tanker - Crude - Panamax	16.3	75.2	37.6
Tanker - Oil Products	12.0	89.1	38.5

DB ID204

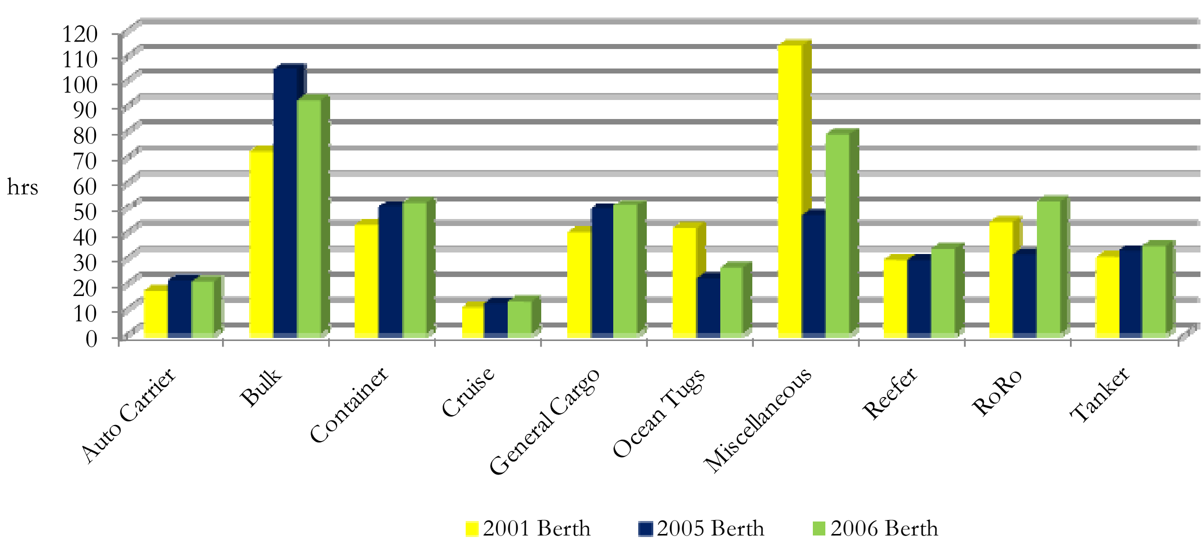
Table 3.28: 2006 Hotelling Times at Anchorage by Vessel Type

Vessel Type	Anchorage Hotelling Time, hours Min	Max	Avg
Auto Carrier	1.4	157.7	24.6
Bulk - General	1.2	241.6	35.8
Bulk Wood Chips	2.5	19.5	9.7
Container - 1000	0.8	52.8	9.4
Container - 2000	0.9	30.1	9.9
Container - 3000	1.1	46.2	8.6
Container - 4000	0.6	24.6	5.2
Container - 5000	1.8	15.1	3.7
Container - 6000	1.3	8.7	3.2
Container - 7000	2.1	2.8	2.4
Container - 8000	0.0	0.0	0.0
Cruise	0.0	0.0	0.0
General Cargo	1.9	149.1	27.4
Ocean Tugs	2.8	75.7	26.5
Miscellaneous	15.0	66.6	41.0
Reefer	3.5	46.0	19.5
RoRo	7.7	7.7	7.7
Tanker - General	1.6	283.8	27.1
Tanker - Chemical	1.1	125.7	19.5
Tanker - Crude - Aframax	5.1	414.8	100.3
Tanker - Crude - Handyboat	1.7	137.3	32.6
Tanker - Crude - Panamax	3.3	753.3	68.3
Tanker - Oil Products	1.2	204.3	26.9

DB ID449

Figure 3.20 compares the average hotelling times at berth by vessel type for activity years 2001, 2005 and 2006. The port-wide average for hotelling at berth in 2006 was 47 hours as compared to 44 hours in 2005.

Figure 3.20: Comparison of Average Hotelling Time at Berth for Vessels that Called the Port in 2001, 2005 and 2006, hours



3.7.5 Frequent Callers

For purpose of this discussion, a frequent caller is a vessel that made six or more calls in one year. The vessels that made a call to a berth at the Port were included, while the vessels that only went to anchorage were not. Table 3.29 shows the percentage of repeat vessels and repeat calls. Container vessels, cruise ships and ocean tugs had the highest percentage of frequent callers in 2006. Tankers, reefer vessels, RoRos, general cargo and bulk vessels are not frequent callers.

Table 3.29: Percentage of Frequent Callers in 2006

	Frequent		Total		Percent	
Vessel Type	**Calls**	**Vessels**	**Calls**	**Vessels**	**Calls**	**Vessels**
Auto Carrier	31	3	72	35	43%	9%
Bulk - General	0	0	211	171	0%	0%
Bulk Wood Chips	0	0	2	2	0%	0%
Container - 1000	166	15	213	35	78%	43%
Container - 2000	94	11	149	35	63%	31%
Container - 3000	118	12	201	43	59%	28%
Container - 4000	336	37	514	107	65%	35%
Container - 5000	209	23	289	64	72%	36%
Container - 6000	145	16	181	28	80%	57%
Container - 7000	11	1	78	16	14%	6%
Container - 8000	0	0	1	1	0%	0%
Cruise	228	7	263	28	87%	25%
General Cargo	0	0	100	64	0%	0%
Ocean Tugs	48	3	53	6	91%	50%
Miscellaneous	0	0	4	3	0%	0%
Reefer	0	0	33	18	0%	0%
RoRo	0	0	3	3	0%	0%
Tanker - General	44	4	122	65	36%	6%
Tanker - Chemical	0	0	43	30	0%	0%
Tanker - Crude - Aframax	0	0	4	4	0%	0%
Tanker - Crude - Handyboat	0	0	11	7	0%	0%
Tanker - Crude - Panamax	0	0	13	11	0%	0%
Tanker - Oil Products	52	3	148	68	35%	4%
Total	**1,482**	**135**	**2,708**	**844**		
Average					**55%**	**16%**

SECTION 4 HARBOR CRAFT

This section presents emissions estimates for the commercial harbor craft source category, including source description (4.1), geographical delineation (4.2), data and information acquisition (4.3), operational profiles (4.4), emissions estimation methodology (4.5), and the emission estimates (4.6).

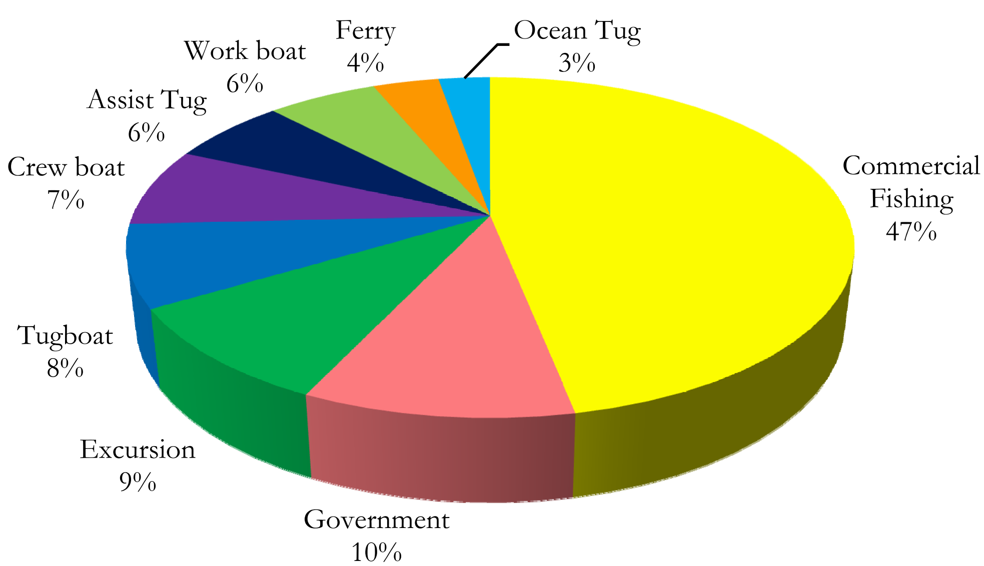
4.1 Source Description

Harbor craft are commercial vessels that spend the majority of their time within or near the Port and harbor. The harbor craft emissions inventory consists of the following vessel types:

- Assist tugboats
- Commercial fishing vessels
- Crew boats
- Ferry vessels
- Excursion vessels
- Government vessels
- Harbor tugboats
- Ocean tugboats
- Work boats

Recreational vessels are not considered to be commercial harbor craft; therefore their emissions are not included in this study. Figure 4.1 presents the distribution of the 256 commercial harbor craft inventoried for the Port in 2006. Commercial fishing vessels represent 47% of the harbor craft inventoried, followed by the government vessels (10%), excursion vessels (9%), harbor tugboats (8%), crew boats (7%), assist tugs (6%) and work boats (6%).

Figure 4.1: Distribution of 2006 Commercial Harbor Craft for Port of Los Angeles



Ocean tugboats included in this section are different from the integrated tug barge (ITB) and articulated tug barge (ATB) included in the ocean-going section of this study. ITB and ATB are seen as a specialized single vessel and are included in the marine exchange data for ocean-going vessels. The ocean tugs in this section are not rigidly connected to the barge and are typically not home-ported here, but may make frequent calls with barges. They are separated from harbor tugboats because their engine loads are higher than harbor tugs which tend to idle more in-between jobs.

This inventory covers harbor craft that operate in the Port of Los Angeles most of the time. There are a number of companies that operate harbor craft in both the Ports of Los Angeles and Long Beach harbors. The activity hours for the vessels that are common to both ports reflect work performed during 2006 for the Port of Los Angeles harbor only[36].

4.2 Geographical Delineation

The geographical extent of the emissions inventory for harbor craft is the boundary for the (SoCAB). Most harbor craft work the majority of the time within the harbor and up to 25 nautical miles from the Port. For those harbor craft that work outside of the harbor and travel to other ports, vessel operators were asked to provide hours up to 50 nautical miles from the Port in order to ensure the SoCAB boundary would be included in the estimated hours.

Figure 4.2: Geographical Extent of Harbor Craft Inventory

[36] This inventory should not be compared to other inventories that may cover a wider area and include vessels at nearby ports.

4.3 Data and Information Acquisition

To collect data for the harbor craft inventory, the following sources were used:

- Vessel owners and/or operators
- Wharfingers data for commercial fishing vessels at Port-owned berths
- List of repowered vessels in South Coast provided by CARB
- List of Port-funded projects

The operating parameters of interest included the following:

- Vessel type
- Number, type and horsepower (or kilowatts) of main engine(s)
- Number, type and horsepower (or kilowatts) of auxiliary engines
- Activity hours for 2006
- Information on percentage of time operating within harbor, up to 25 miles from port and within 25 miles to 50 miles from Port
- Annual fuel consumption
- Qualitative information regarding how the vessels are used in service
- Engine model year
- Replaced engines
- Emission reduction strategies such as: alternative fuels, retrofits with after-treatment, and shore power

The following companies were contacted to collect information on their fleet:

Excursion vessels:

- L.A. Harbor Sportfishing
- 22nd St. Partners, Sportfishing
- Los Angeles Harbor Cruise
- Spirit Cruises
- Fiesta Harbor Cruises
- Seahawk Sportfishing

Commercial fishing vessels:

- Berth 73 and Fish Harbor, Port-owned marinas

Ferry vessels:

- Catalina Channel Express
- Seaway Co. of Catalina

Government Vessels:

- L.A. Fire Department
- L.A. Police Department
- Harbor Department
- Port of Los Angeles Pilots

Workboats:

- Clean Coastal Waters
- Pacific Tugboat Services
- Jankovich

Crewboats:

- U.S. Water Taxi
- American Marine Corp.
- Southern California Ship Services

Assist tugboats and harbor tugs:

- Crowley Marine Services
- Foss Maritime Company
- Millenium Maritime
- Amnav

Harbor and ocean tugs:

- Crowley Petroleum Services
- Sause Brothers Ocean Towing
- Westoil Marine Services
- Peninsula Tugboat Services

4.4 Operational Profiles

Commercial harbor craft companies were identified and contacted to obtain the operating parameters of their vessels.

Tables 4.1 and 4.2 summarize the main and auxiliary engine data, respectively, for each vessel type. The tables below include engine specific information obtained from operators of the vessels included in this inventory. The averages by vessel type in these tables were used as defaults for vessels where the model year, horsepower, or operating activity hour information was missing. The operational hours for some of the vessels that were not at the Port the full year reflect the partial time they worked in the harbor for the 2006 calendar year. For those vessels with "na", there was not enough data to include a model year minimum, maximum and average model year. The following defaults were used for "na" in the tables below:

- For commercial fishing and workboat propulsion engines, an average of 1996 model year
- For commercial fishing, government and workboat auxiliary engines, an average of 1997 model year

Table 4.1: Main Engine Data by Vessel Category

Harbor Vessel Type	Vessel Count	Engine Count	Model year Minimum	Model year Maximum	Model year Average	Horsepower Minimum	Horsepower Maximum	Horsepower Average	Annual Operating Hours Minimum	Annual Operating Hours Maximum	Annual Operating Hours Average
			Propulsion Engines								
Assist Tug	16	32	1982	2005	1997	1251	2541	2023	150	2,500	1,773
Commercial Fishing	120	124	na	2004	na	50	940	236	200	4,000	1,591
Crew boat	19	41	1970	2004	1995	211	1400	407	0	1,805	687
Excursion	24	44	1959	2004	1995	150	530	351	350	6,600	2,150
Ferry	9	20	1997	2004	2002	601	2301	1831	750	1,200	1,115
Government	26	36	1963	2003	1996	24	1801	445	25	1,200	450
Ocean Tug	7	14	1968	2002	1988	801	2001	1431	50	750	261
Tugboat	20	40	1974	2006	1999	200	1876	802	0	3,066	967
Work boat	15	29	na	2005	na	200	801	394	26	2,000	318
Total	**256**	**380**									

DB ID423

Table 4.2: Auxiliary Engine Data by Vessel Category

Harbor Vessel Type	Vessel Count	Engine Count	Model year Minimum	Model year Maximum	Model year Average	Horsepower Minimum	Horsepower Maximum	Horsepower Average	Annual Operating Hours Minimum	Annual Operating Hours Maximum	Annual Operating Hours Average
			Auxiliary Engines								
Assist Tug	16	31	1982	2005	2000	115	200	136	150	3,207	1,830
Commercial Fishing	120	24	na	2004	na	9	195	78	100	4,500	1,621
Crew boat	19	16	1977	2004	1991	11	300	126	100	1,600	693
Excursion	24	26	1981	2003	1997	7	54	39	125	6,600	2,197
Ferry	9	12	1990	2003	1999	17	120	57	750	750	750
Government	26	10	na	2003	na	127	400	212	20	300	158
Ocean Tug	7	14	1968	2003	1990	60	150	93	50	750	261
Tugboat	20	27	1970	2006	2000	21	90	50	80	3,066	1,080
Work boat	15	13	na	2003	na	13	83	33	26	2,000	519
Total	**256**	**173**									

DB ID422

Table 4.3 summarizes the time spent in harbor (55%), at 25 miles out (35%) and up to the basin boundary (10%) for all harbor craft.

Table 4.3: Allocation of Time Spent by Harbor Craft Type

Harbor Vessel Type	Harbor	Up to 25 Miles	Up to Basin Boundary
Assist tug	99%	1%	0%
Commercial fishing	10%	50%	40%
Crew boat	51%	49%	0%
Excursion	35%	57%	13%
Ferry	38%	60%	3%
Government	80%	13%	8%
Ocean tug	50%	25%	25%
Tugboat	81%	15%	4%
Work boat	54%	46%	0%
Average	**55%**	**35%**	**10%**

DB ID424

Harbor vessel owners and operators were asked to identify replaced engines from their fleet. In addition, lists of replaced engines with funding from the Port, Carl Moyer program and other state-funded programs were reviewed to identify vessels with replaced engines. The following observations can be made of the 2006 harbor craft inventory for replaced engines.

- 17 vessels have Tier 2 engines (most engines 2004 and newer)
- 79 vessels have Tier 1 engines (most engines ranging from 2000 to 2003 model year)
- 195 vessels have Tier 0 engines (engines older than 1999)

Note that a vessel may have a combination of engines that meet different standards if the engines are not all replaced at the same time. For example, a vessel may receive funding to replace the auxiliary engines, but not propulsion engines or vice-versa. The following tables show a total of 177 propulsion and auxiliary engines replaced, but the majority of the engines were replaced with Tier 1 engines which were the engines that were available at that time.

Table 4.4 shows that in 2006, 27% of all main engines in harbor crafts that operated at the Port in 2006 were replaced.

Table 4.4: Count of Replaced Main Engines

Harbor Vessel Type	Propulsion Engines Engine Count	Engines Repowered	Repowered Engines, %
Assist tug	32	2	6%
Commercial fishing	124	23	19%
Crew boat	41	19	46%
Excursion	44	13	30%
Ferry	20	18	90%
Government	36	2	6%
Ocean tug	14	4	29%
Tugboat	40	19	48%
Work boat	29	4	14%
Total	**380**	**104**	**27%**

DB ID199

Figure 4.3 shows the distribution of the 104 replaced main engines by vessel type.

Figure 4.3: Distribution of Replaced Propulsion Engines by Vessel Type

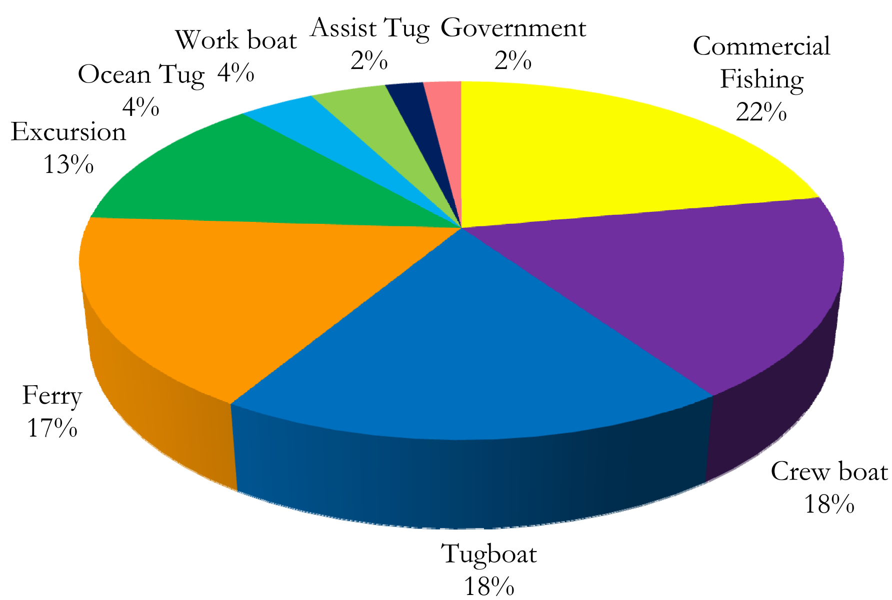


Table 4.5 shows that in 2006, 42% of all auxiliary engines in harbor crafts that operated at the Port in 2006 were replaced.

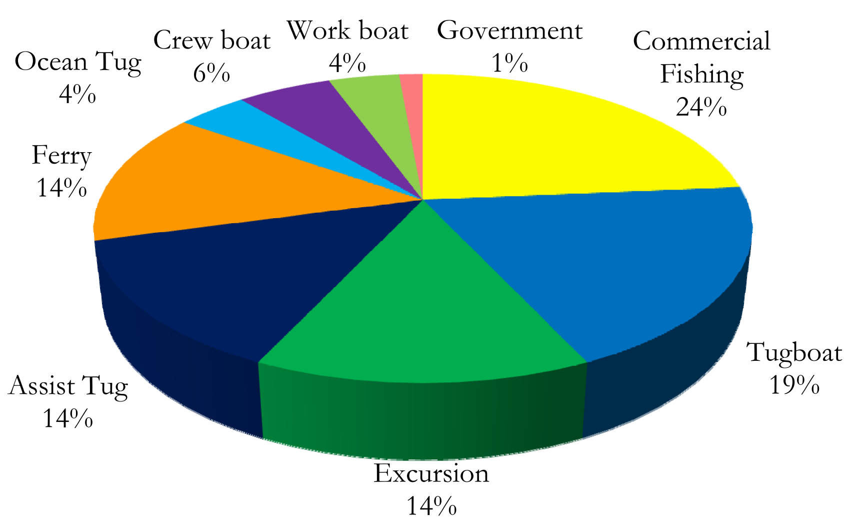
Table 4.5: Count of Replaced Auxiliary Engines

Harbor Vessel Type	Engine Count	Auxiliary Engines Engines Repowered	Repowered Engines, %
Assist tug	31	10	32%
Commercial fishing	24	17	71%
Crew boat	16	4	25%
Excursion	26	10	38%
Ferry	12	10	83%
Government	10	1	10%
Ocean tug	14	4	29%
Tugboat	27	14	52%
Work boat	13	3	23%
Total	**173**	**73**	**42%**

DB ID425

Figure 4.4 shows the distribution of the 73 replaced auxiliary engines by vessel type.

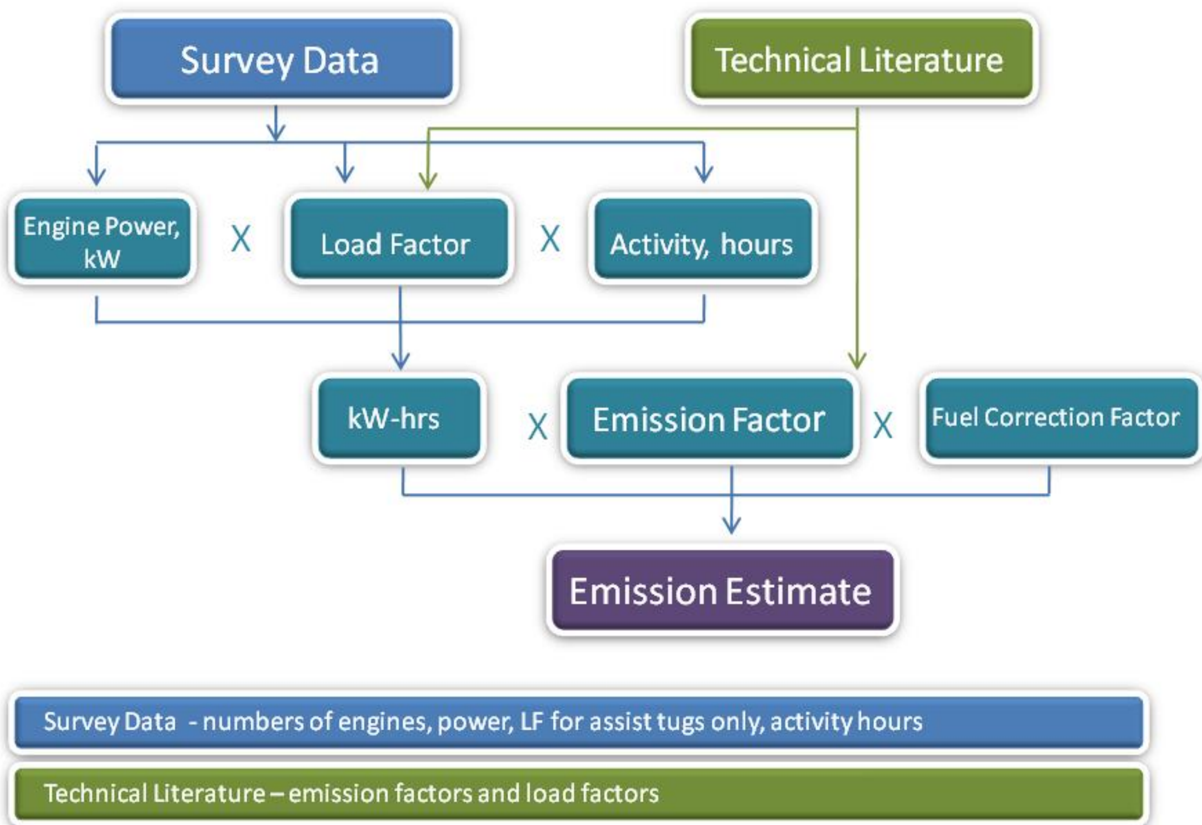
Figure 4.4: Distribution of Replaced Auxiliary Engines by Vessel Type



4.5 Methodology

The emission factors, engine load factors, and emission equations are described in this section. The flow chart in Figure 4.5 graphically breaks down the steps taken to estimate the harbor vessel emissions. Survey data mainly includes the data collected from vessel owners for each main and auxiliary engine. Technical literature was required for the emission factors and load factors which are discussed further in this section. Emissions were estimated on a per engine basis, i.e., the main and auxiliary engines for each vessel were estimated for each vessel.

Figure 4.5: Harbor Craft Emission Estimation Flow Chart



4.5.1 Emission Equations

The basic equation used to estimate harbor vessel emissions is:

$$E = HP \times Act \times LF \times EF \times FCF \qquad \text{Equation 4.1}$$

Where:

E = Emission, g/year
HP = Rated horse-power of the engine in kilowatts
Act = Activity, hours/year
LF = Load Factor
EF = Emission Factor, g/kW-hr
FCF = Fuel Correction Factor

The emission factor (EF) is a function of the zero hour (ZH) emission rate for the engine model year in the absence of any malfunction or tampering of engine components that can change emissions, plus a deterioration rate. The deterioration rate reflects the fact that base emissions of engines change as the equipment is used due to wear of various engine parts or reduced efficiency of emission control devices. The emission factor is calculated as:

Equation 4.2

EF = ZH + (DR x Cumulative Hours)

Where:

> ZH = emission rate when the engine is new and there is no component malfunctioning for a given horsepower category and model year
> DR = deterioration rate (rate of change of emissions as a function of equipment age) Cumulative hours = annual operating hours times age of the equipment

The equation for the deterioration rate is:

Equation 4.3

DR = (DF x ZH) / cumulative hours at the end of useful life

Where:

> DR = deterioration rate
> DF = deterioration factor, percent increase in emissions at the end of the useful life (expressed as %)
> ZH = emission rate when the engine is new and there is no component malfunctioning for a given horsepower category and model year
> Cumulative hours at the end of useful life = annual operating hours times useful life in years

Fuel correction factors are applied to correct the emission rates for the fact that over the years, the fuel properties have changed.

4.5.2 Deterioration Factors, Useful Life and Emission Factors

In order to be consistent, the Port's harbor craft emissions calculations methodology is similar to CARB's recent harbor craft emissions calculations methodology[37], CARB's deterioration rates, useful life, and zero hour emission factors for commercial harbor craft were used. The zero hour emission factors, found in Appendix C, are divided by engine type.

[37] Appendix B: Emissions Estimation Methodology for Commercial Harbor Craft Operating in California. See *http://www.arb.ca.gov/regact/2007chc07/chc07.htm*

Table 4.6: Engine Deterioration Factors for Harbor Craft Diesel Engines

HP Range	PM	NOx	CO	HC
25-50	0.31	0.06	0.41	0.51
51-250	0.44	0.14	0.16	0.28
>251	0.67	0.21	0.25	0.44

Table 4.7: Useful Life by Vessel Type, years

Harbor Vessel Type	Useful Life
Assist tug	23
Commercial fishing	15
Crew boat	22
Excursion	20
Ferry	20
Government	25
Ocean tug	25
Tugboat	23
Work boat	23

The useful life is not consistent with CARB methodology because only one useful life factor per vessel type was used instead of using different useful life factors for main and auxiliary engines by vessel type. The difference in emissions is insignificant (none to 2% by pollutant).

4.5.3 Fuel Correction Factors

Fuel correction factors were used to take into account the use of ULSD used by all harbor craft in 2006. Fuel correction factors used for NO_X, HC, and PM take into account California diesel fuel which is different from EPA diesel fuel. Table 4.8 summarizes the fuel correction factors used for harbor craft.

Table 4.8: Fuel Correction Factors for ULSD

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1995 and older	0.72	0.93	0.043	1.00	0.72	1.00	0.93	0.72
1996 and newer	0.80	0.95	0.043	1.00	0.72	1.00	0.95	0.72

DB ID446

4.5.4 Load Factors

Engine load factor represents the load applied to an engine or the percent of rated engine power that is applied during the engine's normal operation. Table 4.9 summarizes the average engine load factors that were used in this inventory for the various harbor vessel types for their propulsion and auxiliary engines.

Table 4.9: Load Factors

DB ID426

Harbor Vessel Type	Load Factor
Assist tug	0.31
Commercial fishing	0.27
Crew boat	0.45
Excursion	0.42
Ferry	0.42
Government	0.51
Ocean tug	0.68
Tugboat	0.31
Work boat	0.45
Auxiliary Engines	0.43

The 31% engine load factor for assist tugboats is based on actual vessel engine load readings published in the 2001 Port emissions inventory and is not consistent with the 50% engine load used in CARB's latest methodology[38]. The other vessel type load factors are consistent with CARB's latest methodology with one other exception - the tugboat auxiliary engine load factor. CARB uses 43% engine load for all auxiliary engines as listed in Table 3.8, except for 31% used for the auxiliary engines of tugboats. The Port uses 43% for all auxiliary engines, including the tugboats and assist tugboats.

[38] CARB, *Emissions Estimation Methodology for Commercial Harbor Craft Operating in California*, Appendix B.

4.6 Emission Estimates

Table 4.10 and 4.11 summarizes the 2006 estimated emissions for harbor craft vessels by vessel type and engine type. The harbor vessel inventory list can be found in Appendix B.

Table 4.10: 2006 Commercial Harbor Craft Emissions by Engine Type, tpy

Vessel Type	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Assist Tug	Auxiliary	1.3	1.2	1.3	26.0	0.0	12.7	2.7
	Propulsion	18.0	16.6	18.0	459.2	0.2	115.8	26.9
Assist Tug Total		**19.3**	**17.8**	**19.3**	**485.2**	**0.2**	**128.5**	**29.6**
Commercial Fishing	Auxiliary	0.7	0.6	0.7	11.3	0.0	7.1	1.5
	Propulsion	5.3	4.8	5.3	135.0	0.1	31.7	8.3
Commercial Fishing Total		**5.9**	**5.4**	**5.9**	**146.4**	**0.1**	**38.8**	**9.8**
CrewBoat	Auxiliary	0.3	0.3	0.3	8.1	0.0	3.5	0.7
	Propulsion	2.9	2.6	2.9	74.1	0.0	19.7	4.6
Crewboat Total		**3.2**	**2.9**	**3.2**	**82.3**	**0.0**	**23.2**	**5.4**
Excursion	Auxiliary	0.7	0.6	0.7	8.8	0.0	6.3	1.8
	Propulsion	6.1	5.6	6.1	149.9	0.1	40.4	10.2
Excursion Total		**6.8**	**6.2**	**6.8**	**158.7**	**0.1**	**46.7**	**12.0**
Ferry	Auxiliary	0.1	0.1	0.1	1.8	0.0	1.0	0.3
	Propulsion	6.6	6.0	6.6	150.5	0.1	42.0	10.5
Ferry Total		**6.7**	**6.1**	**6.7**	**152.3**	**0.1**	**43.0**	**10.8**
Government	Auxiliary	0.0	0.0	0.0	1.0	0.0	0.3	0.1
	Propulsion	1.6	1.5	1.6	39.9	0.0	10.1	2.6
Government Total		**1.7**	**1.5**	**1.7**	**40.8**	**0.0**	**10.5**	**2.7**
Line Haul Tug	Auxiliary	0.1	0.1	0.1	1.8	0.0	0.7	0.2
	Propulsion	2.0	1.9	2.0	53.3	0.0	13.5	3.1
Line Haul Tug		**2.1**	**2.0**	**2.1**	**55.1**	**0.0**	**14.3**	**3.3**
Tugboat	Auxiliary	0.4	0.3	0.4	5.0	0.0	3.2	0.9
	Propulsion	4.7	4.4	4.7	116.8	0.1	30.5	7.7
Tugboat Total		**5.1**	**4.7**	**5.1**	**121.8**	**0.1**	**33.7**	**8.6**
WorkBoat	Auxiliary	0.1	0.1	0.1	1.5	0.0	0.9	0.2
	Propulsion	0.9	0.8	0.9	21.2	0.0	5.6	1.4
WorkBoat Total		**1.0**	**0.9**	**1.0**	**22.7**	**0.0**	**6.4**	**1.7**
Harbor Vessel Total		**51.7**	**47.6**	**51.7**	**1,265.4**	**0.7**	**345.1**	**83.8**

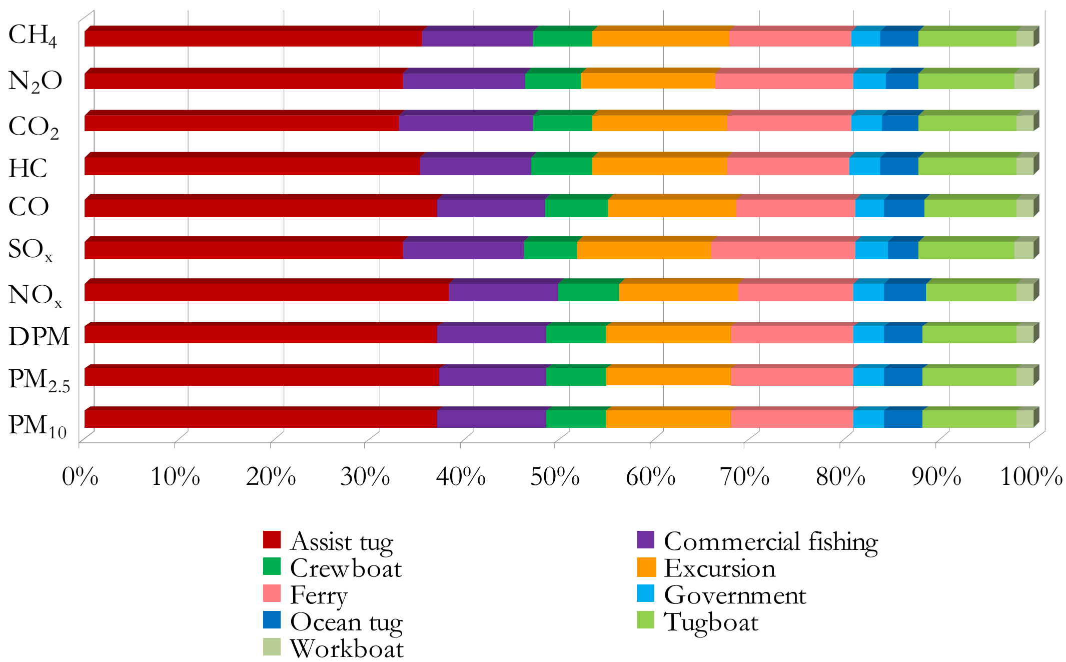
DB ID427

Table 4.11: 2006 Commercial Harbor Craft GHG Emissions by Engine Type, tpy

Vessel Type	Engine Type	CO_2	N_2O	CH_4
Assist tug	Auxiliary	2,240.8	0.1	0.1
	Propulsion	26,937.1	0.9	0.5
Assist tug Total		**29,177.9**	**1.0**	**0.6**
Commercial fishing	Auxiliary	1,149.1	0.0	0.0
	Propulsion	11,116.7	0.3	0.2
Commercial fishing Total		**12,265.8**	**0.4**	**0.2**
Crewboat	Auxiliary	620.9	0.0	0.0
	Propulsion	4,826.9	0.2	0.1
Crewboat Total		**5,447.8**	**0.2**	**0.1**
Excursion	Auxiliary	811.0	0.0	0.0
	Propulsion	11,660.2	0.4	0.2
Excursion Total		**12,471.2**	**0.4**	**0.2**
Ferry	Auxiliary	151.4	0.0	0.0
	Propulsion	11,290.6	0.4	0.2
Ferry Total		**11,442.0**	**0.4**	**0.2**
Government	Auxiliary	79.4	0.0	0.0
	Propulsion	2,852.6	0.1	0.1
Government Total		**2,932.0**	**0.1**	**0.1**
Ocean tug	Auxiliary	140.9	0.0	0.0
	Propulsion	3,121.1	0.1	0.1
Ocean tug		**3,262.0**	**0.1**	**0.1**
Tugboat	Auxiliary	460.5	0.0	0.0
	Propulsion	8,550.6	0.3	0.2
Tugboat Total		**9,011.1**	**0.3**	**0.2**
Workboat	Auxiliary	121.0	0.0	0.0
	Propulsion	1,615.8	0.1	0.0
Workboat Total		**1,736.8**	**0.1**	**0.0**
Harbor craft Total		**87,746.5**	**3.0**	**1.7**

Figure 4.6 shows that approximately 37% of the Port's harbor craft emissions are attributed to assist tugs, 13% to ferries, 13% to excursion vessels, 12% to commercial fishing, 10% to tugboats, 4% to ocean tugs, 3% to government vessels, and 2% to workboats.

Figure 4.6: Harbor Craft Emission Distribution



SECTION 5 CARGO HANDLING EQUIPMENT

This section presents emissions estimates for the cargo handling equipment source category, including source description (5.1), geographical delineation (5.2), data and information acquisition (5.3), operational profiles (5.4), emissions estimation methodology (5.5), and the emission estimates (5.6).

5.1 Source Description

Cargo handling equipment includes equipment used to move cargo (containers, general cargo, and bulk cargo) to and from marine vessels, railcars, and on-road trucks. The equipment typically operates at marine terminals or at rail yards and not on public roadways or lands. This inventory includes cargo handling equipment of 25 hp or greater using diesel, gasoline, or alternative fuels. Due to the diversity of cargo, there is a wide range of equipment types. The majority of the equipment can be classified into one of the following equipment types:

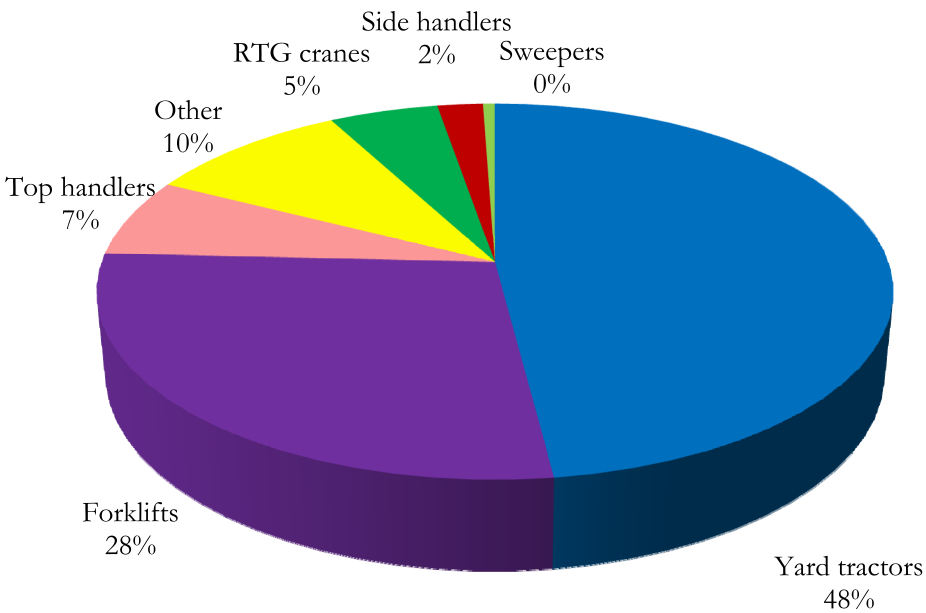
- Forklift
- Rubber tired gantry (RTG) crane
- Side handler
- Sweeper
- Top handler
- Yard tractor
- Other

The "Other" category contains the following:

- Bulldozer
- Dump truck
- Excavator
- Fuel truck
- Loader
- Man lift
- Rail pusher
- Roller
- Skid steer loader
- Trucks (propane, utility, water, vacuum)

Figure 5.1 presents the distribution of the 1,995 pieces of equipment inventoried at the Port for 2006. Out of all CHE inventoried at Port facilities for 2006, 48% were yard tractors, 28% were forklifts, seven percent were top handlers, five percent were RTG cranes, two percent were side handlers and ten percent were other equipment (listed above).

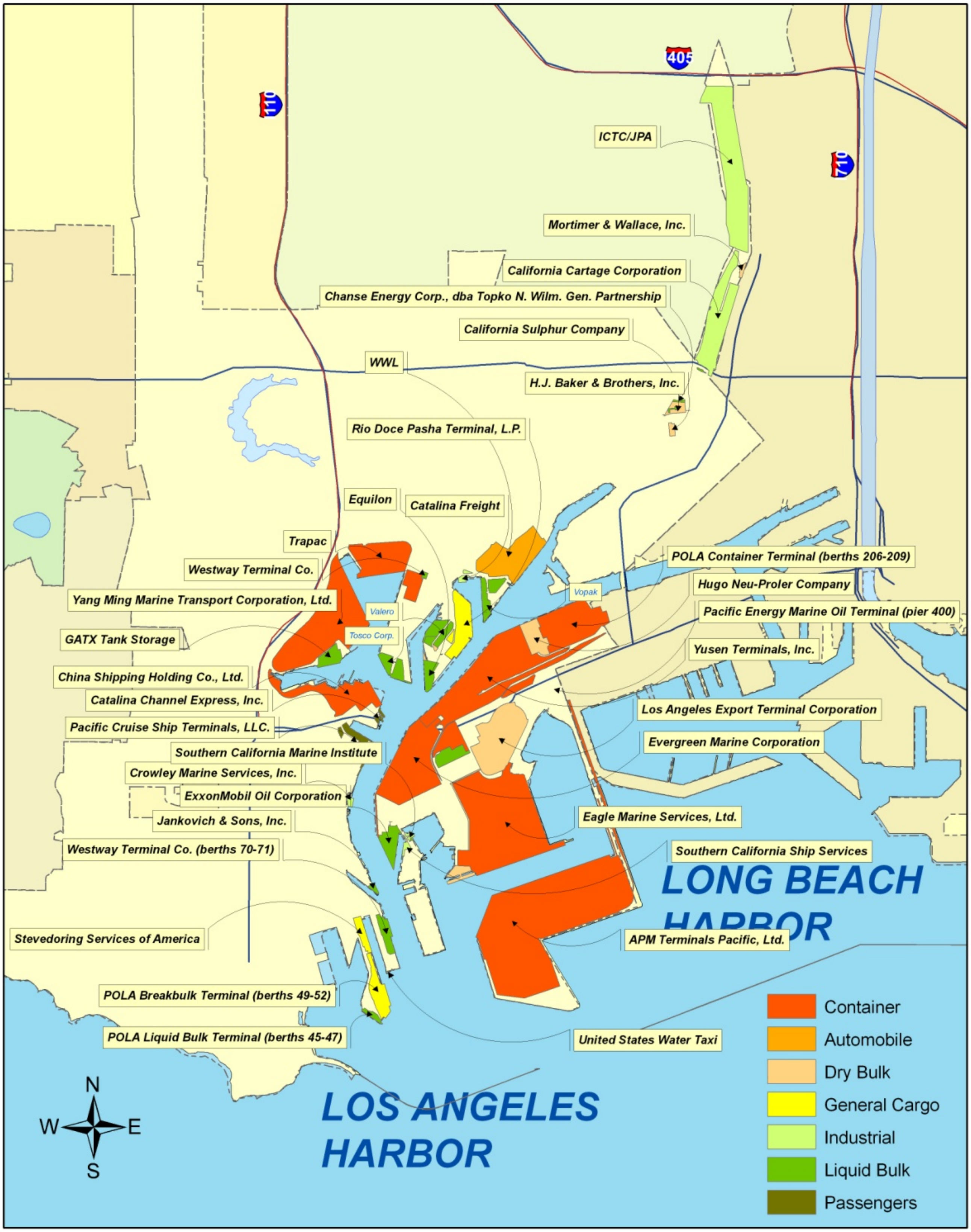
Figure 5.1: Distribution of 2006 Port CHE by Equipment Type



5.2 Geographical Delineation

The 2006 CHE EI consist of equipment from following terminals: container; dry bulk; break bulk; liquid bulk; auto; cruise ship; and equipment from Union Pacific (UP) Intermodal Container Transfer Facility (ICTF) and smaller facilities located within Port boundaries. Figure 5.2 presents a map illustrating the geographical delineation for CHE.

Figure 5.2: CHE EI Geographical Boundaries



Following is the list of the terminals, by cargo type, inventoried in 2006:

Container Terminals:

- Berth 100: West Basin Container Terminal (China Shipping)
- Berths 121-131: West Basin Container Terminal (Yang Ming)
- Berths 136-139: Trans Pacific Container (Trapac) Terminal
- Berths 212-225: Yusen Container Terminal
- Berths 226-236: Seaside Terminal (Evergreen)
- Berths 302-305: APL Terminal (Global Gateway South)
- Berths 401-406: APM Terminals (Pier 400)

Break-Bulk Terminals:

- Berths 49-53, 87-89, 153-155 and 174-181: Pasha Stevedoring Terminals
- Berths 54-55: Stevedore Services of America (SSA)
- Berths 153-155: Crescent Warehouse Company
- Berths 210-211: Hugo Neu-Proler Company

Dry Bulk Terminals:

- California Sulfur
- LA Grain
- Berths 165-166: U.S. Borax

Liquid Terminals:

- Berths 70-71: Westway
- Berths 118-119: Kinder Morgan
- General Petroleum
- Berths 187-191: Vopak
- Berths 167-169: Equillon/Shell Oil
- Berths 238-240: ExxonMobil
- Berths 148-151: ConocoPhillips
- Ultramar/Valero

Auto Terminals:

- Berths 195-199: WWL Vehicle Services Americas (formerly DAS)

Passenger Terminals:

- Berths 91-93: Pacific Cruise Ship Terminals (PCST)

Other Facilities:

- Al Larson
- Union Pacific Intermodal Containers Transfer Facility (ICTF)
- California Cartage
- Southern California (SoCal) Ship Services
- Tri-Marine Fish Company
- Harbor Ice
- San Pedro Forklifts
- Three Rivers Trucking
- California Multimodal

5.3 Data and Information Acquisition

The terminal's maintenance and/or CHE operating staff were contacted either in person or by telephone to obtain information on the CHE specific to their terminal's operation for calendar year 2006. Information collected for each piece of equipment is listed below:

- Equipment type
- Equipment identification number
- Equipment make and model
- Engine make and model
- Rated horsepower
- Model year
- Type of fuel used (diesel, ULSD, gasoline or propane)
- Alternative fuel used, start date (examples include emulsified fuel, O_2 fuel)
- Fuel consumption
- Annual hours of operation (some terminal operators use hour meters)
- Diesel Oxidation Catalyst (DOC) installed and date installed
- Onroad engine installed
- Any other emissions control devices installed

5.4 Operational Profiles

Table 5.1 summarizes the data collected in 2006. The table includes equipment count, horsepower, model year, and annual operating hours for each equipment type.

Table 5.1: CHE Characteristics for All Terminals, 2006

Equipment	Count	Power (horsepower) Min	Max	Average	Model Year Min	Max	Average	Annual Operating Hours Min	Max	Average
Bulldozer	9	140	460	243	1979	2006	1989	0	300	117
Crane	10	103	750	244	1965	2004	1987	120	3,141	848
Electric pallet jack	7	na	na	na	na	na	na	na	na	na
Electric wharf crane	69	na	na	na	na	na	na	na	na	na
Excavator	12	85	428	349	1980	2002	1996	71	5,358	2,656
Forklift	554	40	330	104	1968	2006	1996	3	2,970	983
Loader	18	96	458	272	1972	2006	1994	35	5,588	1,584
Man Lift	18	48	100	78	1989	2006	1998	10	1,136	363
Rail Pusher	3	130	200	170	1993	2004	1999	60	354	238
Roller	1	20	20	20	1980	1980	1980	51	51	51
RMG cranes, electric	12	na	na	na	na	na	na	na	na	na
RTG crane	103	180	685	532	1983	2006	2002	0	6,564	1,802
Side pick	43	136	330	191	1987	2006	2000	0	3,048	1,497
Skid steer Lloader	10	30	94	53	1994	2004	2001	10	1,443	624
Sweeper	11	35	325	120	1995	2005	2000	55	2,002	551
Top handler	134	174	350	285	1972	2006	2000	0	4,637	2,255
Truck	24	97	493	329	1963	2006	1988	35	2,543	1,030
Yard tractor	957	170	250	204	1980	2006	2001	0	8,138	2,372
Total count	**1,995**									

DB ID228

Approximately two-thirds of all CHE equipment at the Port are used by container terminals. Table 5.2 shows the percentage of container terminal CHE as compared to the total Port CHE.

Table 5.2: 2006 Percentage of Container Terminal CHE as Compared to Total CHE

Equipment	Total Count	Container Terminal Count	Percent
Forklift	554	96	17%
RTG crane	103	94	91%
Side pick	43	40	93%
Top handler	134	129	96%
Yard tractor	957	850	89%
Sweeper	11	5	45%
Other	193	105	54%
Total	**1,995**	**1,319**	**66%**

DB ID233

The equipment characteristics for the CHE found at the Port's container terminals are summarized in Table 5.3.

Table 5.3: CHE Characteristics for Container Terminals, 2006

Container Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Electric pallet jack	7	na	na	na	na	na	na	na	na	na
Electric wharf cranes	69	na	na	na	na	na	na	na	na	na
Forklift	96	45	275	142	1972	2006	1997	3	2,970	640
Man Lift	7	80	87	83	1995	2006	2000	100	400	230
Rail Pusher	2	180	200	190	1993	2000	1997	60	300	180
RMG cranes, electric	12	na	na	na	na	na	na	na	na	na
RTG crane	94	180	685	555	1983	2006	2002	0	6,564	1,624
Side pick	40	152	330	194	1987	2006	2000	0	3,048	1,582
Sweeper	5	100	205	138	1995	2005	2000	88	1,000	485
Top handler	129	250	335	286	1987	2006	2000	0	4,637	2,306
Truck	8	100	250	213	1975	2006	1999	488	1,598	760
Yard tractor	850	170	245	207	1987	2006	2001	0	8,138	2,334
Total count	**1,319**									

DB ID229

Table 5.4 shows the equipment characteristics of break-bulk terminal equipment.

Table 5.4: CHE Characteristics for Break-Bulk Terminals, 2006

Break Bulk Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Bulldozer	9	140	460	243	1979	2006	1989	0	300	117
Crane	7	103	750	284	1965	2004	1981	120	3,141	928
Excavator	12	85	428	349	1980	2002	1996	71	5,358	2,656
Forklift	128	40	330	143	1979	2006	1996	46	2,250	718
Loader	13	98	458	297	1972	2003	1993	35	5,588	1,864
Man lift	8	60	100	77	1996	2002	1999	10	1,136	544
Rail pusher	1	130	130	130	2004	2004	2004	354	354	354
Roller	1	20	20	20	1980	1980	1980	51	51	51
Side pick	2	152	152	152	2000	2000	2000	89	144	117
Skid steer loader	6	30	45	42	1997	2004	2002	10	1,443	1,009
Sweeper	5	35	325	118	1996	2002	2000	156	2,002	717
Top handler	3	174	250	225	1979	1990	1986	200	663	357
Truck	14	210	493	409	1963	2002	1983	35	2,543	1,278
Yard tractor	24	174	215	181	1980	2005	1995	89	1,066	533
Total count	**233**									

DB ID231

Table 5.5 shows the equipment characteristics of dry bulk terminal equipment.

Table 5.5: CHE Characteristics for Dry Bulk Terminal Equipment, 2006

Dry Bulk Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Loader	2	110	200	155	1995	1995	1995	1,040	1,040	1,040
Yard tractor	4	250	250	250	1995	1995	1995	2,080	2,080	2,080
Total count	**6**									

DB ID230

There were several facilities within the Port boundary that were included in this inventory that did not fit into the container, dry bulk and break bulk terminal categories listed above. These other facilities/tenants include the liquid bulk terminals, the auto terminal, smaller facilities, and UP ICTF.

Table 5.6: CHE Characteristics for Other Terminals, 2006

Other Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Crane	3	130	174	151	1989	2004	1999	600	780	660
Forklift	330	48	175	76	1987	2002	1997	83	1,500	1,255
Loader	3	96	310	239	1989	2006	1995	200	1,000	733
Man lift	3	48	80	68	1989	1998	1994	120	250	190
RTG crane	9	250	300	294	1988	2005	1997	606	5,315	3,669
Side Pick	1	136	136	136	1992	1992	1992	875	875	875
Skid steer loader	4	54	94	69	1994	2001	1999	20	96	47
Sweeper	1	37	37	37	1999	1999	1999	55	55	55
Top handler	2	335	350	343	1972	1988	1980	41	3,562	1,802
Truck	2	97	370	233	1979	1997	1988	365	365	365
Yard tractor	79	173	250	183	1995	2005	2003	100	6,579	3,360
Total count	**437**									

DB ID232

The 2006 inventory includes 611 pieces of equipment installed with diesel oxidation catalysts (DOC), and 216 yard tractors equipped with certified on-road engines. In addition, 223 pieces of equipment used emulsified fuel in combination with ULSD in 2006. All terminals used ULSD for their 1,482 pieces of diesel equipment.

Table 5.7 is a summary of the emission reduction technologies used on the equipment. It should be noted that some of these technologies may be used in combination with one another. For example, equipment using ULSD and emulsified fuel may also be equipped with on-road engines or DOCs.

Table 5.7: Summary of 2006 CHE Emission Reduction Technologies

Equipment	Total Count	DOC Installed	On-road Engine	Emulsified Fuel	ULSD
Forklifts	554	3	0	15	191
RTG cranes	103	10	0	28	103
Side handlers	43	13	0	10	43
Top handlers	134	54	0	42	134
Yard tractors	957	531	216	128	897
Sweepers	11	0	0	0	10
Other	124	0	5	0	104
Total	**1,926**	**611**	**221**	**223**	**1,482**

DB ID234

Twenty three percent of equipment inventoried was not equipped with a diesel engine; a total of 413 pieces of equipment were powered with propane engines, 10 were powered with gasoline engines, and two yard tractors were equipped with liquefied natural gas (LNG) engines as listed on Table 5.8.

Table 5.8: 2006 Count of Non-Diesel Fueled Engines

Equipment	Propane	Gasoline	LNG
Forklifts	355	8	0
RTG cranes	0	0	0
Side handlers	0	0	0
Top handlers	0	0	0
Yard tractors	58	0	2
Sweepers	0	2	0
Total	**413**	**10**	**2**

DB ID235

The inventory does not include smaller electric equipment that may be at terminals. However, it does include a total of 88 of the following electric equipment:

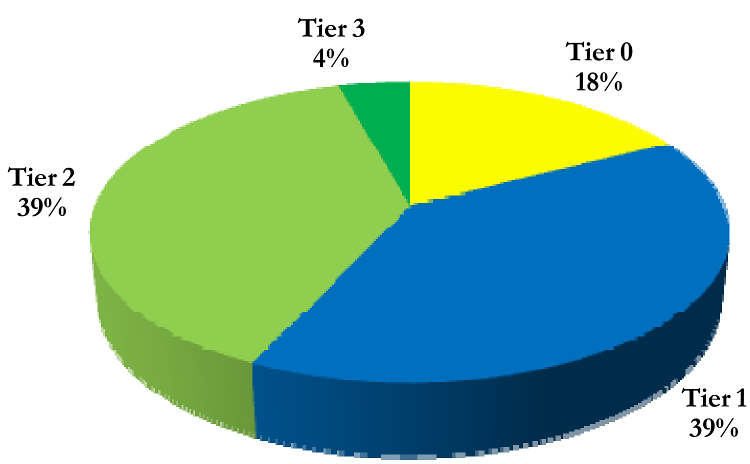
- 12 electric cranes
- 7 electric pallet jacks
- 69 electric wharf cranes (the large ship to shore cranes at container terminals)

Table 5.9 and Figure 5.3 summarize the distribution of diesel equipment by the engine standards which are based on model year and horsepower range. Approximately 18% of the 2006 CHE are Tier 0, 39% are Tier 1, 39% are Tier 2, and 4% are Tier 3.

Table 5.9: Count of Diesel Equipment by Type and Engine Standards

Equipment Type	Tier 0	Tier 1	Tier 2	Tier 3
Yard tractors	53	410	384	50
Forklifts	85	59	47	0
Top handlers	28	33	62	11
Other	65	23	15	1
RTG cranes	15	31	57	0
Side handlers	10	22	11	0
Sweepers	3	6	1	0
Total	**259**	**584**	**577**	**62**

Figure 5.3: Distribution of Diesel Equipment by Engine Standards, %



5.5 Methodology

CARB adopted their CHE Regulation in December 2005. During the development of the rule, CARB's staff estimated the emissions of CHE using a methodology that was different than what was traditionally used in their OFFROAD model. The most significant change from the OFFROAD methodology was the calculation of deterioration rates for CHE equipment. At the time of this CHE emissions inventory development, CARB was not ready to make public the revised CHE emissions inventory calculation tool. However, during the 2005 port-wide emissions inventory process, in order to be consistent with CARB's latest methodology, CARB staff volunteered to estimate the emissions for the cargo handling equipment operating at the Port. The same methodology is used to update 2006 CHE EI.

The basic equation used to estimate CHE emissions in tons is as follows.

Equation 5.1

$$E = Pop \times EF \times HP \times LF \times Act \times FCF \times CF$$

Where:

E = emissions, tons
Pop = population of equipment
EF = emission factor, grams of pollutant per horsepower-hour (g/hp-hr)
HP = rated horsepower for the equipment
LF = load factor (ratio of average load used during normal operations as compared to full load at maximum rated horsepower)
Act = equipment activity, hours of use
FCF = fuel correction factor to reflect changes in fuel properties that have occurred over time
CF = control factor to reflect changes in emissions due to installation of emission reduction technologies or use of alternative fuels not originally included in the emissions factors

The emission factor is a function of the zero hour emission rate for the equipment model year (g/hp-hr) in the absence of any malfunction or tampering of engine components that can change emissions, plus a deterioration rate. The deterioration rate reflects the fact that base emissions of engines change as the equipment is used due to wear of various engine parts or reduced efficiency of emission control devices. The emission factor is calculated as:

Equation 5.2

$$EF = ZH + (DR \times Cumulative\ Hours)$$

Where:

ZH = emission rate when the engine is new and there is no component malfunctioning for a given horsepower category and model year
DR = deterioration rate (rate of change of emissions as a function of equipment age)
Cumulative hours = number of hours the equipment has been in use and calculated as annual operating hours times age of the equipment

5.5.1 Emission Factors

CARB used the same zero hour emission rates as used in the OFFROAD model. The ZH emission rates are a function of fuel, model year and horsepower group as defined in the OFFROAD model. The zero hour emission rate tables are included in Appendix C.

ZH emission rates vary by engine horsepower and model year to reflect the fact that depending upon the size of the engines, different engine technologies and emission standards are applicable. CARB's ZH emission factors by horsepower and engine year were used for:

- diesel engines certified to off-road diesel engine emission standards
- diesel engines certified to onroad diesel emission standards
- gasoline and LPG engines certified to large spark ignited engine (LSI) emission standards
- LNG engine emission factors are based on recent testing of LNG yard tractors[39]

Due to the absence of CHE specific emission data, CARB staff used on-road heavy-duty diesel specific deterioration rates used in EMFAC 7G (an older version of the on-road emissions inventory model). Since the release of EMFAC 7G, CARB staff have updated EMFAC including on-road heavy-duty diesel deterioration rates. However, for OFFROAD engine emissions, CARB continues to use EMFAC7G deterioration rates. The basic assumption used by CARB staff is that the emissions from diesel powered trucks remain stable in the absence of tampering and mal-maintenance (T&M). In other words, diesel engine emissions do not increase over

[39] Dr. Wayne Miller, University of California, Riverside, *A Study of Emissions from Yard Tractors Using Diesel and LNG Fuel,* July, 2007.

time if the equipment is well maintained. Over time emissions may increase if the equipment is not maintained properly, which causes various engine components affecting emissions to malfunction.

CARB staff estimated emissions deterioration using the so called "Radian Model[40]" which identified various diesel engine components malfunctions, the frequency of malfunction and the related impact on emissions. Based on this information, staff calculated the change in on-road heavy-duty engine emissions over time.

For CHE equipment, CARB staff estimated the emission factor increase over the useful life cumulative mileage of the on-road engines and assumed that the emissions for CHE will deteriorate in the similar manner over the equipment's useful life. This useful life estimate was determined through CHE surveys conducted by CARB staff.

The equation for the deterioration rate is:

Equation 5.3

DR = (DF x ZH) / cumulative hours at the end of useful life

Where:

DR = deterioration rate (expressed as $g/hp\text{-}hr^2$)
DF = deterioration factor, percent increase in emissions at the end of the useful life (expressed as %)
ZH = emission rate when the engine is new and there is no component malfunctioning for a given horsepower category and model year
Cumulative hours at the end of useful life = annual operating hours times useful life in years

The Port believes that the use of CARB's deterioration rates results in an overestimate of CHE emissions. In discussions with terminal operators, the Port determined that the CHE are well maintained compared to on-road heavy-duty trucks. CARB staff needs to further refine their methodology to properly account for the CHE maintenance practices of terminal operators.

5.5.2 Load Factor, Useful Life, and Deterioration Rates

Load factor is defined as the ratio of average load experienced by the equipment during normal operation as compared to full load at maximum rated horsepower. It accounts for the fact that in their normal operations, engines are not used at their maximum horsepower rating. Equipment specific load factors used for the 2006 EI are the same as those used by CARB to support cargo handling regulations adopted in 2005, with the exception of yard tractors. A recent in-field study conducted by the Port in consultation with CARB's staff indicated a lower load factor for the yard

[40] Heavy-Duty Diesel Vehicle Inspection and Maintenance Study - Volume II - Quantifying the Problem.

tractors operating at ports. Based on supporting data collection during the yard tractor study, the Port is using a new load factor of 39% for yard tractors, as compared to the previous load factor of 65%.

According to CARB, at 80% of the useful life of an engine, 50% of the original equipment remains in the fleet. In addition, it is assumed that at the end of the useful life, 20% of the original equipment remains in the fleet. Table 5.10 lists the equipment type, the useful life and load factor used, respectively.

Table 5.10: 2006 CHE Useful Life and Load Factors

Port Equipment	Useful Life	Load Factor
RTG crane, crane	24	0.43
Excavator	16	0.57
Forklift	16	0.3
Top handler, side pick, reach stacker	16	0.59
Aerial lift, truck, other with offroad engine	16	0.51
Truck, other with onroad engine	16	0.51
Sweeper	16	0.68
Loader, backhoe	16	0.55
Yard tractor with offroad engine	12	0.39
Yard tractor with onroad engine	12	0.39

Table 5.11 lists the new deterioration factors used by CARB by horsepower group.

Table 5.11: Deterioration Factors by Horsepower Group

Horsepower Group	PM	NO_x	CO	HC
50	31%	6%	41%	51%
120	44%	14%	16%	28%
175	44%	14%	16%	28%
250	44%	14%	16%	28%
500	67%	21%	25%	44%

DB ID445

5.5.3 Control Factors

Control factors were used to reflect the change in emissions due to the use of various emissions reduction technologies such as DOC and alternative fuels (emulsified fuel). Table 5.12 shows the emission reduction percentages used by CARB in the emissions estimates for the various technologies used by the Port equipment. In this table, a positive number is a reduction, while a negative number signifies an increase in emissions. The control factor is 1 minus the emission reduction in decimal. For example, 70% reduction has a control factor of 0.3; while a -10% has a control factor of 1.10.

Table 5.12: CHE Emission Reductions Percentages

Technology	PM	NO_x	CO	HC	SO_x	CO_2	N_2O	CH_4
DOC	30%	0%	70%	70%	na	na	0%	70%
Emulsified fuel	30%	15%	-10%	-23%	na	na	15%	-23%
DOC + emulsified fuel	50%	20%	67%	63%	na	na	20%	63%

DB ID474

CARB's sources for the emission reductions are as follows:

- DOC: CEC Report (Air Quality Implications of Backup Generators in California Volume Two: Emission Measurements From Controlled and Uncontrolled Backup Generators)[41]
- Emulsified Fuel: CARB/POLA Yard Truck Test Program[42]
- DOC + emulsified fuel: CARB Letter to Port (1 May 06) and Verified Technology[43]

Table 5.13 lists the fuel correction factors for diesel fuel and ULSD.

Table 5.13: Fuel Correction Factors

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1995 and older	0.72	0.93	0.043	1	0.72	1	0.93	0.72
1996 and newer	0.80	0.95	0.043	1	0.72	1	0.95	0.72

DB ID444

41 See *http://www.enenrgy.ca.gov/pier/final_project_reports/CEC-500-2005-049.html*
42 See *http://www.arb.ca.gov/msprog/offroad/cargo/documents/yttest.pdf.*
43 See *http://www.arb.ca.gov/diesel/verdev/level2/level2.htm.*

5.6 Emission Estimates

CHE emissions estimates are broken down by terminal type, equipment type, and by terminal. Terminals have been assigned a unique identifier in order to maintain confidentiality. A summary of the CHE emission in tons per year by terminal type by pollutant for 2006 is presented in Tables 5.14 and 5.15.

Table 5.14: 2006 CHE Emissions by Terminal Type, tpy

Terminal Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto	0.0	0.0	0.0	0.2	0.0	1.5	0.1
Break-Bulk	10.2	9.4	10.0	259.0	0.1	149.0	19.6
Container	35.5	33.1	34.8	1,357.9	1.7	517.8	44.9
Cruise	0.3	0.3	0.3	9.9	0.0	16.3	1.8
Dry Bulk	0.7	0.7	0.7	13.8	0.0	5.2	1.1
Liquid	0.1	0.0	0.0	2.0	0.0	3.4	0.2
Other	5.4	5.1	5.1	210.6	0.2	284.2	26.9
Total	**52.2**	**48.5**	**50.9**	**1,853.3**	**2.0**	**977.3**	**94.6**

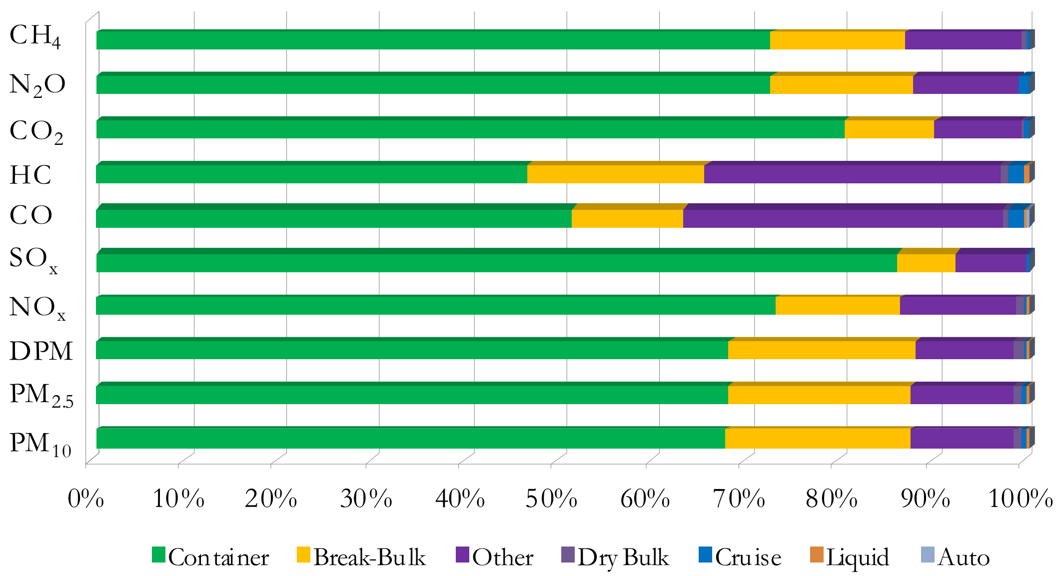
DB ID450

Table 5.15: 2006 CHE GHG Emissions by Terminal Type, tpy

Terminal Type	CO_2	N_2O	CH_4
Auto	20.7	0.0	0.0
Break-Bulk	28,446.2	0.4	0.9
Container	230,267.3	4.1	4.9
Cruise	809.5	0.0	0.0
Dry Bulk	1,700.9	0.0	0.1
Liquid	147.3	0.0	0.0
Other	24,316.2	0.5	0.8
Total	**285,708.1**	**5.0**	**6.6**

Figure 5.4 presents the percentage of cargo handling equipment emissions by terminal type. Approximately 65% to 70% of the Port's CHE PM and NO_x emissions, 85% of the SO_x emissions and 45% to 50% of the CO and hydrocarbon emissions are attributed to the container terminals. Break-bulk terminals and other type of facilities account for the remainder of the emissions. The facilities with propane forklifts and equipment with alternative fuels have higher CO and hydrocarbon emissions.

Figure 5.4: 2006 CHE Emissions by Terminal Type, %



Tables 5.16 and 5.17 present the emissions by equipment type. Figure 5.5 presents the percentage of cargo handling equipment emissions by equipment type.

Table 5.16: 2006 CHE Emissions by Equipment Type, tpy

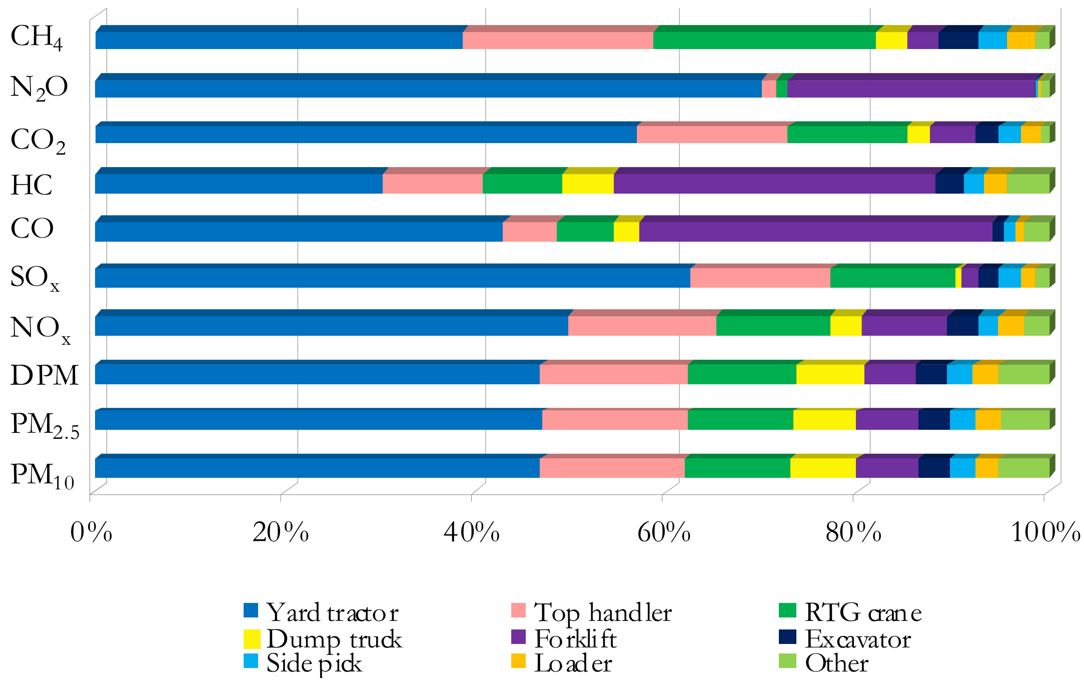
Port Equipment	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Bulldozer	Diesel	0.1	0.1	0.1	1.8	0.0	0.5	0.1
Crane	Diesel	0.9	0.9	0.9	18.8	0.0	7.7	1.3
Dump truck	Diesel	3.5	3.2	3.5	63.1	0.0	25.2	5.1
Excavator	Diesel	1.7	1.6	1.7	56.0	0.0	12.3	2.8
Forklift	Gasoline	0.0	0.0	0.0	7.2	0.0	19.4	1.7
Forklift	Propane	0.6	0.5	0.0	104.5	0.0	306.9	25.7
Forklift	Diesel	2.7	2.5	2.7	50.2	0.0	20.4	3.8
Fuel truck	Gasoline	0.0	0.0	0.0	1.1	0.0	2.0	0.2
Fuel truck	Diesel	0.2	0.2	0.2	4.4	0.0	1.5	0.2
Loader	Diesel	1.4	1.3	1.4	43.3	0.0	9.3	2.2
Man lift	Diesel	0.2	0.2	0.2	2.2	0.0	1.2	0.2
Rail pusher	Diesel	0.0	0.0	0.0	0.4	0.0	0.1	0.0
Roller	Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RTG aux eng	Diesel	0.3	0.2	0.3	3.9	0.0	2.6	0.2
RTG crane	Diesel	6.1	5.7	6.1	231.8	0.3	57.7	7.9
Side pick	Diesel	1.4	1.3	1.4	45.3	0.0	10.5	2.0
Skid steer loader	Diesel	0.1	0.1	0.1	0.9	0.0	0.7	0.2
Sweeper	Gasoline	0.0	0.0	0.0	1.2	0.0	3.8	0.2
Sweeper	Diesel	0.2	0.2	0.2	2.3	0.0	1.1	0.2
Top handler	Diesel	7.8	7.3	7.8	285.4	0.3	55.2	9.8
Vacuum truck	Diesel	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Wateer truck	Diesel	0.8	0.7	0.8	12.2	0.0	3.8	1.1
Yard tractor	LNG	0.0	0.0	0.0	0.6	0.0	0.0	0.5
Yard tractor	Propane	0.7	0.6	0.0	48.6	0.0	261.6	8.2
Yard tractor	Diesel	23.6	22.0	23.6	867.9	1.2	173.9	21.0
Total		**52.2**	**48.5**	**50.9**	**1,853.3**	**2.0**	**977.3**	**94.6**

DB ID237

Table 5.17: 2006 CHE GHG Emissions by Equipment Type, tpy

Port Equipment	Engine Type	CO_2	N_2O	CH_4
Bulldozer	Diesel	230.1	0.0	0.0
Crane	Diesel	1,720.3	0.0	0.1
Dump truck	Diesel	6,755.0	0.1	0.2
Excavator	Diesel	7,096.9	0.1	0.3
Forklift	Gasoline	313.3	0.0	0.0
Forklift	Propane	6,546.8	0.0	0.0
Forklift	Diesel	6,057.3	0.1	0.2
Fuel truck	Gasoline	57.3	0.0	0.0
Fuel truck	Diesel	706.4	0.0	0.0
Loader	Diesel	5,523.2	0.1	0.2
Man lift	Diesel	262.8	0.0	0.0
Rail pusher	Diesel	51.5	0.0	0.0
Roller	Diesel	0.9	0.0	0.0
RTG aux eng	Diesel	525.6	0.0	0.0
RTG crane	Diesel	37,630.7	0.8	1.5
Side pick	Diesel	6,363.4	0.1	0.2
Skid steer loader	Diesel	115.7	0.0	0.0
Sweeper	Gasoline	112.5	0.0	0.0
Sweeper	Diesel	343.1	0.0	0.0
Top handler	Diesel	44,872.7	0.8	1.2
Vacuum truck	Diesel	10.6	0.0	0.0
Wateer truck	Diesel	1,318.5	0.0	0.0
Yard tractor	LNG	106.0	0.0	0.0
Yard tractor	Propane	7,471.7	0.0	0.0
Yard tractor	Diesel	151,515.8	2.8	2.7
Total		**285,708.1**	**5.0**	**6.6**

Figure 5.5: 2006 CHE Emissions by Equipment Type, %



SECTION 6 RAILROAD LOCOMOTIVES

This section presents emissions estimates for the railroad locomotive source category, including source description (6.1), geographical delineation (6.2), data and information acquisition (6.3), operational profiles (6.4), emissions estimation methodology (6.5), and the emission estimates (6.6).

6.1 Source Description

Railroad operations are typically described in terms of two different types of operation, line haul and switching. Line haul refers to the movement of cargo over long distances (e.g., cross-country) and occurs within the Port as the initiation or termination of a line haul trip, as cargo is either picked up for transport to destinations across the country or is dropped off for shipment overseas. Switching refers to the assembling and disassembling of trains at various locations in and around the Port, sorting of the cars of inbound cargo trains into contiguous "fragments" for subsequent delivery to terminals, and the short distance hauling of rail cargo within the Port. It is important to recognize that "outbound" rail freight is cargo that has arrived on vessels and is being shipped to locations across the U.S., whereas "inbound" rail freight is destined for shipment out of the Port by vessel. This is contrary to the usual port terminology of cargo off-loaded from vessels referred to as "inbound" and that loaded onto vessels as "outbound."

Locomotives used for line haul operations are typically large, powerful engines of 3,000 to 4,000 hp or more, while switch engines are smaller, typically having 1,200 to 3,000 hp engines. Older line haul locomotives have often been converted to switch duty as newer line haul locomotives with more horsepower have become available. Figures 6.1 and 6.2 illustrate typical line haul and switching locomotives, respectively, in use at the Port. Note that the switching locomotives in use at the Port, some of which date to the 1950s, were replaced with new, low-emitting locomotives during 2007 as part of an agreement among the Ports of Los Angeles and Long Beach and the Pacific Harbor Line, owners/operators of the switchers.

The Port is served by three railway companies:

- Burlington Northern and Santa Fe (BNSF)
- Union Pacific (UP)
- Pacific Harbor Line (PHL)

These railroads primarily transport intermodal (containerized) freight, with lesser amounts of dry bulk, liquid bulk, and car-load (box car) freight. PHL performs most of the switching operations within the Port, while BNSF and UP provide line haul service to and from the Port and also operate switching services at their off-port locations. The two railroads that provide line haul service to the Port are termed Class 1 railroads, based on their relative size and revenues.

Figure 6.1: Typical Line Haul Locomotive

Figure 6.2: Typical Switching Locomotive

6.2 Geographical Delineation

Figure 6.3 illustrates the rail track system serving both ports, and Figure 6.4 presents a broader view of the major rail routes in the air basin that are used to move port-related intermodal cargo.

Figure 6.3: Port Area Rail Lines

Figure 6.4: Air Basin Major Intermodal Rail Routes

6.3 Data and Information Acquisition

The locomotive section of the EI presents an estimate of emissions associated with Port-related activities of the locomotives operating within the Port and outside the Port to the boundary of the SoCAB. Information regarding these operations has been obtained from:

- Previous emissions studies
- Port cargo statistics
- Input from railroad operators

PHL has previously provided data in the form of files downloaded from their locomotives' electronic event recorders. Similar to the "black boxes" installed in aircraft, the event recorders maintain a record of several locomotive operating parameters on a second-by-second basis, including throttle notch setting, locomotive speed, and direction of travel. The recorders have limited storage capacity and typically maintain two to three days of data with the oldest data being overwritten as new data is accumulated. PHL provided a download from each of its locomotives covering the same approximate 2-day period of operation. The railroad also provided a record of fuel used in each of its locomotives during 2006.

The line haul railway company operating a rail yard on Port property, Intermodal Container Transfer Facility (ICTF) also provided information on their switch engines, including representative fuel usage. In addition, railroad personnel were interviewed for an overview of their operations in the area. As stated previously, certain information related to line haul locomotive fleets has been obtained from railroad companies' Internet websites. Additionally, terminal operators and Port departments have provided information on Port rail operations that provides an additional level of understanding of overall line haul rail operations.

Throughput information provided by the railroad companies to the ports was used to estimate on-Port and off-Port rail activity. It should be noted that data collection is particularly difficult with respect to estimating rail emissions associated with Port activities. As a result, the rail data for locomotive operations associated with Port activities as presented in the 2006 Port inventory is somewhat less refined and specific than the data for other emission source categories. The Port continues to work with the railroads to further enhance the accuracy of the port activity data on which the rail emissions inventory is based.

The specific activities included in the emission estimates include movement of cargo within Port boundaries, or directly to or from port-owned properties (such as terminals and on-port rail yards). Rail movements of cargo that occur solely outside the port, such as switching at off-port rail yards, and movements that do not either initiate or end at a Port property (such as east-bound line hauls that initiate in central Los Angeles intermodal yards) are not included.

6.4 Operational Profiles

6.4.1 Rail System

The rail system is described below in terms of the activities that are undertaken by locomotive operators. Specifically, descriptions are provided for the assembly of outbound trains, the disassembly of inbound trains, and the performance of switching operations, as well as a detailed listing of the activities of line haul and switching operations.

Outbound Trains

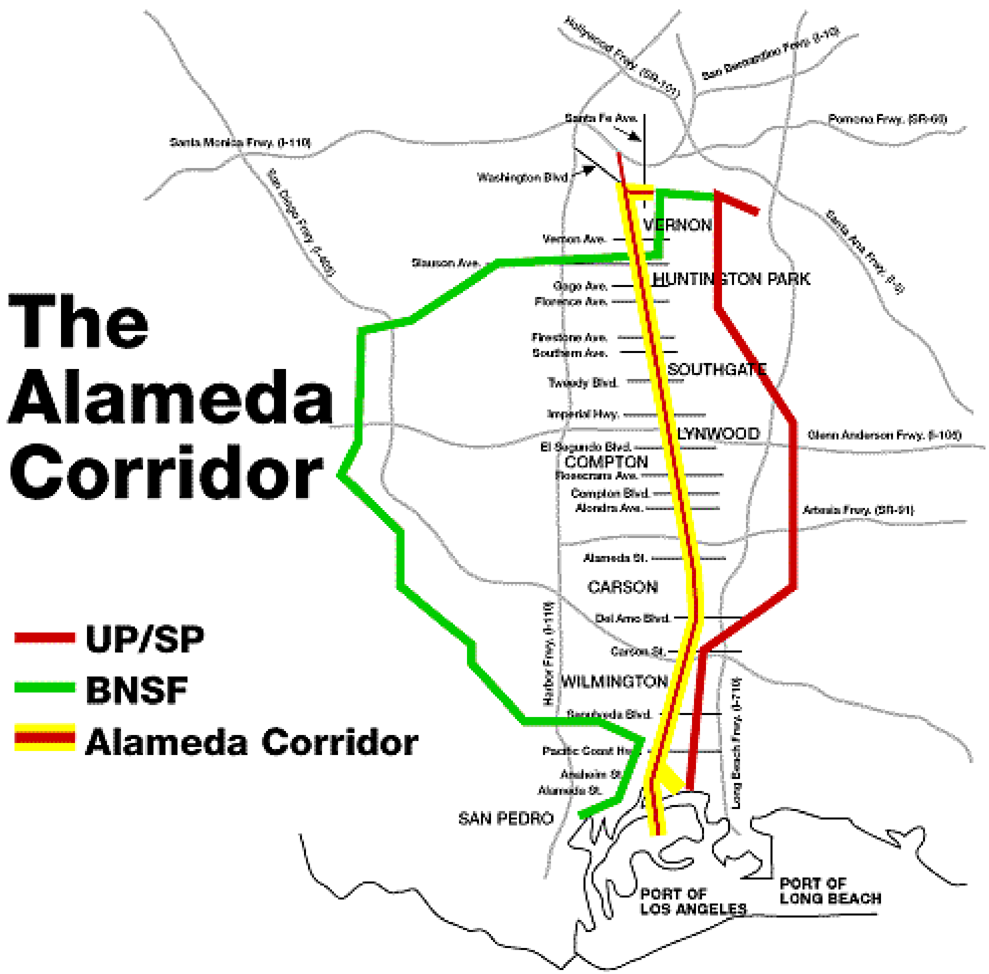
The assembly of outbound trains occurs in one of three ways. Container terminals with sufficient track space build trains on-terminal, using flat cars that have remained on site after the off-loading of inbound containers or those brought in by one of the railroads. Alternatively, containers can be trucked (drayed) to an off-terminal transfer facility where the containers are transferred from truck chassis to railcars. A third option is for the terminal to store individual railcars or build a partial train on-terminal, to be collected later by a railroad (typically PHL) and moved to a rail yard with sufficient track to build an entire train.

Within the Port, complete trains can be built at the terminals servicing Yang Ming and American Presidents Line (APL). In addition, the Terminal Island Container Transfer Facility (TICTF) is shared by Nippon Yusen Kaisha (NYK) and Evergreen as a location to build trains. Trains are also built outside of the Port at the Watson Yard, the Dolores Yard, and the Manuel Yard, and at locations within the POLB. If containers to be transported by rail are not loaded onto railcars at the Port, they are typically hauled by truck (drayed) to off-port locations operated by the line haul railroads. The containers are loaded onto railcars at these locations.

Alameda Corridor

The Alameda Corridor is a 20-mile rail line running between the San Pedro Bay area and downtown Los Angeles used by intermodal and other trains servicing the San Pedro Bay Ports and other customers in the area. Running largely below grade, the Alameda Corridor provides a more direct route between downtown Los Angeles and the Port than the routes that had previously been used, shortening the travel distance and eliminating many at-grade crossings (reducing traffic congestion). Figure 6.5 illustrates the route of the Alameda Corridor and the routes it has replaced.

Figure 6.5: Alameda Corridor



Inbound Trains

In-bound trains that carry cargo (or empty containers) that are all destined for the same terminal are delivered directly to the terminal by the Class 1 railroad if the receiving terminal has the track space to accommodate all of the cars at one time (e.g., the TICTF on Terminal Island). Trains carrying cargo that is bound for multiple terminals with one or both Ports are staged by the Class 1 railroads at several locations, where they are broken up, typically by PHL, and delivered to their destination terminals. Inbound trains are also delivered to off-Port locations such as the Watson Yard, the ICTF operated by UP, the Dolores Yard, and the Manuel Yard. Of these off-Port locations, only the ICTF is included in the emission estimates presented in this emissions inventory, because of its status as a joint powers authority of the Port of Los Angeles and the Port of Long Beach.

Switching

Switching locomotives deliver and pick up railcars transporting containers, liquid and dry bulk materials, and general cargo to and from terminals at the Port. Switching operations take place around the clock, seven days per week, although weekend activity is generally lower than weekday or weeknight activity.

PHL is the primary switching railroad at the Port. PHL operations are organized into scheduled shifts, each shift being dispatched to do specified tasks in shift-specific areas. For example, there is a daily shift that operates on the west side of the Port, servicing liquid bulk terminals and storage facilities in that area. As another example, another daily shift operates in the POLB servicing the Toyota import terminal and various other non-container terminals in the POLB. Other shifts move empty or laden container flat cars to and from container terminals. Much of the work involves rearranging the order of railcars in a train to organize cars bound for the same destinations (inbound or outbound) into contiguous segments of the train, and to ensure proper train dynamics. Train dynamics can include, for example, locating railcars carrying hazardous materials the appropriate minimum distance from the locomotives, and properly distributing the train's weight. Although there is a defined schedule of shifts that perform the same basic tasks, there is little consistency or predictability to the work performed during a given shift or at a particular time.

Specific Activities
Locomotive activities of the Class 1 railway companies consist of:

- Delivering inbound trains (and/or empty railcars) to terminals or to the nearby rail yards, using line haul locomotives.
- Picking up trains from the terminals or nearby rail yards and transporting them to destinations across the country, using line haul locomotives.
- Breaking up inbound trains and sorting rail cars into contiguous fragments, and delivering the fragments to terminals, using switch locomotives.

Locomotive switching activities consist of:

- Breaking up inbound trains and sorting railcars into contiguous fragments, and delivering the fragments to terminals.
- Delivering empty container flat cars to terminals.
- Delivering rail cars to non-container facilities, and removing previously delivered rail cars. (For example, delivering full tank cars to a terminal that ships product and removing empties, or delivering empty tank cars to a terminal that receives product and removing full ones.)
- Rearranging full and empty railcars to facilitate loading by a terminal.
- Picking up outbound containers in less than full train configuration and transporting them to a yard for assembly into full trains – to be transported out of the Port by one of the line haul railroads.

6.4.2 Locomotives and Trains

Locomotives operate differently from other types of mobile sources with respect to how they transmit power from engine to wheels. While most mobile sources use a physical coupling such as a transmission to transfer power from the engine to the wheels, a locomotive's engine turns a generator or alternator powering an electric motor that, in turn, powers the locomotive's wheels. The physical connection of a typical mobile source means that the engine's speed is dictated by the vehicle's speed through a fixed set of gear ratios, resulting in the highly transient operating conditions (particularly engine speed and load) that characterize mobile source operations. In contrast, the locomotive's engine and drive system operate more independently, such that the engine can be operated at a particular speed without respect to the speed of the locomotive itself. This allows operation under more steady-state load and speed conditions, and as a result locomotives have been designed to operate in a series of discrete throttle settings called notches, ranging from notch positions one through eight, plus an idle position.

Many locomotives also have a feature known as dynamic braking, in which the electric drive engine operates as a generator to help slow the locomotive, with the resistance-generated power being dissipated as heat. While the engine is not generating motive power under dynamic braking, it is generating power to run cooling fans, so this operating condition is somewhat different from idling. Switch engines typically do not feature dynamic braking.

Line Haul Locomotives

Line haul locomotives are operated in the Port by BNSF and UP. Because the function of line haul locomotives is to transport freight to and from destinations across the country, there is no readily identifiable "fleet" of line haul locomotives that call on the Port other than the Class 1 railroads' nation-wide fleets.

The characteristics of BNSF line haul locomotives operating within the Port were estimated from a sampling of BNSF locomotives that called on the Port area in 2001 updated with information provided in 2007. The sample of locomotives, primarily the 6-axle General Electric (GE) C44-9W (also known as Dash 9's), has an average of 4,256 horsepower. The 2007 data confirmed that the Dash 9 is still the predominant BNSF locomotive calling at the Port.

Basic specifications of UP locomotives were obtained from the railroad's Internet website.[44] The UP website lists approximately 6,500 line haul locomotives in the company's nation-wide fleet, with an average power rating of 3,655 horsepower. Most of the locomotives are six-axle units, the remainder being four-axle units. Six-axle locomotives are generally more powerful than four-axle locomotives. Most of the UP locomotives calling on the Port are six-axle, 4,000-horsepower Electromotive Division (EMD) SD70s.

Line haul locomotives are typically operated in groups of two to five units, with three or four units being most common, depending on the power requirements of the specific train being pulled and the horsepower capacities of available locomotives. Thus, two higher-horsepower locomotives may be able to pull a train that would take three units with lower power outputs. Locomotives operated in sets are connected such that every engine in the set can be operated in unison by an engineer in one of the locomotives.

Switching Locomotives

Most switching within the Port is conducted by PHL. The Class 1 railroads also conduct switching at their off-port locations. At times, PHL personnel operate BNSF or UP switch locomotives. PHL's fleet in 2006 consisted of 20 switch engines ranging from 1,200 to 2,000 hp, with an average of 1,823 hp. While the PHL fleet consists of several models, all are powered by 12- or 16-cylinder EMD engines.

[44] *See: http://www.uprr.com.*

Early in 2006, PHL, the Port, and the Port of Long Beach concluded an agreement whereby the two ports will help fund the replacement of PHL's locomotives with new locomotives operating with low-emission Tier 2 engines. The existing fleet described above will be removed from Port service as the new locomotives are received during 2007.

During 2006, PHL also test-ran a hybrid diesel/electric switcher and a unit running on a set of relatively small diesel engines and generators rather than one large engine. The hybrid locomotive runs a relatively small diesel engine to charge a bank of batteries that provide motive power, while the generator set (genset) switcher is able to shut down individual engines when power needs are lower. Both types of locomotives are certified to EPA Tier 2 locomotive standards, which will be the minimum standard met by PHL's future locomotive acquisitions under the agreement noted above.

The Class 1 railroads also operate switch engines in and around the Port, primarily at their switching yards outside of the Port. Table 6.1 lists the switch engines that have been reported as working as switching locomotives in the area by PHL or by one of the other railroads.

Table 6.1: Typical On- and Off-Port Port Switching Locomotives

Locomotive Model	Engine Mfr	Engine Model	Horsepower (each)
SW-1200	EMD	`	1,200
SW-1200	EMD	12-567-BC	1,200
GP-7	EMD	16-567-BC	1,500
GP-9	EMD	16-567-C	1,750
SD-18	EMD	16-567-D3	1,800
SD-20	EMD	16-567-D1	2,000
SD-20	EMD	16-645-CE	2,000
GP-7	EMD	not reported	1,500
GP-9	EMD	not reported	1,750
GP-30	EMD	not reported	2,250
GP-38	EMD	not reported	not reported
GP-39-2	EMD	not reported	2,300
SD-40	EMD	not reported	3,000

Train Configuration

Container trains are the most common type of train seen at the Port. While equipment configurations vary, these trains are typically made up of up to 25 double-stack railcars, each railcar consisting of five platforms capable of carrying up to four TEUs of containerized cargo (e.g., most platforms can carry up to two 40-foot containers). With this configuration the capacity of a train is 500 TEUs or about 278 containers at an average ratio of 1.8 TEU/container. As a practical matter not all platforms carry four TEUs because not all platforms are double stacked; the current capacity or "density" is approximately 80% (meaning a 25-car train would carry 500 TEUs x 80% = 400 TEUs).

In developing off-port line haul locomotive emission estimates, the following assumptions were made regarding the typical make-up of trains traveling the Alameda Corridor and beyond: 23 double-stack railcars, 80% density, for a capacity of 368 TEUs or 204 containers (average). These assumptions are consistent with information developed for the No Net Increase Task Force's evaluation of 2005 Alameda Corridor locomotive activities.[45] Average train capacity assumptions for on-port emission estimates are lower based on reported container throughput and weekly/annual train information provided by Port terminals. It is assumed that train sizes are adjusted in the off-port rail yards prior to or after interstate travel to or from the Port.

6.5 Methodology

The following section provides a description of the methods used to estimate emissions from switching and line haul locomotives operating within the Port and in the South Coast Air Basin.

Emissions have been estimated using the information provided by the railroads and the terminals, and from published information sources such as the EPA's Regulatory Support Document (RSD) published as background to EPA's locomotive rule-making process.[46] For in-Port switching operations, the throttle notch data and fuel use information provided by the switching companies have been used along with EPA data on emission rates by throttle notch. Off-Port switching emissions have been estimated using 2005 fuel use data previously provided by the railroad company operating the ICTF, scaled to the increase in facility throughput between 2005 and 2006. For the limited line haul operations in the Port, emission estimates have been based on schedule and throughput information provided by the railroads and terminal operators and on EPA operational and emission factors. Off-Port line haul emissions have been estimated using cargo movement information provided by the line haul railroads, and weight and distance information developed for the 2005 emissions inventory. A detailed explanation of emission calculation methods is presented below.

[45] Personal communication, Art Goodwin, Alameda Corridor Transportation Authority, with Starcrest Consulting Group, LLC, February 2005.

[46] EPA Office of Mobile Sources, *Locomotive Emission Standards Regulatory Support Document,* April 1998, revised.

Different calculation methods were required because different types of information were used for different activities. However, an attempt has been made to standardize the activity measures used as the basis of calculations in order to develop consistent methodologies and results.

6.5.1 Switching Emissions

Separate emission estimates have been prepared for the companies that provide switching services within and near the Port based on the information available from each company. Estimation methods differ because the companies provided different types of information, as described below.

Emissions from PHL's on-port switching operations have been based on their reported locomotive fuel use, site-specific throttle notch frequencies, and emission factors from the EPA documents cited above.

First, the characteristics of the PHL fleet operating in 2006 were evaluated to develop a fleet average horsepower rating. Because several locomotives normally operate as coupled pairs, these pairs were considered as one "locomotive" when developing the averages. Table 6.2 lists the "in-use" rated horsepower characteristics of the 2006 fleet. Note that each locomotive pair as mentioned above is counted as one locomotive in this table, hence the total of 17 at the bottom of the table.

Table 6.2: Horsepower Characteristics of PHL Locomotives

Locomotive Model	Engine Model	Number	Each	Rated Horsepower In Use	Total
Pair of SW-1200s	12-567-C	1	1,200	2,400	2,400
Pair of SW-1200s	12-567-C/BC	1	1,200	2,400	2,400
Single SW-1200	12-567-C	1	1,200	1,200	1,200
SD-18	16-567-D3	4	1,800	1,800	7,200
SD-20	16-567-D1	1	2,000	2,000	2,000
SD-20	16-567-CE	2	2,000	2,000	4,000
SD-20	16-645-E	1	2,000	2,000	2,000
SD-20	16-645-CE	1	2,000	2,000	2,000
GP-7/GP-9 Pair	16-567-C/BC	1	1,750/1,500	3,250	3,250
SD-38-2	16-645-E	2	2,000	2,000	4,000
SD-40T	16-645-E3	2	3,000	3,000	6,000
Total		17			36,450
Average locomotive horsepower:					**2,144**

Next, the average notch-specific horsepower values for the "average" switch locomotive operated by this company have been calculated by multiplying the average rated horsepower value by notch-specific percentages derived from the EPA's RSD cited above. The percentages represent the fraction of total rated horsepower that is produced in each throttle setting. This process is illustrated in the example below, for throttle notch setting 1, with results for all throttle settings shown in Table 6.3.

Equation 6.1

83 hp / 1,750 hp = 0.047, or 4.7%

2,144 hp x 0.047 = 101 hp

In this example, the average notch 1 power in the RSD data is 83 hp, which is divided by the average rated power of the locomotives tested for the RSD, 1,750 hp. The result is 0.047, or 4.7%; this means that 4.7% of the power of the average locomotive (in the RSD dataset) is used at throttle notch position 1. The next step is to multiply the average horsepower rating of the locomotives doing switch duty at the Port (2,144 hp) by the percentage of power used by the RSD locomotives. This result is 101 horsepower, meaning that the switch engines in use at the Port use an average of 101 hp while in throttle notch position 1.

This calculation is repeated for each throttle notch position, as shown in Table 6.3.

Table 6.3: Calculation of Notch-Specific In-Use Horsepower

Notch	RSD Power in Notch, bhp	% of Avg. Rated bhp	Avg. in-use Power, bhp
DB	67	3.8%	81
Idle	14	0.8%	17
1	83	4.7%	101
2	249	14.2%	304
3	487	27.8%	596
4	735	42.0%	900
5	1,002	57.3%	1,229
6	1,268	72.5%	1,554
7	1,570	89.7%	1,923
8	1,843	105.3%	2,258
Average RSD hp:	**1,750**	**Avg. local hp:**	**2,144**

(Note: in these tables, "DB" refers to "dynamic braking," a feature of some locomotives' operation that does not apply to this switching locomotive fleet. The term is included because it is part of the published EPA data set.)

The next step is to develop notch-weighted hourly emission rates, first by using the in-use horsepower values described above to convert the RSD average switching emission rates from g/hp-hr to pounds per hour (lbs/hr). The conversion is calculated as follows:

Equation 6.2

$$(g/hp\text{-}hr \times hp) / (453.6\ g/lb) = lb/hr$$

The two sets of emission rates (g/hp-hr and lb/hr) are presented in Tables 6.4 and 6.5, where the values in Table 6.5 have been obtained by multiplying those in Table 6.4 by the in-use horsepower figures presented in Table 6.3.

For example, for NO_X emissions and throttle notch setting 1, the Table 6.4 value of 16.63 g/bhp-hr is multiplied by the notch position 1 horsepower value of 101 hp in Table 6.3 and divided by 453.6 g/lb to result in an estimate of 3.70 lb/hr as shown in Table 6.5. This calculation is repeated for each throttle notch position, as shown in Table 6.5.

Table 6.4: Horsepower-Based Emission Factors from RSD

Notch	PM g/bhp-hr	NO_x g/bhp-hr	CO g/bhp-hr	HC g/bhp-hr
DB	1.05	40.20	8.49	3.98
Idle	2.26	77.70	16.81	9.18
1	0.29	16.63	2.56	1.49
2	0.37	12.26	1.51	0.67
3	0.34	13.09	0.83	0.43
4	0.26	14.27	0.57	0.37
5	0.24	15.10	0.53	0.38
6	0.29	15.88	0.67	0.40
7	0.25	16.37	1.26	0.44
8	0.29	16.15	2.97	0.47

Table 6.5: Hourly Notch-Specific Emission Rates

Notch	PM lb/hr	NO_x lb/hr	SO_x lb/hr	CO lb/hr	HC lb/hr
DB	0.19	7.18	0.02	1.52	0.71
Idle	0.08	2.91	0.004	0.63	0.34
1	0.06	3.70	0.02	0.57	0.33
2	0.25	8.22	0.07	1.01	0.45
3	0.44	17.20	0.13	1.09	0.56
4	0.51	28.32	0.20	1.12	0.72
5	0.64	40.92	0.27	1.43	1.03
6	0.98	54.40	0.34	2.29	1.37
7	1.08	69.41	0.43	5.33	1.86
8	1.42	80.38	0.50	14.80	2.34

Table 6.5 also includes hourly emission rates of SO_x that have been estimated on the basis of a mass balance approach and a typical fuel sulfur content of 330 ppm by weight. The mass balance approach assumes that the sulfur (S) in the fuel is converted to SO_2 and emitted during the combustion process. While the mass balance approach calculates SO_2 specifically, it is used as a reasonable approximation of SO_x. The following example shows the calculation for throttle notch position 1.

Equation 6.3

$$\frac{330 \text{ lbs S}}{1{,}000{,}000 \text{ lbs fuel}} \times \frac{0.336 \text{ lbs fuel}}{\text{hp-hr}} \times \frac{2 \text{ lbs } SO_2}{\text{lb S}} \times 101 \text{ hp} = 0.02 \text{ lbs } SO_2/\text{hr}$$

In this calculation, 330 ppm S is written as 330 lbs S per million lbs of fuel. The value of 0.336 lbs fuel/hp-hr is an average brake-specific fuel consumption derived from EPA's technical literature on locomotive emission factors. Two pounds of SO_2 is emitted for each pound of sulfur in the fuel because the atomic weight of sulfur is 32 while that of SO_2 is 64, meaning that the weight of an amount of sulfur doubles when it is expressed as SO_2. Finally, the average in-use horsepower value for throttle notch position 1 is 101 hp, as presented in Table 6.3. This calculation was carried out for each throttle notch position; the results are shown in Table 6.5.

A notch-weighted average emission rate has been estimated using time-in-notch percentages developed from the event recorder data provided by the switching company. Each hourly value in Table 6.5 is multiplied by the percentage corresponding to the respective notch setting. The percentages and resulting fractional emission rates are shown in Table 6.6. Because the time-in-notch fractions together represent all of the locomotives' operating time, the products obtained from the multiplication of pounds per hour by time fraction can be summed to provide a notch-weighted hourly emission rate that is representative of the average locomotive (or pair of locomotives) operating with an average site-specific throttle notch distribution.

Continuing the example of NO_X emissions for throttle notch position 1, the 3.70 lb/hr from Table 6.5 is multiplied by the notch position 1 percentage of 5.9% (or 0.059) listed in Table 6.6 under "wt'd avg % in mode" to obtain the value of 0.22.

Equation 6.4

$$3.70\ lb/hr \times 0.059 = 0.22$$

Each of the hourly rates in Table 6.5 is similarly multiplied by the percentage corresponding to each throttle notch position. The results are summed for each pollutant to calculate weighted average emission rates.

Table 6.6: Time-in-Notch and Weighted Average Emission Rates

Notch	wt'd avg % in mode	PM % x lb/hr	NO_x % x lb/hr	SO_x % x lb/hr	CO % x lb/hr	HC % x lb/hr
DB	0.0%	0.00	0.00	0.000	0.00	0.00
Idle	67.4%	0.05	1.96	0.003	0.42	0.23
1	5.9%	0.004	0.22	0.001	0.03	0.02
2	7.7%	0.02	0.63	0.005	0.08	0.03
3	6.7%	0.03	1.16	0.009	0.07	0.04
4	5.3%	0.03	1.49	0.011	0.06	0.04
5	3.0%	0.02	1.24	0.008	0.04	0.03
6	2.0%	0.02	1.11	0.007	0.05	0.03
7	0.9%	0.01	0.64	0.004	0.05	0.02
8	1.1%	0.02	0.88	0.005	0.16	0.03
Weighted average lb/hr		**0.20**	**9.33**	**0.05**	**0.97**	**0.46**

These lb/hr emission rates were converted to g/hp-hr emission factors using an estimate of the average in-use horsepower developed from the weighted average percent time in mode (Table 6.6) and the average notch-specific in-use horsepower (Table 6.3), as summarized in Table 6.7 below. The percentage of time in each notch setting is multiplied by the average power at that notch – the results are summed for all notches to estimate the overall average in-use horsepower level.

Table 6.7: Estimate of Average In-Use Horsepower

Notch	Site-specific wt'd avg % in mode	Avg. in-use Power, bhp	% x bhp
DB	0.0%	81	0.0
Idle	67.4%	17	11.5
1	5.9%	101	5.9
2	7.7%	304	23.4
3	6.7%	596	40.1
4	5.3%	900	47.5
5	3.0%	1,229	37.1
6	2.0%	1,554	31.7
7	0.9%	1,923	17.7
8	1.1%	2,258	24.7
Weighted average horsepower			**240**

To develop the g/hp-hr emission factors, the lb/hr rates shown in the bottom row of Table 6.6 were multiplied by 453.6 (to convert pounds to grams) and divided by the 240 horsepower average shown in Table 6.7. These emission factors are appropriate for most of the on-port switching locomotives burning normal off-road diesel fuel.

As noted above, PHL also test-ran a hybrid diesel/electric switcher and a gen-set switcher certified to EPA Tier 2 emission levels. In addition, most switchers (all except the two Tier 2 models) ran a substantial amount of emulsified diesel fuel, a low-emission fuel made by blending a small amount of water with regular diesel fuel. The Tier 2 emission factors are from EPA's Regulatory Support Document cited above, and emission factors for the use of emulsified fuel are based on the control factors used for emulsified fuel use in other types of diesel equipment in this inventory. The off-port switcher emission factors are baseline (generic before-control) factors from EPA's Regulatory Support Document. In addition to the emission factors discussed above, greenhouse gas emission factors from EPA references[47] were used to estimate emissions of greenhouse gases CO_2, CH_4, and N_2O from all locomotives. Emission factors for all switching locomotives, including those used for the off-port switching activity, are listed in Table 6.8.

[47] CO_2 - Tables A-28 and A-36, page A-39, Annex 2 of the report (EPA #430-R-07-002, April 2007) entitled: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*; CH_4 and N_2O - Table A 101, page A-120 in Annex 3 of the same report.

Table 6.8: Switching Emission Factors, g/hp-hr

Fuel or Locomotive Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
PHL w/CARB Diesel	0.38	0.35	0.38	17.6	0.09	1.83	0.87
PHL w/Emulsion Fuel	0.27	0.24	0.27	14.96	0.09	2.25	0.96
Off-Port Switchers	0.44	0.40	0.44	17.4	0.09	1.83	1.01
Tier 2 Locomotives	0.21	0.19	0.21	7.30	0.09	1.83	0.52

Table 6.8: Switching Emission Factors, g/hp-hr (cont'd)

Fuel or Locomotive Type	CO_2	N_2O	CH_4
PHL w/CARB Diesel	487	0.013	0.040
PHL w/Emulsion Fuel	487	0.013	0.040
Off-Port Switchers	487	0.013	0.040
Tier 2 Locomotives	487	0.013	0.040

EPA's RSD does not include emission factors for SO_x. Table 6.8 includes an estimate of SO_x emissions based on PHL's reported use of EPA on-road diesel fuel, which has been assumed to have a sulfur content of 330 ppm. Additionally, all particulate emissions are assumed to be PM_{10} and DPM; $PM_{2.5}$ emissions have been estimated as 92% of PM_{10} emissions.

The activity measure used in the switching emission estimates is total horsepower-hours of activity, derived from the locomotive-specific fuel use data provided by PHL for the on-port switching, and an estimate of off-port switching fuel use derived from information provided earlier by the railroad operating the off-dock rail yard that is located on Port property. For the off-dock rail yard, the reported 2005 fuel usage was multiplied by the ratio of 2006 to 2005 container throughput reported by the railroad (706,293/600,750 or an increase of 18%, using the assumption that switching activity increased linearly with container throughput).

As an example of how fuel use was used to estimate total hp-hrs, a total of 10,000 gallons of fuel per year would be divided by the fuel use factor of 0.048 gallons per hp-hr (gal/hp-hr) to produce an estimate of 208,333 hp-hrs. This would be multiplied by the g/hp-hr emission factors to estimate the mass of emissions over the year.

PHL operates within both the Port of Los Angeles and the Port of Long Beach. While some of the shifts are focused on activities in only one of the ports, other shifts may work in either or both ports depending upon the day's needs for switching services. Therefore, it is not possible to clearly designate which shifts operate solely within the Port of Los Angeles so a method was required for apportioning emissions between the two ports. To do this, the previous baseline emissions inventory evaluated the work shifts as to whether they are likely to work in either port exclusively or in both ports. The result was a split of 69% of activity within the Port of Los Angeles and 31% within the Port of Long Beach. The difference between the two ports' allocations is so great in part because PHL's main yard is within the Port of Los Angeles, so almost all work shifts involve at least some activity within the Port of Los Angeles.

Rail cargo from both the Port of Los Angeles and the Port of Long Beach are handled at the off-dock ICTF, and the complexities of the rail system are such that apportionment of activity (and emissions) between the two ports is difficult. The previous baseline emissions inventories used an allocation of 55% Port of Los Angeles and 45% Port of Long Beach – this allocation has been maintained for the current inventories because it still seems a reasonable assumption, given that the Port of Los Angeles' overall TEU throughput represented about 54% of the two ports' combined throughput in 2006. Regardless of apportionment, the sum of the two ports' emissions represents all of the estimated switching emissions from locomotives operated at the ICTF.

6.5.2 Line Haul Locomotive Emissions

Emissions from line haul locomotives operating in the Port have been estimated on an activity basis, i.e., estimates of the number and characteristics of locomotives that arrive and depart with cargo. The information used in developing these estimates has been obtained from the Port and Port terminals.

The number of locomotive trips in the Port has been estimated by evaluating cargo movements, percentage of cargo transported by rail, and typical number of locomotives per train, using a methodology similar to that used for the 2001 baseline emissions inventory. Emission factors have been taken from EPA's RSD documentation representing EPA's projected 2006 nationwide fleet of line haul locomotives, as shown in Tables 6.9 and 6.10. The emission factors are presented in terms of grams per horsepower-hour (g/hp-hr) as listed in the RSD documentation.

Table 6.9: Emission Factors for Line Haul Locomotives, g/hp-hr

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
EF, g/bhp-hr	0.30	0.27	0.30	8.1	0.59	1.28	0.44

Table 6.10: GHG Emission Factors for Line Haul Locomotives, g/hp-hr

	CO_2	N_2O	CH_4
EF, g/bhp-hr	487	0.040	0.013

On-Port Line Haul Emissions

On-port line haul locomotive activity has been estimated through an evaluation of the amount of cargo reported by the terminals to be transported by rail and their reported average or typical number of trains per week or per year. These numbers have been combined with assumptions regarding the number of locomotives, on average, that are involved with on-port line haul railroad moves, and the average duration of incoming and outgoing port trips, similar to the approach taken for the 2001 baseline emissions inventory. The number of trains per year, locomotives per train, and on-port hours per train were multiplied together to calculate a total of locomotive hours per year. While most of the rail cargo, and the basis for these estimates centers on container traffic, the local switching railroad has reported that they prepare an average of one train per day of cargo other than containers for transport out of the San Pedro Bay Ports area. It has been assumed that a similar number of trains are inbound, and that the total number has an even split between both ports. Therefore, the number of trains per year includes an average of one non-container train every other day in each direction (for an annual total of 366 additional trains for each port).

Table 6.11: On-Port Line Haul Locomotive Activity

Activity Measure	Inbound	Outbound	Totals
Number of trains/year	5,250	5,803	11,052
Number of locomotives/train	3	3	NA
Hours on Port/trip	1.0	2.5	NA
Locomotive hours/year	15,749	43,520	59,269

The average load factor for a typical line haul locomotive calling on the Port has been estimated by multiplying the percentage of full power in each throttle notch setting by the average percentage of line haul locomotive operating time in that setting. Both of these sets of percentages are EPA averages listed in the RSD documentation. This average load factor is probably overestimated because the throttle notch distribution is representative of nation-wide operation; including time traveling uphill when the higher notch positions are most often used. However, detailed throttle notch information has not been made available to enable the development of a location-specific average load factor.

Table 6.12: Estimated Average Load Factor

Notch	% of Full Power in Notch	% of Operating Time in Notch	% Full Power x % Time
DB	2.1%	12.5%	0.003
Idle	0.4%	38.0%	0.002
1	5.0%	6.5%	0.003
2	11.4%	6.5%	0.007
3	23.5%	5.2%	0.012
4	34.3%	4.4%	0.015
5	48.1%	3.8%	0.018
6	64.3%	3.9%	0.025
7	86.6%	3.0%	0.026
8	102.5%	16.2%	0.166
Average line haul locomotive load factor:			**28%**

The estimated number of locomotive hours for the Port was multiplied by an average locomotive horsepower and the average load factor discussed above to estimate the total number of horsepower-hours for the year:

Equation 6.5

59,269 locomotive hours/year x 4,000 horsepower/locomotive x 0.28

= 66.4 million horsepower-hours (rounded)

Emission estimates for on-port line haul locomotive activity were calculated by multiplying this estimate of horsepower-hours by the emission factors listed in Tables 6.9 and 6.10 in terms of g/hp-hr.

Out-of-Port Line Haul Emissions

Line haul locomotive activity between the Port and the air basin boundary has been estimated through an evaluation of the amount of Port cargo transported by rail and of average or typical train characteristics such as number of containers and number of gross tons per train. In this way, estimates have been prepared of gross tonnage and fuel usage, similar to the methodology used for the previous Port emissions inventories.

The four components to locomotive activity that were estimated to develop the off-port emission estimates are the number of trains, the average weight of each train, the distances traveled within the South Coast Air Basin, and the amount of fuel used per ton-mile of train activity. Using the average train capacities discussed above (average 204 containers per train) and the two San Pedro Bay Ports' 2006 intermodal throughputs, the average number of port-related trains was estimated to be 40 per day through the Alameda Corridor[48] including non-container trains discussed above. The gross weight (including locomotives, railcars, and freight) of a typical train was estimated to be 5,300 tons, using the assumptions in Table 6.13. The distance assumptions are 21 miles for the Alameda Corridor and 84 miles between the northern end of the Alameda Corridor to the Air Basin boundary. The latter distance is an average of the east and south routes taken by UP trains and the east route taken by most BNSF trains, weighted by the percentage distribution of freight reported in the 2001 baseline emissions inventory, as shown in Table 6.14 (information from 2001 was used because information from both railroads was not available for the 2005 inventory period). Gross ton-miles were calculated by multiplying together the number of trains, the gross weight per train, and the miles traveled, as summarized in Table 6.15. This table also shows the estimated total fuel usage, estimated by multiplying the gross tons by the average 2001 fuel consumption factor for the two line haul railroads (1.328 gallons of fuel per ton-mile), as reported in the 2001 baseline emissions inventory. The railroads' fuel consumption factors may have been lower in 2006 than in 2001, but the railroads declined to provide the 2006 factors for publication, citing confidentiality. The use of the average of their 2001 factors (which have been published in the Port's baseline inventory) will produce a conservatively high estimate of fuel use. Also listed in Table 6.15, is the estimated total out-of-port horsepower-hours, calculated by dividing the fuel use by the fuel use factor of 0.048 gal/hp-hr.

Table 6.13: Assumptions for Gross Weight of Trains

Train Component	Approx. Weight lbs	Weight tons (short)	Number per train	Weight tons (short)
Locomotive	420,000	210	4	840
Railcar (per double-stack platform)	40,000	20	115	2,300
Container		10.6	204	2,160
Total weight per train, gross tons				**5,300**

[48] Overall Alameda Corridor traffic for 2005 was an average of 55 per day. This includes non-port-related traffic; See: *www.acta.org/PDF/CorridorTrainCounts.pdf.*

Table 6.14: Train Travel Distance Assumptions

	Miles	% of freight, 2001	Miles x %
UP - LA east	84	36%	30
UP - LA south	91	10%	9
BNSF - LA east	82	54%	44
Weighted average distance			**84**

Table 6.15: Gross Ton-Mile, Fuel Use, and Horsepower-hour Estimate

	Distance miles	Trains per year	MMGT per year	MMGT-miles per year
Alameda Corridor	21	8,633	46	966
Central LA to Air Basin Boundary	84	8,633	46	3,864
Million gross ton-miles				**4,830**
Estimated gallons of fuel (millions)				**6.4**
Estimated million horsepower-hours				**133**

Emission estimates for out-of-port line haul locomotive activity were calculated by multiplying this estimate of overall horsepower-hours by the emission factors in terms of g/hp-hr.

6.6 Emission Estimates

A summary of estimated emissions from locomotive operations related to the Port is presented below in Tables 6.16 and 6.17. These emissions include operations within the Port and Port-related emissions outside the Port out to the boundary of the South Coast Air Basin. The distribution of emissions is presented graphically in the figure below which shows line haul emissions accounting for 85% to 90% of the total locomotive emissions.

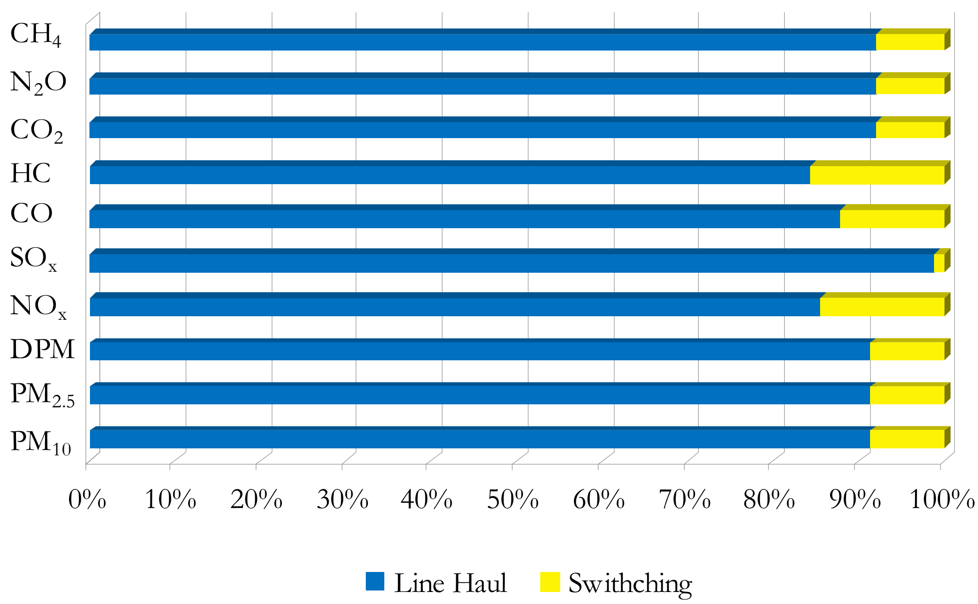
Table 6.16: Port-Related Locomotive Operations Estimated Emissions, tpy

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Swithching	6.3	5.7	6.3	301.7	1.7	39.1	18.0
Line Haul	65.9	59.3	65.9	1,779.4	129.6	281.2	96.7
Port of Los Angeles Total	**72.2**	**65.0**	**72.2**	**2,081.1**	**131.3**	**320.3**	**114.7**

Table 6.17: GHG Port-Related Locomotive Operations Estimated Emissions, tpy

	CO_2	N_2O	CH_4
Swithching	9,223.3	0.8	0.2
Line Haul	106,986.5	8.8	2.9
Port of Los Angeles Total	**116,209.9**	**9.5**	**3.1**

Figure 6.6: Distribution of 2006 Locomotive Emissions by Category, %



SECTION 7 HEAVY-DUTY VEHICLES

This section presents emissions estimates for the heavy-duty vehicles source category, including source description (7.1), geographical delineation (7.2), data and information acquisition (7.3), operational profiles (7.4), emissions estimation methodology (7.5), and the emission estimates (7.6).

7.1 Source Description

Trucks are used extensively to move cargo, particularly containerized cargo, to and from the terminals that serve as the bridge between land and sea transportation. Trucks deliver cargo to local and national destinations, and they also transfer containers between terminals and off-port railcar loading facilities, an activity known as draying. In the course of their daily operations, trucks are driven onto and through the terminals, where they deliver and/or pick up cargo. They are also driven on the public roads within the Port boundaries, and on the public roads outside the Port.

This report deals exclusively with diesel-fueled HDVs, as there were few, if any, gasoline-fueled or alternatively-fueled counterparts in use in 2006. The most common configuration of HDV is the articulated tractor-trailer (truck and semi-trailer) having five axles, including the trailer axles. The most common type of trailer in the study area is the container trailer, built to accommodate standard-sized cargo containers. Additional trailer types include tankers, boxes, and flatbeds. A tractor traveling without an attached trailer is called a "bobtail."(no trailer load) A tractor pulling an unloaded container trailer chassis is known simply as a "chassis." These vehicles are all classified as heavy HDVs regardless of their actual weight because the classification is based on gross vehicle weight rating (GVWR), which is a rating of the vehicle's total carrying capacity. Therefore, the emission estimates do not distinguish among the different configurations.

As examples of typical HDVs, Figure 7.1 shows a container truck transporting a container in a terminal, and Figure 7.2 shows a bobtail. The equipment images shown in the figures are not photographs of actual pieces of equipment used at the surveyed terminals but are for illustrative purposes only.

Figure 7.1: Truck with Container

Figure 7.2: Bobtail Truck

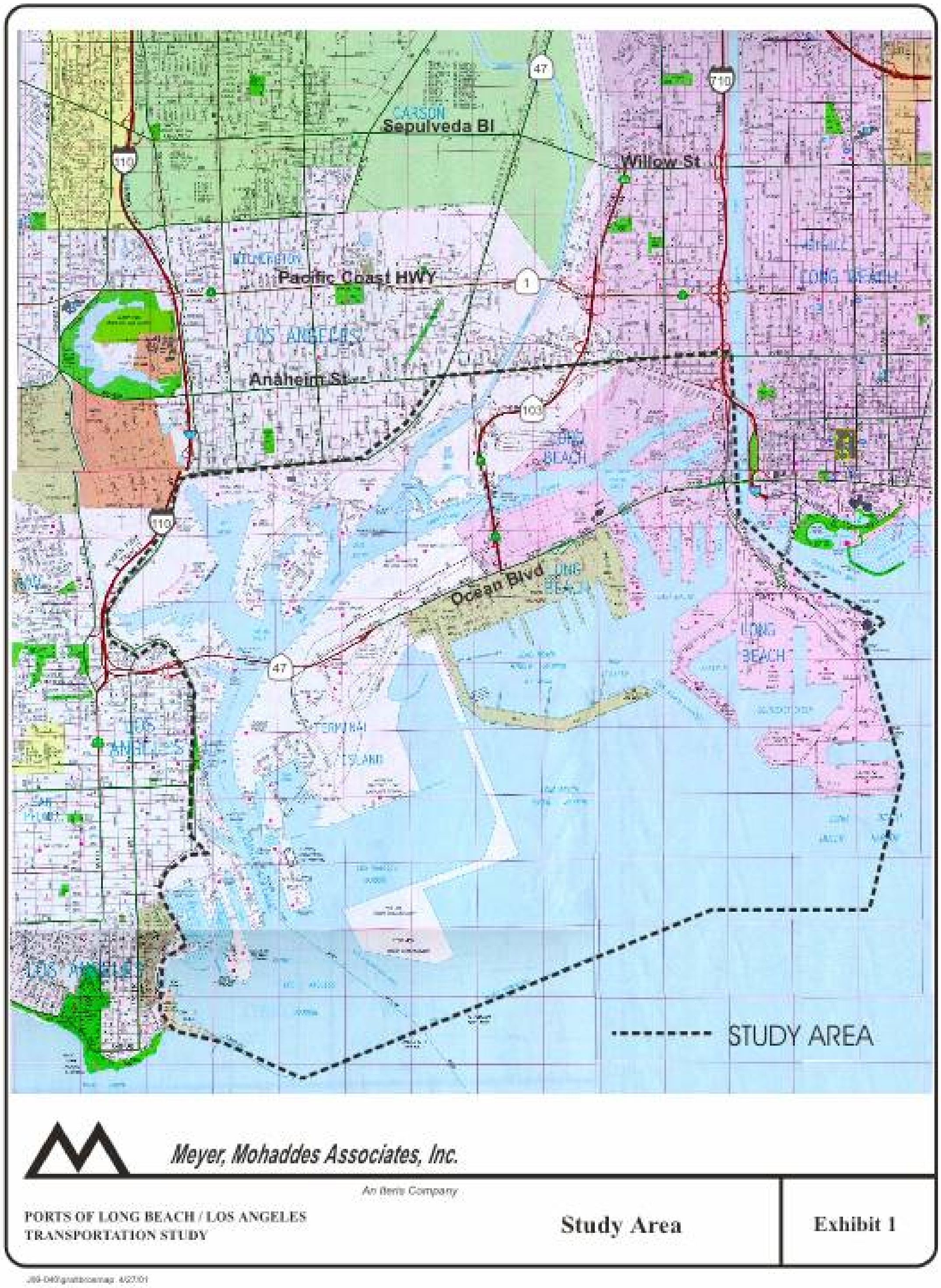
7.2 Geographical Delineation

To develop emission estimates, truck activities have been evaluated as having three components:

- On-terminal operations, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.
- Off-terminal operations, consisting of travel on public roads outside the Port boundaries but within SoCAB. This includes travel within the boundaries of the adjacent Port of Long Beach, because the routes many trucks take run through both ports on the way to and from Port terminals.

Figure 7.3 shows the roadways in and around the Port that the HDVs use in daily operations. The figure presents the scope of a traffic study that evaluated traffic patterns in both the Port of Los Angeles and the Port of Long Beach. That traffic study and its use in developing the HDV emission estimates presented in this report are discussed in more detail in the following subsections.

Figure 7.3: Port and Near-Port Roadways



7.3 Data and Information Acquisition

Data for the HDV emission estimates came from two basic sources: terminal interviews and computer modeling of on-road HDV volumes, distances, and speeds. These information sources are discussed below.

7.3.1 On-Terminal

The Port and their consultant collected information regarding on-terminal truck activity during in-person and telephone interviews with terminal personnel. This information included their gate operating schedules, on-terminal speeds, time and distance traveled on terminal while dropping off and/or picking up loads, and time spent idling at the entry and exit gates. Most terminals were able to provide estimates of these activity parameters, although few keep detailed records of information such as gate wait times and on-terminal turn-around time. However, the reported values appear to be reasonable and have been used in estimating on-terminal emissions, except as noted in the following text.

7.3.2 On-Road

The Port retained a consultant (Iteris, previously known as Meyer Mohaddes Associates) to develop estimates of on-road truck activity inside and outside the Port. To do this, the consultant used trip generation and travel demand models they have used in previous Port transportation studies[49] to estimate the volumes (number of trucks) and average speeds on roadway segments between defined intersections.

The trip generation model was derived from a computer model designed to forecast truck volumes that was developed by Moffatt & Nichol Engineers (M&N), who were team members on the *2001 Port Transportation Study*. The Port's consultant developed and validated the trip generation model using terminal gate traffic count data. They reported in their traffic study report that the model validation confirmed that the model was able to predict truck movements to within two to 10 percent of actual truck counts for all the container terminals combined, and to within 15 percent or better for the majority of individual terminals (MMA 2001). These were considered to be excellent validation results considering the variability of operating conditions and actual gate counts on any given day. The main input to the trip generation model for this study consisted of the average daily container throughput in 2006.

The results of the trip generation model were used as input to a Port-area travel demand model also developed by Iteris. This model was based on the regional model used for transportation planning by the Southern California Association of Governments (SCAG), the federally designated Metropolitan Planning Organization for the SoCAB area. Iteris incorporated port-specific truck travel information from

[49] Meyer, Mohaddes Associates, Inc.,. *Ports of Long Beach/Los Angeles Transportation Study*, June 2001(MMA 2001) and Meyer, Mohaddes Associates, Inc., *Port of Los Angeles BaselineTransportation Stud, April 2004y.*

the trip generation model, as well as the results of an origin/destination survey of approximately 3,300 Port-area truck drivers, into the Port-area travel demand model.

The travel demand model produced terminal-specific estimates of truck traffic volumes and speeds over defined Port roadway segments. A brief example is provided in Table 7.1. The traffic volumes and distances were combined to produce estimates of vehicle miles of travel (VMT), which in turn were used with the speed-specific EMFAC emission factors (discussed below) to estimate on-Port on-road driving emissions associated with each container terminal. The same model was used to produce estimates of Port-related truck traffic traveling through the POLB, such as toward the 710 Freeway across Terminal Island.

The roadway volumes of truck traffic outside the Port area were estimated by Iteris using a regional analysis that modeled Port-related trucks bi-directionally on highways and major thoroughfares within the greater Los Angeles area until the trucks leave the highways and enter city streets. The intent was to model Port-related trucks on their way from the Port until they make their first stop, whether for delivery of a container to a customer or to a transloading facility, or reach the boundary of the South Coast Air Basin. Transloading is the process of unloading freight from its overseas shipping container and re-packing it for overland shipment to its destination.

Table 7.1: On-Road HDV Activity Modeling Results – Example

Roadway Segment	From	To	Direction	Bobtails	Chassis	Con-tainers	Dist. miles	Speed mph
Anaheim St	Anaheim Wy	9th Street	East Bound	313	62	366	0.65	40
Santa Fe	Canal	Santa Fe	East Bound	71	-	57	0.18	20
Canal	Harbor	Canal	East Bound	95	13	131	0.21	29
Henry Ford	SR-47 SB Off Ramp	Henry Ford	East Bound	96	46	301	0.69	40

7.4 Operational Profiles

Based on the data and information collected, activity profiles were developed for on-terminal and off-terminal truck traffic, as described below.

7.4.1 On-Terminal

Table 7.2 illustrates the range and average of reported characteristics of on-terminal truck activities at Port container terminals. The total number of trips was based on information provided by the terminals.

Table 7.2: Summary of Reported Container Terminal Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	17.5	1.5	NA	0.28	0.40	0.20
Minimum	10	0.9	NA	0.08	0.08	0.00
Average	13	1.2	NA	0.15	0.27	0.05
Total			**4,696,134**			

Table 7.3 shows the same summary data for the terminals and facilities other than container terminals. The total number of trips was based on information provided by the terminals.

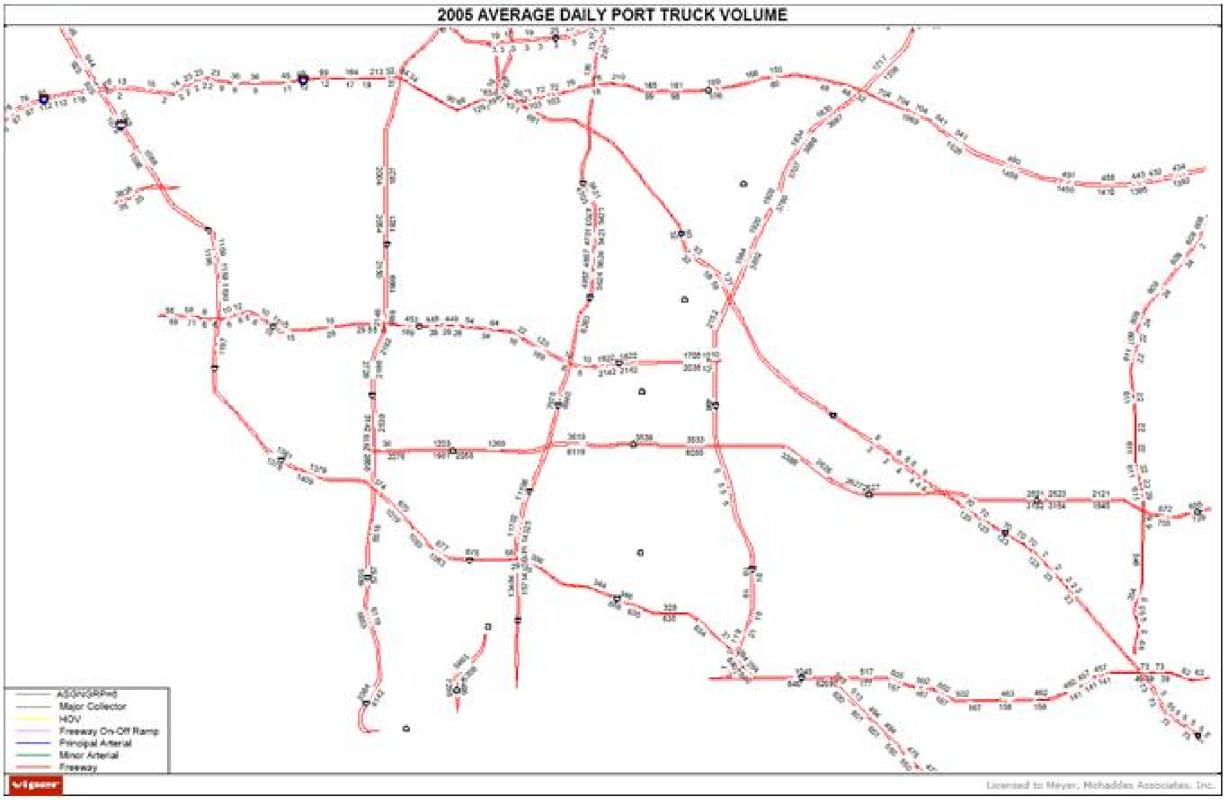
Table 7.3: Summary of Reported Non-Container Facility Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	20.0	1.0	NA	0.42	0.50	0.25
Minimum	2	0.0	NA	0.00	0.00	0.00
Average	9	0.3	NA	0.10	0.13	0.04
Total	0	0	**1,661,047**	0	0	0

7.4.2 On-Road

Figure 7.4 provides a graphical example of the regional analysis, a map of area roadways listing the number of trucks on each segment of road, in each direction of travel. The information on these maps was incorporated into the same calculations as used for the in-port on-road estimates described above. The daily traffic estimates are based on average week-day activity during a peak month. They have been annualized for the emission estimates presented in this inventory by adjusting for peak to average conditions on the basis of 255 weekdays of terminal operation per year, and assuming that weekend activity accounts for 15% of total annual activity. These adjustments are empirically derived factors used by the Port in their planning processes requiring annualization of daily activity measures.

Figure 7.4: Regional Traffic Volume Map



During the Technical Working Group's (TWG) review of the 2005 draft emissions inventory report, the traffic modeling discussed above was extensively examined with respect to two key components: the number of truck trips to and from Port terminals and the total number of miles these trips generated within the Air Basin. The review took place over several meetings of the TWG (including staff members from Ports, consultant, CARB, SCAQMD and EPA) and primarily consisted of reconciling the trip and VMT estimates produced by the terminal and regional models with independent estimates prepared by CARB.

In comparison with the independent activity estimates developed by CARB, the model results on which this inventory is based are somewhat higher, as full reconciliation of the methodologies was not achieved within the time frame of this inventory or of CARB's regulatory development schedule. The CARB model is focused on container truck traffic and estimates considerably lower VMT than the Port models' estimates for container traffic alone. As a result of the discrepancy, the San Pedro Bay Ports and CARB, along with SCAQMD, have pledged to continue working together to understand the differences in the methodologies and to conduct the reviews and studies necessary to reconcile them to ensure the best, most supportable estimates possible for upcoming revisions to the Ports' inventories.

7.5 Methodology

This section discusses how the emission estimates were developed based on the data collected from terminals or developed by traffic modeling. Figure 7.5 illustrates this process in a flow diagram format for the three components of the HDV evaluation previously discussed (on-terminal, on-Port, and regional components) It is important to note that the speed specific gram per mile emission rates estimated by CARB's EMFAC 2007 model were used in support of this analysis. However, because EMFAC does not directly report the gram per hour emission rates associated with idle engine operation, CARB's published low idle emission rates, rather than the modeled output was used.

This subsection describes the specific methodology used to develop the emission estimates for HDVs in the various locations described above. The general form of the equation for estimating the emissions inventory for a fleet of on-road vehicles is:

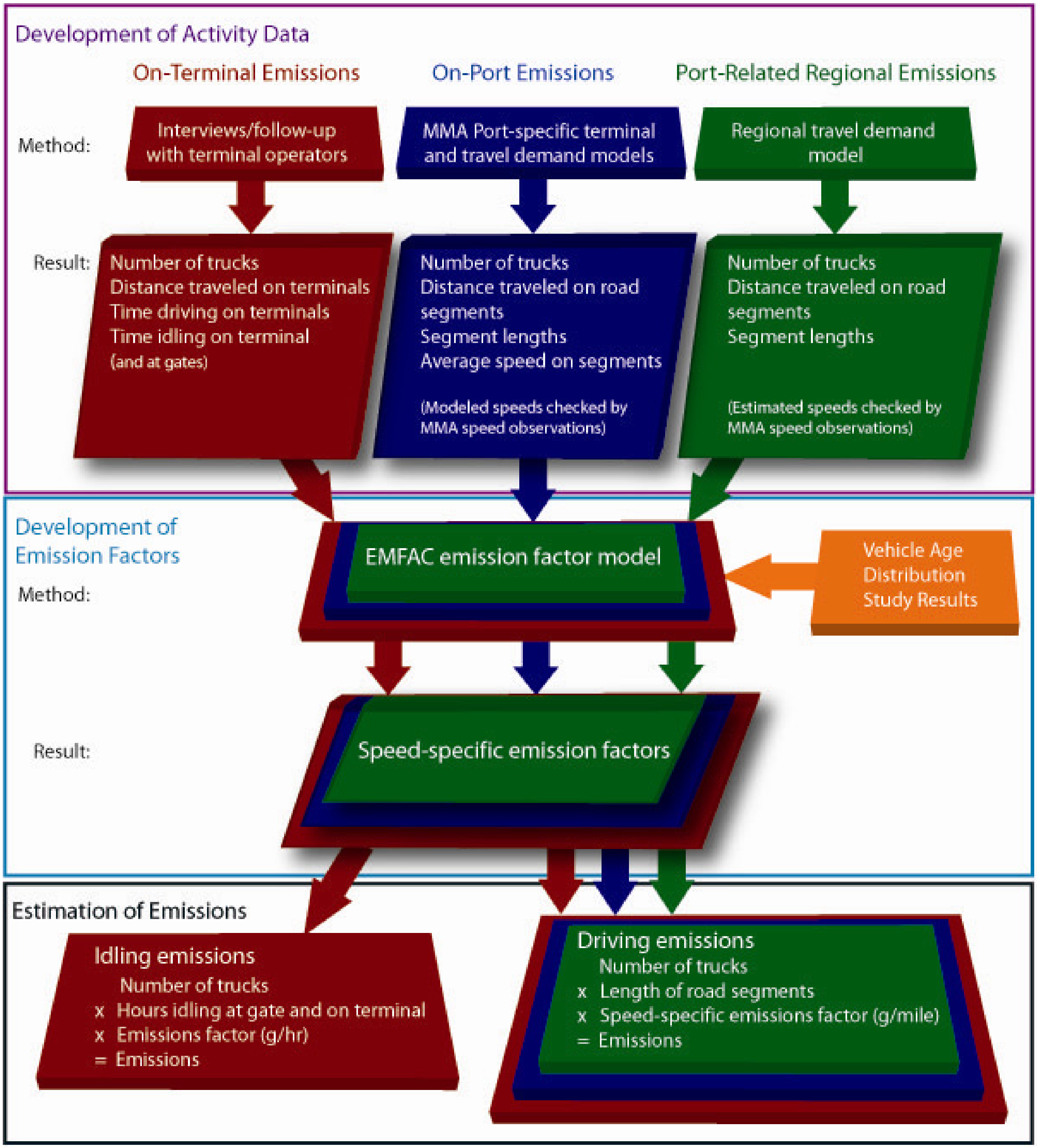
Equation 7.1

Emissions = Population x Basic Emission Rate x Activity x Correction Factor

Where:

Population = number of vehicles of a particular model year in the fleet
Basic Emission Rate = amount of pollutants emitted per unit of activity for vehicles of that model year
Activity = the average number of miles per truck
Correction Factor = adjustment to Basic Emission Rate for specific assumptions of activity and/or atmospheric conditions

Figure 7.5: HDV Emission Estimating Process



The basic emission rate is modeled as a straight line with a "zero mile rate" (ZMR) or intercept representing the emissions of the vehicle when new (well maintained and un-tampered), plus a "deterioration rate" (DR) or slope representing the gradual increase in the emission rate over time or as a function of use (mileage). For heavy-duty diesel trucks the deterioration rate is expressed as grams per mile traveled per 10,000 accumulated miles.

Equation 7.2

Basic Emission Rate = ZMR + (DR x Cumulative Mileage /10,000)

In estimating the emissions from heavy-duty trucks, two types of activity can be considered: running emissions that occur when the engine is running with the vehicle moving at a given speed, and idle emissions that occur when the engine is running but the vehicle is at rest. Running emissions are expressed in grams per mile, while idle emissions are expressed in grams per hour. The emission factors (g/mi or g/hr) are multiplied by the activity estimates, VMT or hours of idle operation, to derive a gram per day (g/day) or gram per year inventory.

7.5.1 The EMFAC model

The CARB has developed a computer model to calculate the emissions inventories of various vehicle classes in the California fleet. EMFAC 2007, the latest official version of the model, has been approved by the EPA for use in California and this model, with noted exceptions, was used to estimate the emissions of heavy-heavy-duty diesel trucks that call on the Port.

Although the EMFAC model produces ton per day estimates of emissions by vehicle class, it is generally a macro-scale model that is inappropriate for estimating inventories at a sub-county level. In order to calculate the inventory of emissions for Port-related heavy-duty trucks, the emission factors and correction factors from EMFAC were coupled with Port specific truck activity estimates.

7.5.2 Basic Emission Rates

The basic emission rates of heavy duty-diesel trucks included in EMFAC are derived from tests of vehicles randomly selected from the in-use fleet. Because CARB has imposed progressively more stringent standards for the allowable emissions from trucks over many years, different model years of trucks have been certified to specific standards and, therefore, are assumed to emit at different rates. Table 7.4 lists the emission factors used to estimate the emission of trucks visiting the Port.

Table 7.4: Emission Factors in EMFAC 2007 (ZMR in g/mi – DR in g/mi/10,000mi)

Model Years	HC		CO		NO_x		PM		CO_2	
	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR
Pre-87	1.20	0.027	7.71	0.176	23.0	0.019	1.73	0.028	2237	0.00
87-90	0.94	0.032	6.06	0.209	22.7	0.026	1.88	0.025	2237	0.00
91-93	0.62	0.021	2.64	0.090	19.6	0.039	0.78	0.014	2237	0.00
94-97	0.46	0.024	1.95	0.103	19.3	0.046	0.51	0.011	2237	0.00
98-02	0.47	0.024	1.99	0.103	18.9	0.053	0.56	0.010	2237	0.00
03-06	0.30	0.011	0.87	0.031	12.5	0.052	0.35	0.005	2237	0.00

CARB has included an update to the idle emissions rates for heavy-duty diesel trucks and their "low idle" emission rates were used in developing the emissions inventory for the Port. These factors are presented in Table 7.5.

Table 7.5: Idle Emission Rates in EMFAC 2007 (g/hr)

Model Years	HC	CO	NO_x	PM	CO_2
Pre-1987	25.9	28.4	45.7	4.76	4,640
1987-90	15.2	23.4	70.2	2.38	4,640
1991-93	12.1	21.5	78.4	1.78	4,640
1994-97	9.68	19.8	85.3	1.33	4,640
1998-02	7.26	17.8	92.1	0.92	4,640
2003-06	5.97	16.6	95.5	0.72	4,640

A more in-depth explanation of CARB's heavy-duty diesel inventory estimation methodology can be found in their document "*Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors*"[50] 3 April 2006.

While most emissions from heavy-heavy duty diesel trucks are estimated on a per-mile or per-hour basis, the inventory SO_x was calculated based upon an estimate of the amount of fuel consumed. The following equation was used to derive the SO_x inventory.

[50] See: *http://www.arb.ca.gov/msei/supportdocs.html#onroad.(CARB* 2006)

Equation 7.3

$$SO_x \text{ emissions (tpd)} = \frac{(X \text{ g S}/1{,}000{,}000 \text{ g fuel}) \times (3{,}311.21 \text{ g/gallon}) \times (2 \text{ g } SO_x / \text{g S}) \times (Y \text{miles/day})}{(5.268 \text{ miles/gallon}) \times (453.59 \text{ g/lb} \times 2{,}000 \text{ lbs/ton})}$$

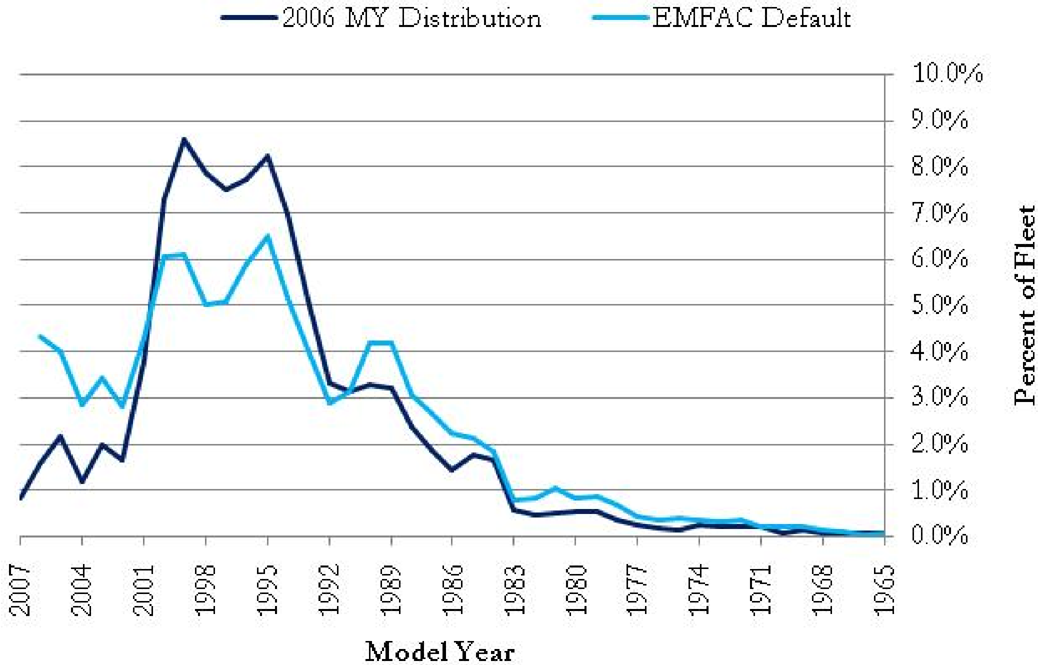
In this equation, g is grams, S is sulfur, and lb is pounds. The emission calculations have been based on the introduction of 15 ppm ULSD as commercially available onroad diesel fuel at the beginning of September 2006. The weight of a gallon of diesel fuel is assumed to be 7.3 pounds or 3,311.21 grams (7.3 lbs x 453.59 g/lb). Based on the EMFAC model, the fleet average fuel economy of the heavy-heavy duty diesel fleet is assumed to be 5.268 miles per gallon. The estimates of daily vehicle miles of travel were from the Iteris trip generation and travel demand modeling for in-Port and regional on-road travel, and were derived through tenant surveys for the on-terminal estimates.

7.5.3 Age Distribution

The age distribution (count of vehicles by model year) of trucks calling upon the Port was determined through evaluation of license plate numbers provided by several container terminals. This is an on-going project of the two ports and the age distribution will be updated periodically as new data is received and evaluated.

Over 2,000,000 records were received from the terminals, which yielded about 49,000 unique license plate numbers. Registration information was requested from the California Department of Motor Vehicles and 29,540 records were returned with model year information. The distribution of the truck population by age is presented in Figure 6.6 below. The average age of the Port-related fleet was determined to be 11.4 years, which is in reasonable agreement with the EMFAC estimate of heavy-duty diesel trucks in operation within the South Coast Air Basin of 11.5 years. While the average age is similar, the EMFAC distribution includes a greater proportion of trucks in the newest age range (up to seven years old) and correspondingly fewer trucks in the eight to 13-year age range.

Figure 7.6: Population Distribution of the Heavy-Duty Truck Fleets



EMFAC carries an estimate of 45 model years of population within each calendar year ranging from the newest, for which the model year is the same as the current calendar year, to the oldest where the model year is the current calendar year minus 45. Therefore, EMFAC does not allow the model year to be greater than the current calendar year. For purposes of this analysis, 2007 model year trucks that were in the sample of license plates provided by the terminals were assumed to have the same activity as 2006 model year trucks.

7.5.4 Mileage Accrual Rates/Cumulative Mileage

Since no data were available to estimate the actual mileage of each truck visiting the Port, the mileage accrual rates from EMFAC were used. The mileage accrual rates are the estimates of the miles traveled each year by vehicles of a specific age and type of vehicle. When vehicles are new, the mileage accrual rates are assumed to be at their highest. The miles per year tend to decline as the truck ages.

CARB has also modified the mileage accrual rates used in EMFAC as discussed in their document entitled "*Redistribution of Heavy-Heavy Duty Diesel Truck Vehicle Miles Traveled in California*" 13 September 2006[51]. The mileage accrual rates included in the EMFAC 2007 update and used in this analysis are shown in Table 7.6.

[51] See: *http://www.arb.ca.gov/msei/supportdocs.html#onroad*

Table 7.6: Mileage Accrual Rates Heavy-Heavy Duty Diesel Trucks in EMFAC 2007 (mi/yr)

Truck Age (years)	Miles/Year	Truck Age (years)	Miles/Year	Truck Age (years)	Miles/Year
1	80,705	13	43,854	25	16,662
2	85,152	14	39,965	26	15,164
3	86,460	15	36,504	27	13,653
4	85,386	16	33,452	28	12,136
5	82,571	17	30,772	29	10,629
6	78,547	18	28,417	30	9,159
7	73,755	19	26,335	31	7,759
8	68,546	20	24,469	32	6,467
9	36,199	21	22,764	33	5,324
10	57,926	22	21,171	34	4,369
11	52,881	23	19,645	35	3,363
12	48,169	24	18,150	36+	3,363

The cumulative mileage of a vehicle is assumed to be the sum of its mileage accrual rates. That is, for a three year old truck, for example, the average odometer reading would be assumed to be 252,317 miles, or 80,705 + 85,152 + 86,386. In turn, the cumulative mileage is used to assess the level of deterioration to be added to the basic emission rate (see above).

In keeping with our example of a three year old truck, the basic emission rate for NO_x would be calculated as follows:

Equation 7.4

18.9 g/mi (ZMR) + 0.053 g/mi/10K miles (DR) x 252,317 miles (Cumulative Mileage) = 20.24 g/mi

A population weighted basic emission rate for each pollutant was derived performing the calculation above for each model year; the results were then weighted by the population fraction in each model year. These fleet weighted emission rates are presented in Table 7.7.

Table 7.7: Heavy Heavy-Duty Diesel Truck Fleet Weighted Emission Rates

Pollutant	Emission Rate (g/mile)
HC	1.875
CO	13.182
NO_x	20.992
PM	1.515

7.5.5 Correction Factors

As stated earlier, correction factors are used to adjust the basic emission rates to reflect vehicle specific activity such as speed and type and quality of fuel burned, and specific ambient conditions such as temperature and relative humidity. In order to better reflect the emissions of the Port truck fleet, the basic emission rates were adjusted for both fuel and speed.

Fuel correction factors are applied to adjust for differences in the fuel used during certification or in-use testing, and the fuel used in routine operation. According to CARB's memo in which the EMFAC 2007 heavy-duty diesel emission rates are discussed, the reported emission factors represent pre-clean diesel rates. CARB diesel has a lower sulfur and aromatic hydrocarbon content compared to pre-clean diesel. According to CARB's memo entitled "*On-Road Emissions Inventory Fuel Correction Factors,*" 26 July 2005, a 28 percent reduction in HC, 25 percent reduction in NO_x and a seven percent reduction in PM should be applied to the basic emission rates to reflect the benefits of CARB diesel. The fuel correction factors are applied as multiplicative modifiers to the basic emission rates. That is, a 25 percent reduction would yield a correction factor of 0.75. Table 7.8 lists the diesel fuel correction factors.

Table 7.8: CARB Diesel Fuel Correction Factors

Pollutant	Fuel Correction Factor
HC	0.72
CO	1.0
NO_x	0.75
PM	0.93

Speed is used as a surrogate for the work of the engine or load and emissions tend to increase or decrease as load increases or decreases. The basic emission rates are derived from testing vehicles over a reference cycle with a single average speed of about 20 miles per hour (the Urban Dynamometer Driving Schedule or UDDS). Speed correction factors adjust the basic emission rates for cycles or trips of differing speeds.

As running emissions are expressed in terms of grams per mile, the speed correction factors tend to be higher at the extremes of speed. At high speeds, the vehicle's engine has to work harder to overcome wind resistance and emissions tend to increase as a consequence. At low speeds, the vehicle has to overcome inertia and rolling resistance. Although emissions tend to be lower at lower speeds, as the distance approaches zero the grams/mile ratio increases. The result is a generally "U" shaped curve describing the impact of speed on emissions.

In the current version of EMFAC, at least two pollutant specific speed correction factors are needed to properly characterize the emissions of the heavy-duty truck fleet. The equation and coefficients needed to derive the speed correction factors included in EMFAC 2007 are described in CARB documentation[52].

Equation 7.5

$$\textit{Speed Correction Factor} = A + (B \times \textit{Speed}) + (C \times \textit{Speed}^2)$$

Table 7.9 lists the speed correction factor coefficients.

[52] Amendment to EMFAC Modeling Change Technical Memo, *Revision of Heavy Heavy-duty Diesel Truck Emission factors and Speed Correction Factors*, 20 October 2006.

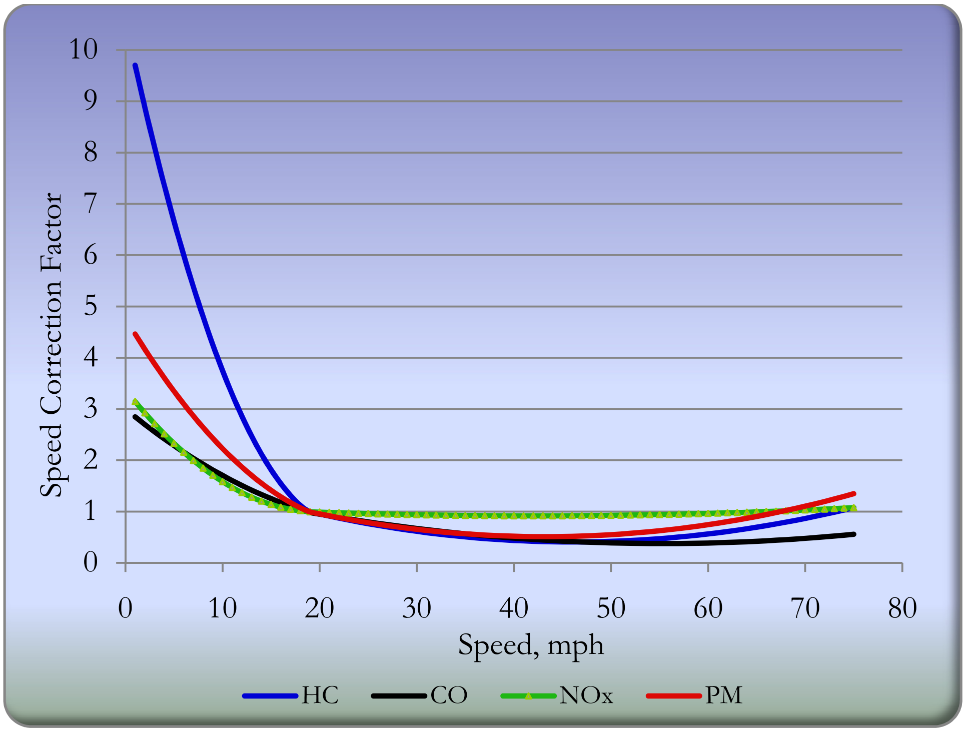
Table 7.9: CARB Speed Correction Factor Coefficients

Pollutant	Model Year Group	Speed Range	A	B	C
HC	**Pre-1991**	5.00 - 18.8	7.1195	-0.4789	0.008159
		18.8 - 65.0	1.6373	-0.04189	0.0003884
	1991-2002	5.00 - 18.8	11.614	-0.9929	0.02278
		18.8 - 65.0	2.3019	-0.08712	0.0009773
	2003+	5.00 - 18.8	10.219	-0.8937	0.02146
		18.8 - 65.0	1.6053	-0.03799	0.0002985
CO	**Pre-1991**	5.00 - 65.0	1.6531	-0.04198	0.0003352
	1991-2002	5.00 - 18.8	3.0388	-0.1511	0.002267
		18.8 - 65.0	1.8753	-0.05664	0.0005141
	2003+	5.00 - 18.8	6.2796	-0.5021	0.01177
		18.8 - 65.0	1.3272	-0.02463	0.000336
NO_x	**Pre-1991**	5.00 - 18.8	2.2973	-0.1173	0.002571
		18.8 - 65.0	1.3969	-0.02658	0.0002725
	1991-2002	5.00 - 18.8	3.7668	-0.2862	0.007394
		18.8 - 65.0	1.0771	-0.005981	0.00009271
	2003+	5.00 - 18.8	2.7362	-0.148	0.002958
		18.8 - 65.0	1.5116	-0.03357	0.0003118
PM	**Pre-1991**	5.00 - 18.8	2.6039	-0.1266	0.002198
		18.8 - 65.0	1.4902	-0.03121	0.0002733
	1991-2002	5.00 - 18.8	5.7807	-0.4032	0.007918
		18.8 - 65.0	2.2766	-0.08661	0.0009948
	2003+	5.00 - 18.8	1.4086	-0.02313	0.00007449
		18.8 - 65.0	1.4881	-0.0408	0.0007894

These speed correction factors were used to derive speed specific emission factors for each pollutant at 5 mile per hour increments for use in this analysis. This was accomplished by deriving the model year and pollutant specific speed correction factors and then weighting each factor by the population of Port trucks in each model year group. Figure 7.7 shows the fleet weighted speed correction factors for each pollutant.

The speeds used in the on-road emission calculations were estimated by the travel demand modeling discussed previously. The on-terminal speeds are those reported as average on-terminal speeds by the respective terminal operators.

Figure 7.7: Fleet Weighted Speed Correction Factors



7.6 Emission Estimates

On-terminal and on-road emissions have been estimated by terminal and are summed to represent Port-wide emissions. As discussed above, on-terminal emissions are based on terminal-specific information such as number of trucks passing through the terminal and the distance they travel on-terminal, and the Port-wide totals are the sum of the terminal-specific estimates. The on-Port on-road emissions were estimated on a terminal-specific basis for the container terminals, using the travel demand modeling results discussed above, which estimated how many trucks from each container terminal traveled along each section of road within the port. The off-Port on-road emissions were estimated for Port trucks in general (not terminal-specific) in a similar manner to the on-Port estimates, using travel demand model results to estimate how many trucks travel along defined roadways in the SoCAB on the way to their first cargo drop-off point. In most cases, emissions have been allocated to the non-container terminals using a ratio approach based on the number of trucks visiting each non-container terminal relative to the total number of container terminal truck calls. This approach was used because the in-Port travel demand model does not include terminal-specific estimates for Port terminals other than container terminals. The ratio approach assumes that the trucks servicing non-container terminals have the same general activity patterns as trucks servicing the container terminals, in terms of speed and mileage within the Port and in the region. There are five non-container terminal businesses located on Port

property to the north of the main Port area whose trucks primarily serve on-Port terminals and make round trips between the business and the Port. Facility-specific estimates have been developed for these businesses, using facility-specific information related to the number of round trips made per day.
Idling emissions were estimated separately for the on-terminal estimates, since the off-terminal traffic modeling analysis reported only volumes, distances, and average speeds, which were used to estimate VMT. This is a valid approach because the average speeds include estimates of normal traffic idling times and the emission factors are designed to take this into account.

Since annual activity was used for the on-terminal analysis, emissions have been calculated as tons per year, with idling and transit activities estimated separately. Table 7.10 summarizes the two modes of on-terminal operation by terminal.

Table 7.10: 2006 On-Terminal VMT and Idling Hours by Terminal ID

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	830,000	539,500
Container	1,682,037	635,436
Container	594,787	105,740
Container	914,453	381,022
Container	997,677	308,805
Container	756,497	294,193
Other	91,286	36,225
Other	132,780	52,691
Other	15,660	13,050
Other	3,818	1,909
Dry Bulk	1,250	625
Break Bulk	650	953
Auto	3,750	2,505
Liquid	80	160
Break Bulk	58,500	25,350
Liquid	22	0
Dry Bulk	1,044	8,526
Break Bulk	2,400	440
Break Bulk	26,843	17,000
Other	2,088	5,986
Other	64	527
Other	10,179	1,414
Other	991,340	498,974
Liquid	11,406	28,744
Liquid	3,227	2,689
Total	**7,131,837**	**2,962,463**

Emission estimates for HDV activity associated with Port terminals and other facilities are presented in the following tables. Tables 7.11 and 7.12 summarize emissions from HDVs associated with all Port terminals.

Table 7.11: Summary of HDV Emissions, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	7,131,837	31	28	31	528	0.9	236	106
On-Road	307,914,072	374	344	374	8,051	39	2,572	493
Totals	**315,045,909**	**404**	**372**	**404**	**8,579**	**40.30**	**2,808**	**599**

Table 7.12: Summary of HDV GHG Emissions, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	7,131,837	38,342	4	5
On-Road	307,914,072	660,984	88	23
Totals	**315,045,909**	**699,326**	**92**	**28**

Tables 7.13 and 7.14 show emissions associated with container terminal activity separately from emissions associated with other Port terminals and facilities.

Table 7.13: Summary of HDV Emissions Associated with Container Terminals, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	5,775,450	26	23	26	421	0.7	192	87
On-Road	277,422,931	337	310	337	7,253	35	2,317	444
Totals	**283,198,381**	**362**	**333**	**362**	**7,675**	**36.23**	**2,509**	**532**

Table 7.14: Summary of HDV GHG Emissions Associated with Container Terminals, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	5,775,450	30,772	3	4
On-Road	277,422,931	595,520	80	21
Totals	**283,198,381**	**626,291**	**83**	**25**

Tables 7.15 and 7.16 show emissions associated with other Port terminals and facilities separately.

Table 7.15: Summary of HDV Emissions Associated with Other Port Terminals, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	1,356,387	5	5	5	107	0.2	44	18
On-Road	30,491,141	37	34	37	798	4	254	49
Totals	**31,847,528**	**42**	**39**	**42**	**904**	**4.07**	**299**	**67**

Table 7.16: Summary of HDV GHG Emissions Associated with Other Port Terminals, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	1,356,387	7,570	1	1
On-Road	30,491,141	65,464	9	2
Totals	**31,847,528**	**73,035**	**10**	**3**

SECTION 8 SUMMARY OF 2006 EMISSION RESULTS

The emission results for the Port of Los Angeles 2006 Inventory of Air Emissions are presented in this section. Tables 8.1 and 8.2 summarize the 2006 total Port-related emissions in the South Coast Air Basin by category in tons per year.

Table 8.1: 2006 Port-related Emissions by Category, tpy

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	644	515	546	6,614	5,711	601	279
Harbor craft	52	48	52	1,265	1	345	84
Cargo handling equipment	52	49	51	1,853	2	977	95
Rail locomotives	72	65	72	2,081	131	320	115
Heavy-duty vehicles	404	372	404	8,579	40	2,808	599
Total	**1,224**	**1,048**	**1,126**	**20,392**	**5,886**	**5,052**	**1,170**

DB ID457

Table 8.2: 2006 Port-related GHG Emissions by Category, tpy

Category	CO_2	N_2O	CH_4
Ocean-going vessels	406,440	23	3
Harbor craft	87,746	3	2
Cargo handling equipment	285,708	5	7
Rail locomotives	116,210	10	3
Heavy-duty vehicles	699,326	92	28
Total	**1,595,431**	**133**	**42**

The greenhouse gas emissions summarized in Table 8.3 are in metric tons per year (2,200 lbs/ton) instead of the short tons per year (2,000 lbs/ton) used throughout the report. Table 8.3 includes the CO_2 equivalent which is derived by multiplying the GHG emissions estimates by the following global warming potential (GWP)[53] values and then adding them together:

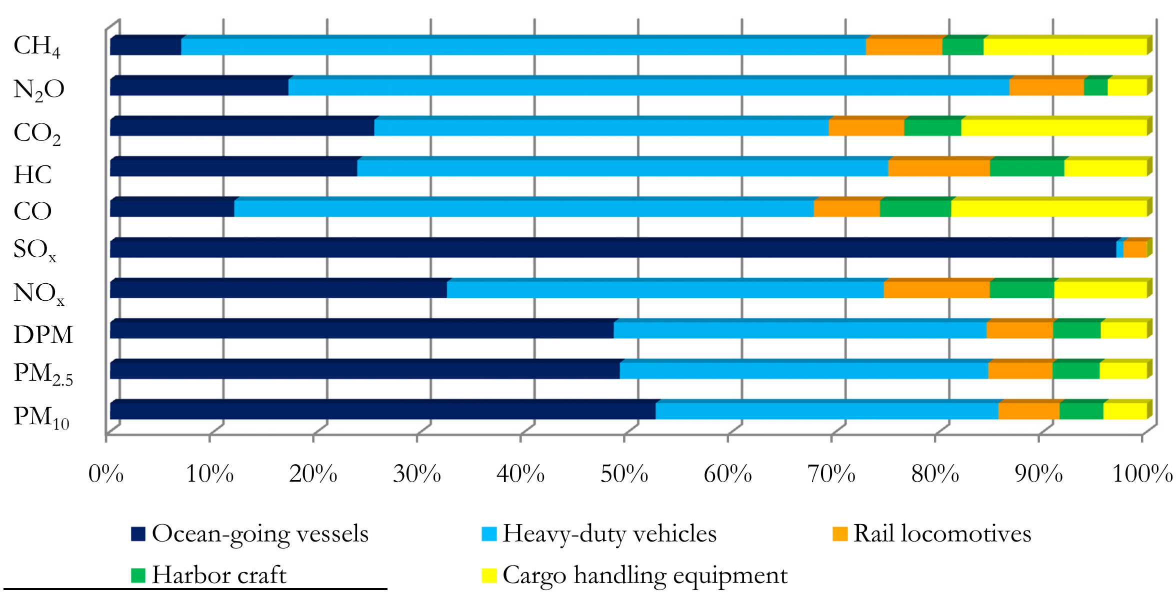
- CO_2 – 1
- CH_4 – 21
- N_2O – 310

Table 8.3: 2006 Port-related GHG Emissions by Category, MT/yr

Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	375,977	369,491	21	3
Harbor craft	80,659	79,770	3	2
Cargo handling equipment	261,276	259,735	5	6
Rail locomotives	108,394	105,645	9	3
Heavy-duty vehicles	662,276	635,751	84	25
Total	**1,488,581**	**1,450,391**	**121**	**38**

Figure 8.1 shows the distribution of the 2006 total port-related emissions for each pollutant and category.

Figure 8.1: 2006 Port-related Emissions by Category, %



[53] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, 15 April 2008.

In order to put the Port-related emissions into context, the following figures and tables compare the Port's contributions to the other sources in the South Coast Air Basin. The 2006 SoCAB emissions used for this comparison were interpolated from the 2005 and 2008 emissions listed in the 2007 AQMP Appendix III[54].

[54] SCAQMD, *Final 2007 AQMP Appendix III Table A-2, Base & Future Year Emissions Inventories*, June 2007.

Figure 8.2: 2006 DPM Emissions in the South Coast Air Basin, %

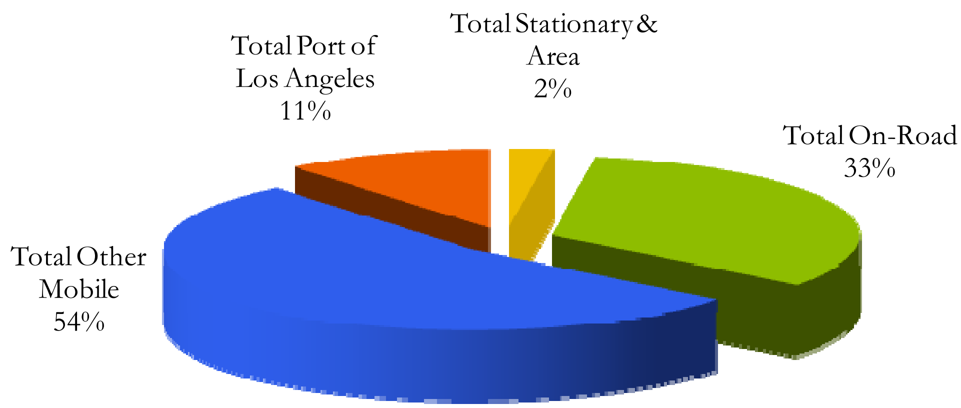


Figure 8.3: 2006 NO_x Emissions in the South Coast Air Basin, %

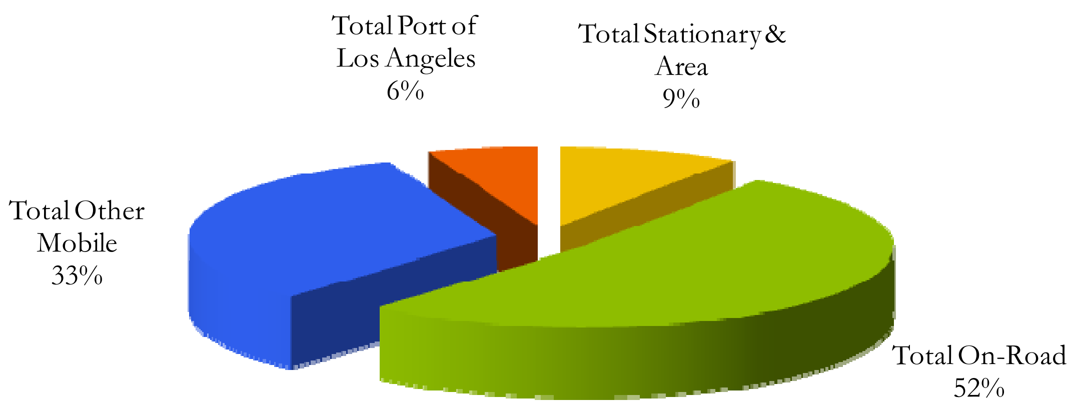
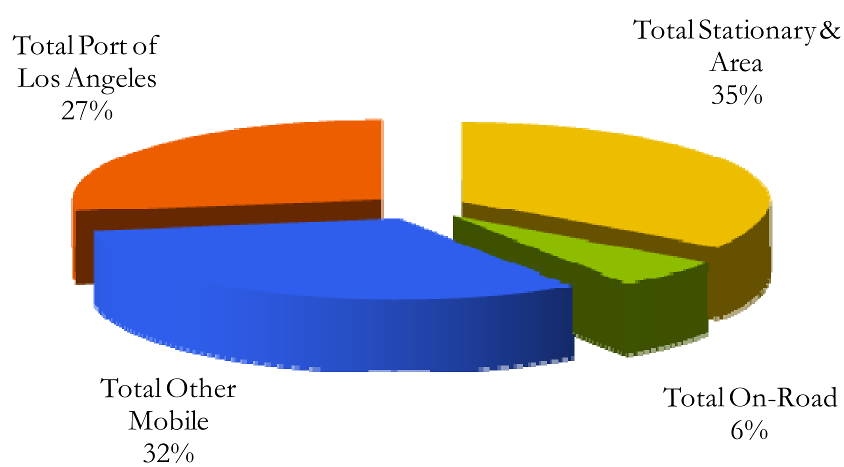


Figure 8.4: 2006 SO_x Emissions in the South Coast Air Basin, %



Tables 8.4 through 8.6 show by source subcategory, the percent emissions as it relates to the source category, the total Port-related emissions, and the South Coast Air Basin emissions. For example, containership DPM emissions are 63% of the OGV emissions, 31% of the Port emissions and 3% of the South Coast Air Basin emissions.

Table 8.4: 2006 DPM Emissions Percentage Comparison, tpy and %

Category	Subcategory	DPM Emissions	Percent DPM Emissions of Total Category	Port	SoCAB AQMP
CHE	RTG crane, crane	7	13%	1%	0%
CHE	Forklift	3	5%	0%	0%
CHE	Top handler, side pick	9	18%	1%	0%
CHE	Other	9	18%	1%	0%
CHE	Yard tractor	24	46%	2%	0%
CHE	**Subtotal**	**51**	**100%**	**5%**	**0%**
OGV	Auto carrier	6	1%	1%	0%
OGV	Bulk vessel	33	6%	3%	0%
OGV	Containership	345	63%	31%	3%
OGV	Cruise	82	15%	7%	1%
OGV	General cargo	15	3%	1%	0%
OGV	Ocean tugboat	1	0%	0%	0%
OGV	Miscellaneous	0	0%	0%	0%
OGV	Reefer	7	1%	1%	0%
OGV	RoRo	1	0%	0%	0%
OGV	Tanker	57	11%	5%	1%
OGV	**Subtotal**	**546**	**100%**	**49%**	**5%**
Harbor Craft	Assist tug	19	37%	2%	0%
Harbor Craft	Harbor tug	5	10%	0%	0%
Harbor Craft	Commercial fishing	6	11%	1%	0%
Harbor Craft	Ferry	7	13%	1%	0%
Harbor Craft	Line haul tug	2	4%	0%	0%
Harbor Craft	Government	2	3%	0%	0%
Harbor Craft	Excursion	7	13%	1%	0%
Harbor Craft	Crewboat	3	6%	0%	0%
Harbor Craft	Work boat	1	2%	0%	0%
Harbor Craft	**Subtotal**	**52**	**100%**	**5%**	**1%**
HDV	On-Terminal	31	8%	3%	0%
HDV	On-Road	374	92%	33%	4%
HDV	**Subtotal**	**404**	**100%**	**36%**	**4%**
Rail	Switching	6	9%	1%	0%
Rail	Line haul	66	91%	6%	1%
Rail	**Subtotal**	**72**	**100%**	**6%**	**1%**
Port	**Total**	**1,126**		**100%**	**11%**
SoCAB AQMP	**Total**	**10,264**			

Table 8.5: 2006 NO_x Emissions Percentage Comparison, tpy and %

Category	Subcategory	NO_x Emissions	Percent NO_x Emissions of Total Category	Port	SoCAB AQMP
CHE	RTG crane	236	13%	1%	0%
CHE	Forklift	162	9%	1%	0%
CHE	Top handler, side pick	331	18%	2%	0%
CHE	Other	208	11%	1%	0%
CHE	Yard tractor	917	49%	4%	0%
CHE	**Subtotal**	**1,853**	**100%**	**9%**	**1%**
OGV	Auto carrier	73	1%	0%	0%
OGV	Bulk vessel	338	5%	2%	0%
OGV	Containership	4,470	68%	22%	1%
OGV	Cruise	789	12%	4%	0%
OGV	General cargo	157	2%	1%	0%
OGV	Ocean tugboat	24	0%	0%	0%
OGV	Miscellaneous	1	0%	0%	0%
OGV	Reefer	72	1%	0%	0%
OGV	RoRo	7	0%	0%	0%
OGV	Tanker	682	10%	3%	0%
OGV	**Subtotal**	**6,614**	**100%**	**32%**	**2%**
Harbor Craft	Assist tug	485	38%	2%	0%
Harbor Craft	Harbor tug	122	10%	1%	0%
Harbor Craft	Commercial fishing	146	12%	1%	0%
Harbor Craft	Ferry	152	12%	1%	0%
Harbor Craft	Line haul tug	55	4%	0%	0%
Harbor Craft	Government	41	3%	0%	0%
Harbor Craft	Excursion	159	13%	1%	0%
Harbor Craft	Crewboat	82	7%	0%	0%
Harbor Craft	Work boat	23	2%	0%	0%
Harbor Craft	**Subtotal**	**1,265**	**100%**	**6%**	**0%**
HDV	On-Terminal	528	6%	3%	0%
HDV	On-Road	8,051	94%	39%	2%
HDV	**Subtotal**	**8,579**	**100%**	**42%**	**2%**
Rail	Switching	302	14%	1%	0%
Rail	Line haul	1,779	86%	9%	1%
Rail	**Subtotal**	**2,081**	**100%**	**10%**	**1%**
Port	**Total**	**20,392**		**100%**	**6%**
SoCAB AQMP	**Total**	**354,298**			

Table 8.6: 2006 SO_x Emissions Percentage Comparison, tpy and %

Category	Subcategory	SO_x Emissions	Percent SO_x Emissions of Total Category	Port	SoCAB AQMP
CHE	RTG crane	0	15%	0%	0%
CHE	Forklift	0	2%	0%	0%
CHE	Top handler, side pick	0	15%	0%	0%
CHE	Other	0	5%	0%	0%
CHE	Yard tractor	1	61%	0%	0%
CHE	**Subtotal**	**2**	**100%**	**0%**	**0%**
OGV	Auto carrier	52	1%	1%	0%
OGV	Bulk vessel	303	5%	5%	1%
OGV	Containership	2,994	52%	51%	14%
OGV	Cruise	751	13%	13%	3%
OGV	General cargo	171	3%	3%	1%
OGV	Ocean tugboat	1	0%	0%	0%
OGV	Miscellaneous	2	0%	0%	0%
OGV	Reefer	75	1%	1%	0%
OGV	RoRo	4	0%	0%	0%
OGV	Tanker	1,358	24%	23%	6%
OGV	**Subtotal**	**5,711**	**100%**	**97%**	**27%**
Harbor Craft	Assist tug	0.2	34%	0%	0%
Harbor Craft	Harbor tug	0.1	10%	0%	0%
Harbor Craft	Commercial fishing	0.1	13%	0%	0%
Harbor Craft	Ferry	0.1	15%	0%	0%
Harbor Craft	Line haul tug	0.0	3%	0%	0%
Harbor Craft	Government	0.0	3%	0%	0%
Harbor Craft	Excursion	0.1	14%	0%	0%
Harbor Craft	Crewboat	0.0	6%	0%	0%
Harbor Craft	Work boat	0.0	2%	0%	0%
Harbor Craft	**Subtotal**	**1**	**100%**	**0%**	**0%**
HDV	On-Terminal	1	2%	0%	0%
HDV	On-Road	39	98%	1%	0%
HDV	**Subtotal**	**40**	**100%**	**1%**	**0%**
Rail	Switching	2	1%	0%	0%
Rail	Line haul	130	99%	2%	1%
Rail	**Subtotal**	**131**	**100%**	**2%**	**1%**
Port	**Total**	**5,886**		**100%**	**27%**
SoCAB AQMP	**Total**	**21,462**			

SECTION 9 COMPARISON OF 2006, 2005 AND 2001 FINDINGS AND EMISSION ESTIMATES

The emissions for 2006, 2005 and 2001 calendar year activity are compared in this section. Each subsection contains the emissions table and chart comparisons, states how the emissions estimates were derived and compares findings for that source category. For each specific source category, if there was a methodological change in 2006, then the 2005 emissions were recalculated using 2005 activity with the new 2006 methodology to provide a valid basis for comparison. If there was no change in methodology, then the emissions included in the 2005 EI report were used for the comparison.

Methodological differences for 2006 vs. 2005:

OGV

- The methodology used in 2006 to estimate OGV emissions is the same as what was used in 2005 Inventory of Air Emissions (2005 Port Inventory)

Harbor Craft

The same methodology with the following exceptions:

- Emission factors changed (used EPA's EF in 2005 Port Inventory, used CARB's EF in 2006)
- In 2005 Port Inventory, deterioration rates were not included in the calculations, but 2006 methodology includes deterioration rates
- The load factor for excursion vessels and ferries changed from 0.76 in 2005 to 0.42 in 2006
- Recreational vessels were not included as part of the comparison

CHE

The same methodology with the following exception:

- The load factor for yard tractors changed from 0.65 in 2005 to 0.39 in 2006 based on a 2006 in-field study conducted by ports in consultation with CARB's staff

Rail

- The methodology used in 2006 to estimate rail emissions is the same as what was used in 2005 Port Inventory

HDV

- The methodology used in 2006 to estimate HDV emissions is the same as what was used in 2005 Port Inventory

Methodological differences for 2006 vs. 2001:

OGV

- The methodology used in 2006 to estimate OGV emissions is the same as what was used in 2005 Port Inventory, thus the adjusted 2001 OGV emissions found in 2005 Port Inventory were used for comparison

Harbor Craft

The same methodology with the following exceptions:

- Emission factors changed (used EPA's EF in 2001 and 2005 Port Inventory, used CARB's EF in 2006)
- In 2005 and 2001 Port Inventories, deterioration rates were not included in the calculations, but 2006 methodology includes deterioration rates
- Recreational vessels were not included as part of the comparison

CHE

The same methodology with the following exception:

- The load factor for yard tractors changed from 0.57 in 2001 to 0.39 in 2006 based on a 2006 in-field study conducted by ports in consultation with CARB's staff

Rail

- The methodology used in 2006 to estimate rail emissions is the same as what was used in 2005 Port Inventory , thus the adjusted 2001 rail emissions found in 2005 Port Inventory were used for comparison

HDV

- The methodology used in 2006 to estimate HDV emissions is the same as what was used in 2005 Port Inventory, thus the adjusted 2001 HDV emissions found in 2005 Port Inventory were used for comparison

Table 9.1 and Figure 9.1 illustrate the differences in vessel calls and container cargo throughputs between 2001, 2005 and 2006. From 2005 to 2006, there was a 13% increase in TEU throughput, the number of total calls increased by 16%, and containership calls increased by 14%. From 2001 to 2006, although the number of calls stayed the same, the TEU throughput increased by 63%.

Table 9.1: TEUs and Vessel Call Comparison, %

EI Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2006	2,708	1,626	8,469,853	5,209
2005	2,341	1,423	7,484,625	5,260
2001	2,717	1,584	5,183,520	3,272
2006-2005	**16%**	**14%**	**13%**	**-1%**
2006-2001	**0%**	**3%**	**63%**	**59%**

Figure 9.1: TEUs and Vessel Call Comparison, %

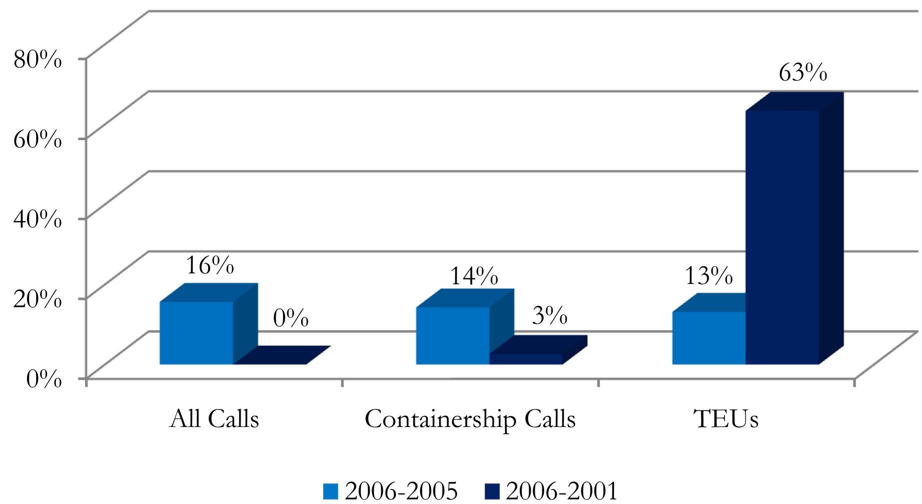


Table 9.2 present the total net change in emissions for all source categories in 2006 as compared to 2005 and 2001.

Table 9.2: Port-wide Emissions Comparison, tpy and % Change

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006 Total	1,224	1,048	1,126	20,392	5,886	5,052	1,170
2005 Total	1,139	973	1,056	18,245	5,767	4,340	1,030
2001 Total	954	809	na	15,543	5,975	3,499	806
2006-2005	**7%**	**8%**	**7%**	**12%**	**2%**	**16%**	**14%**
2006-2001	**28%**	**30%**	**na**	**31%**	**-1%**	**44%**	**45%**

Figure 9.2 presents the percent change in emissions between 2005 and 2006. From 2005 to 2006, emissions increased 7% to 8% for particulate matter, 12% for NO_x, 2% for SO_x, 16% for CO and 14% for HC.

Figure 9.2: Port-wide Emissions Comparison, 2006-2005, % Change

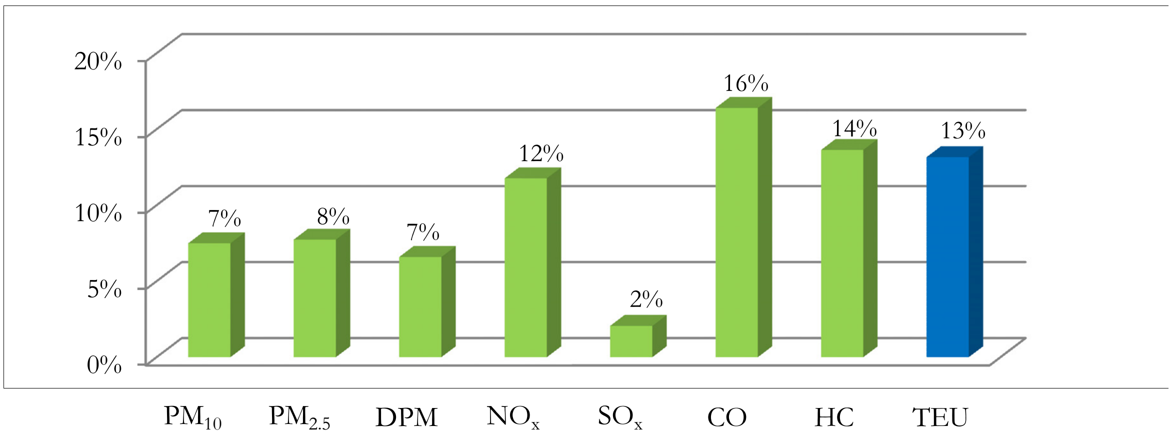


Figure 9.3 presents the percent change in emissions from between 2001 and 2006. From 2001 to 2006, emissions increased 28% to 30% for PM, 31% for NO_x, 44% for CO, and 45% for HC. SO_x emissions decreased by 1% mainly due to diesel CHE and harbor craft using CARB diesel with 15 ppm sulfur in 2006.

Figure 9.3: Port-wide Emissions Comparison, 2006-2001, % Change

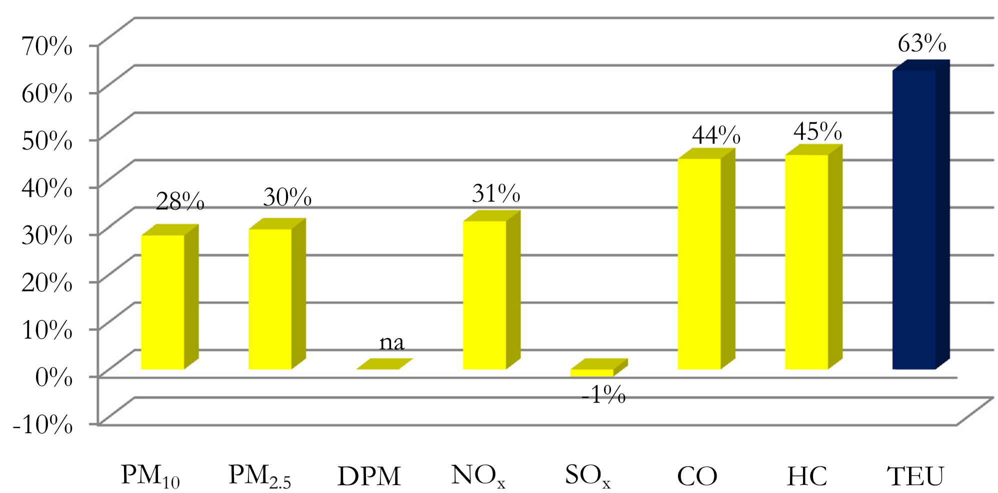
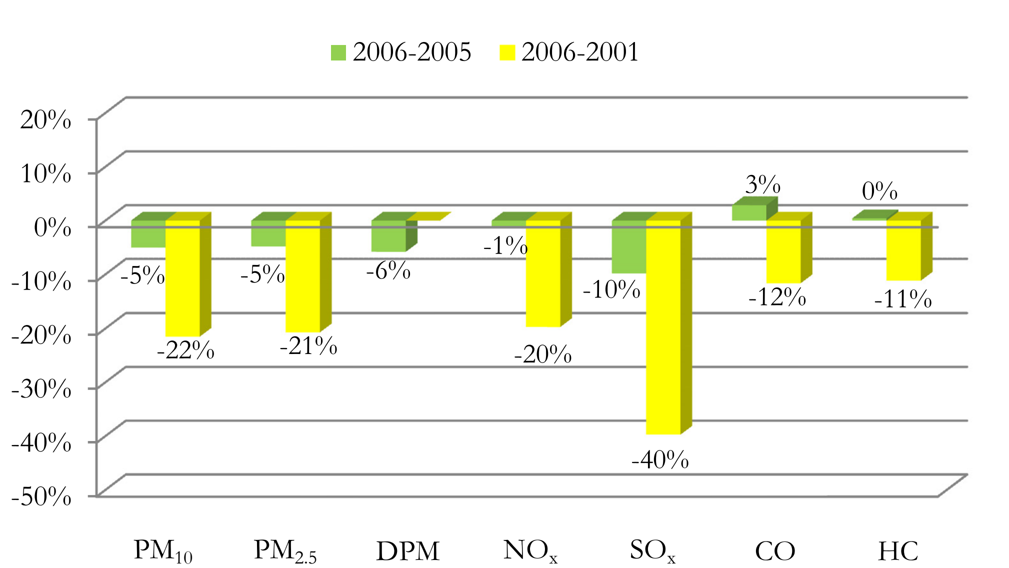


Table 9.3 and Figure 9.4 compares emissions efficiency changes between 2005 to 2006 and 2001 to 2006. For 2005 to 2006, emissions efficiency for PM improved 5% to 6%, NO_x improved 1%, and SO_x improved 10%. Emissions efficiency for HC did not change and CO lost emissions efficiency by 3%. For 2001 to 2006, all pollutant emission efficiencies improved. Emissions efficiency improved 21% for PM, 20% for NO_x, 40% for SO_x, 12% for CO and 11% for HC between 2006 and 2001.

Table 9.3: Port-Wide Emissions Efficiency, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	1.4	1.2	1.3	24.1	6.9	6.0	1.4
2005	1.5	1.3	1.4	24.4	7.7	5.8	1.4
2001	1.8	1.6	na	30.0	11.5	6.8	1.6
2006-2005	**-5%**	**-5%**	**-6%**	**-1%**	**-10%**	**3%**	**0%**
2006-2001	**-22%**	**-21%**	**na**	**-20%**	**-40%**	**-12%**	**-11%**

Figure 9.4: Port-wide Changes in Emissions Efficiency, % Change



9.1 Ocean-going Vessels

The various emission reduction strategies for ocean-going vessels are listed in Table 9.4 and summarized below:

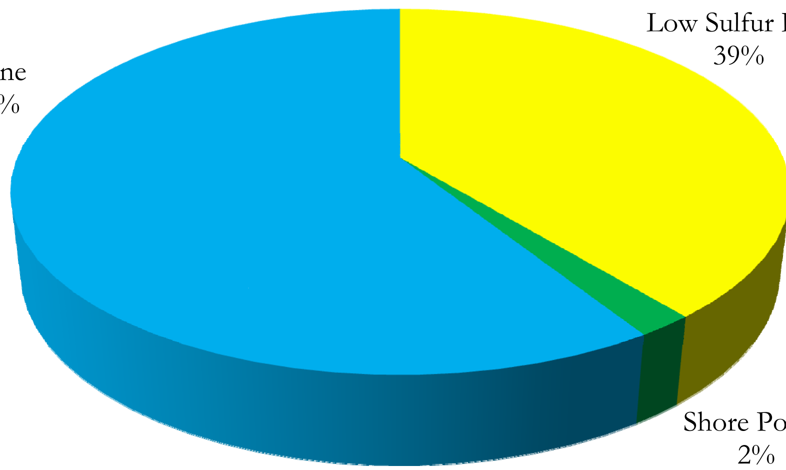
- The percent of calls with vessels that had fuel-efficient slide valves is 7% as compared to 4% in 2005.
- The percent of calls with IMO-compliant vessels (model year 2000 and newer) is 44% in 2006 as compared to 32% in 2005.
- Shore Power continued at berth 100 and the percent of total calls that Shore Powered was 2% for both 2006 and 2005.
- The percent of vessels that switched to a cleaner fuel for auxiliary engines at berth is 39% in 2006 as compared to 27% in 2005.
- The percentage of vessels that switched to a cleaner fuel for main engines during transit is 10% in 2006 as compared to 3% in 2005, and 0% in 2001.
- In 2006, approximately 84% of total vessel calls complied with the VSR program as compared to 64% in 2005 and 58% (for calls from Oct to Dec) in 2001.

Table 9.4: Count of Vessels and Calls with Emission Reduction Strategies

	Slide Valve		IMO-Compliant		Shore Power		Fuel Switch Aux	Fuel Switch Main	VSR
Year	# Vessels	# Calls	# Vessels	# Calls	# Vessels	# Calls	% of Calls	% of Calls	% of Calls
2006	29	191	432	1,183	23	61	39%	10%	84%
2205	22	100	271	740	17	40	27%	3%	64%

Figure 9.5 shows that in 2006, 41% of the vessel calls used a lower sulfur fuel (39%) or used shore power at berth (2%).

Figure 9.5: 2006 Distribution of Vessel Calls that Switch to Cleaner Fuel at Berth



Engine activity is measured as a product of the engine kilowatts and the annual activity in hours. Table 9.5 compares the overall engine activity (in terms of kW-hrs) in 2001, 2005 and 2006. The table shows that the total engine activity went up in 2006 by 8% from 2005 and 5% from 2001. The engine activity has a direct impact on emissions.

Table 9.5: OGV Power Comparison, kW-hr

	Total All Engines Total kW-hr	Main Eng Total kW-hr	Aux Eng Total kW-hr	Boiler Total kW-hr
CY 2006	489,973,405	179,297,185	206,770,806	103,905,415
CY 2005	455,470,216	167,174,105	197,769,140	90,526,971
CY 2001	467,138,476	212,359,344	167,454,248	87,324,885
2006-2005	**8%**	**7%**	**5%**	**15%**
2006-2001	**5%**	**-16%**	**23%**	**19%**

The methodology used in 2006 to estimate OGV emissions was the same as that was used in 2005. Thus, the 2006 OGV emissions are compared to the 2005 and adjusted 2001 OGV emissions found in the 2005 EI report. Table 9.6 shows the emissions estimate comparisons for calendar year 2006, 2005 and 2001 for OGV in tons per year and as a percent change, respectively.

Table 9.6: OGV Emissions Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	TEU
2006	644	515	546	6,614	5,711	601	279	8,469,853
2005	634	507	552	6,206	5,609	540	247	7,484,625
2001	567	453	na	6,594	5,857	633	219	5,183,520
2006-2005	**2%**	**2%**	**-1%**	**7%**	**2%**	**11%**	**13%**	**13%**
2006-2001	**14%**	**14%**	**na**	**0%**	**-2%**	**-5%**	**27%**	**63%**

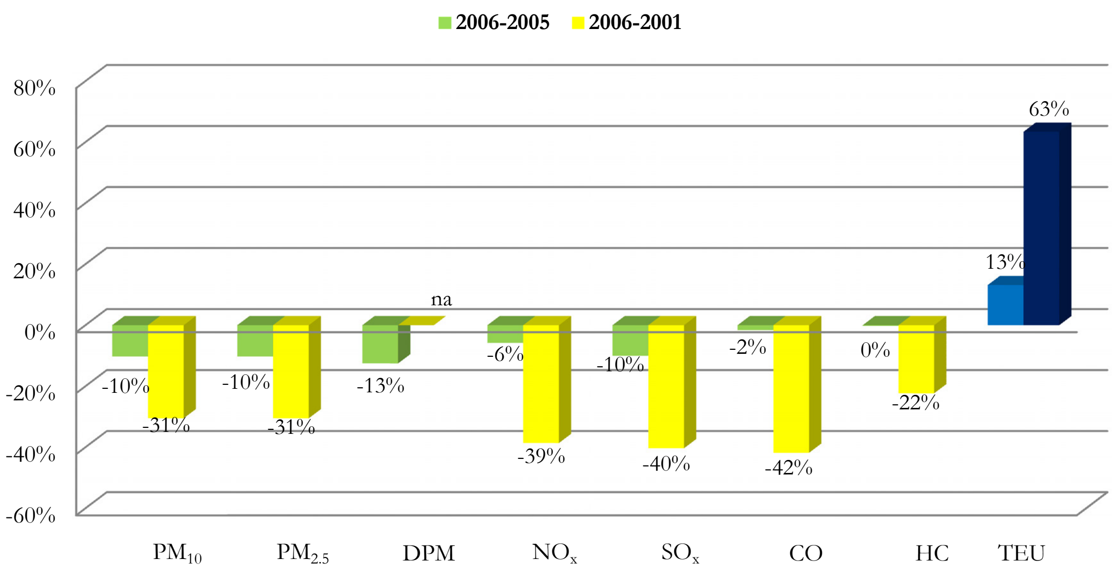
Table 9.7 and Figure 9.6 show the emissions efficiency changes for 2006-2005 and 2006-2001. From 2005 to 2006, there was a 13% increase in TEU throughput and emissions efficiency improved 2% to 13% for the various pollutants, with the exception of HC which did not change. From 2001 to 2006, despite a 63% increase in TEU throughput, emissions efficiency improved from 22% to 42% across all pollutants.

Table 9.7: OGV Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	0.8	0.6	0.6	7.8	6.7	0.7	0.3
2005	0.8	0.7	0.7	8.3	7.5	0.7	0.3
2001	1.1	0.9	na	12.7	11.3	1.2	0.4
2006-2005	**-10%**	**-10%**	**-13%**	**-6%**	**-10%**	**-2%**	**0%**
2006-2001	**-31%**	**-31%**	**na**	**-39%**	**-40%**	**-42%**	**-22%**

In the figure below, the light blue column represents TEU change from 2005 to 2006 (13%) and the dark blue column represents TEU changed from 2001 to 2006 (63%).

Figure 9.6: OGV Emissions Efficiency Comparison, %



9.2 Harbor Craft

Table 9.8 summarizes the number of harbor craft inventoried for 2006, 2005 and 2001. Overall, there was no significant change in the total vessel count between 2006 and 2005 and a 35% decrease in from 2001 to 2006. Commercial fishing vessels decreased significantly from 2001 to 2005. Crew boat vessel count was down in 2005, but bounced back in 2006. In 2001, the ocean tugs and line haul tugboats were not inventoried on a vessel by vessel basis, so the count is not included in the 2001 vessel count column.

Table 9.8: Harbor Craft Count Comparison

Harbor Vessel Type	2006 Count	2005 Count	2001 Count	2006-2005 % Change	2006-2001 % Change
Assist tug	16	16	18	0%	-11%
Commercial fishing	120	130	260	-8%	-54%
Crew boat	19	9	17	111%	12%
Excursion	24	24	27	0%	-11%
Ferry	9	9	9	0%	0%
Government	26	27	24	-4%	8%
Ocean tug	7	7	na	0%	na
Tugboat	20	19	24	5%	-17%
Work boat	15	14	17	7%	-12%
Total	**256**	**255**	**396**	**0%**	**-35%**

Table 9.9 summarizes the percent distribution of engines based on engine standards. For this comparison, the following model years fall into the Tier 0, Tier 1 and Tier 2:

- Tier 0 are engines older than 1999
- Tier 1 engines' model year ranges from 2000 to 2003
- Tier 2 engines' model year are 2004+

In 2001, model year was not known for all engines, but it can be assumed that close to 100% of the harbor craft had engines in the Tier 0 range since the engine model year was probably 1999 or older.

Between 2001 and 2005, many engines were replaced as a result of the Carl Moyer Program and Port-funded projects to reduce emissions in the harbor. In 2005, 64% of the engines were Tier 0 engines; 30% had Tier 1 engines and 7% had Tier 2 engines. In 2006, the percentage of Tier 0 engines was further reduced to 61% and the Tier 2 percentage increased to 10%.

Table 9.9: Harbor Craft Engine Standards Comparison by Tier

	Tier 0	Tier 1	Tier 2
CY 2006	61%	29%	10%
CY 2005	64%	30%	7%
CY 2001	100%	0%	0%

Table 9.10 compares the engines by vessel type and Tier for 2005 and 2006. Although many vessels have been repowered, there are still many Tier 0 engines at the Port. This is due to the high cost of replacing engines and the time it requires the vessel to be out of service which is lost revenue for the harbor craft owners.

Table 9.10: Harbor Craft Engine Standards Comparison by Vessel Type

Harbor Vessel Type	2006 Tier 0	2006 Tier 1	2006 Tier 2	2005 Tier 0	2005 Tier 1	2005 Tier 2
Assist tug	31	20	12	35	24	4
Commercial fishing	108	34	6	149	42	6
Crew boat	30	18	9	14	18	9
Excursion	45	23	2	45	23	2
Ferry	4	18	10	8	14	10
Government	34	12	0	34	12	0
Ocean tug	20	8	0	20	8	0
Tugboat	32	21	14	32	23	8
Work boat	35	7	0	31	7	0
Total Engines	**339**	**161**	**53**	**368**	**171**	**39**

As can be seen in Table 9.11, there was a 4% decrease in total engine count from 2005 to 2006 and a 26% decrease in total engine count from 2001 to 2006. The engine count decrease is mainly due to commercial fishing vessel population which continues to decline.

Table 9.11: Harbor Craft Engine Comparison

	Vessel Count	All Engines Count	Total Hp-hr
CY 2006	256	553	115,940,879
CY 2005	255	578	115,692,693
CY 2001	396	748	122,879,494
2006-2005	**0%**	**-4%**	**0%**
2006-2001	**-35%**	**-26%**	**-6%**

In order to be consistent with CARB, the Port's 2006 harbor craft emissions calculation methodology followed CARB's recent harbor craft emissions calculations methodology. CARB's deterioration rates, useful life, and zero hour emission factors for commercial harbor craft were used. Because this was a change from the methodology used for the 2005 and 2001 emission estimates, the 2005 and 2001 emissions were re-calculated using the 2006 emissions methodology in order to make a meaningful comparison. Some of the significant changes in harbor craft methodology from 2005 and 2001 to 2006 include:

- Emission factors changed (used EPA's EF in 2005 and 2001, used CARB's EF in 2006)
- In the 2005 and 2001 Port EIs, deterioration rates were not included in the calculations, but the 2006 methodology includes deterioration rates
- The load factor for excursion vessels and ferries changed from 0.76 in 2005 to 0.42 in 2006

The resulting 2005 and 2001 harbor craft emissions based on 2006 methodology are used to compare to the 2006 emissions below. Table 9.12 shows the emissions estimate comparisons for calendar year 2006, 2005 and 2001 for harbor craft in tons per year and as a percent change.

Table 9.12: Harbor Craft Emission Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	52	48	52	1,265	1	345	84
2005	56	52	56	1,336	6	369	89
2001	82	75	na	1,777	18	443	145
2006-2005	**-8%**	**-8%**	**-8%**	**-5%**	**-90%**	**-7%**	**-5%**
2006-2001	**-37%**	**-37%**	**na**	**-29%**	**-96%**	**-22%**	**-42%**

The reductions in emissions are due to vessel repowers mainly occurring between 2001 and 2005 calendar years and the use of ULSD by all harbor craft vessels in 2006 which reduced the SO_x emissions considerably. In 2005, some vessels, especially all the government vessels, had used ULSD voluntarily. Between 2005 and 2006, there was a significant reduction (90%) in SO_x emissions due to the use of 15 ppm ULSD in all harbor craft equipped with diesel engines in 2006. For the other pollutants, there was a 5% to 8% reduction in emissions from 2005 to 2006. Between 2001 and 2006, there was a 96% reduction in SO_x emissions due to the use of 15 ppm ULSD in all harbor craft equipped with diesel engines in 2006. For the other pollutants, there was a 22% to 42% reduction in emissions from 2001 to 2006.

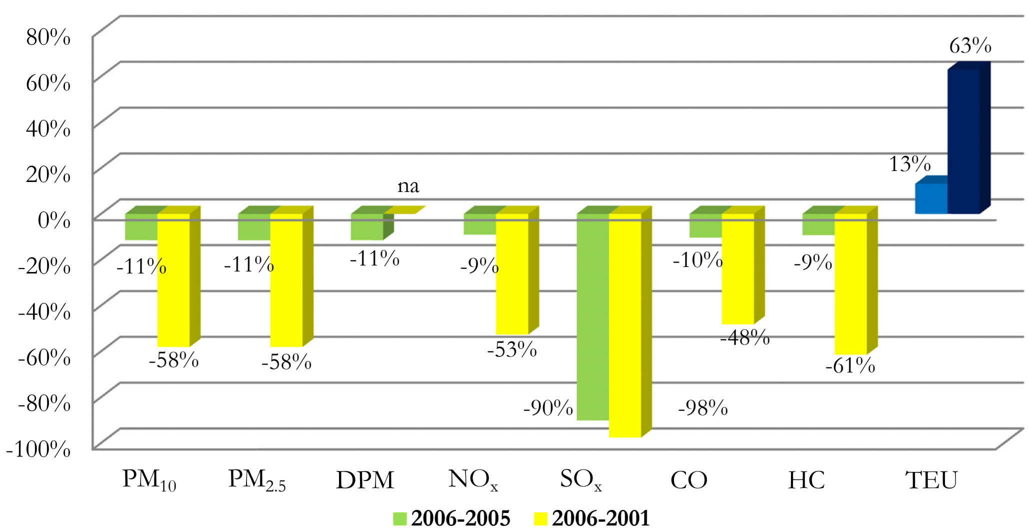
Table 9.13 and Figure 9.7 show the emissions efficiency changes for 2006-2005 and 2006-2001. From 2005 to 2006, there was a 13% increase in TEU throughput and emissions efficiency improved 16% to 91%. From 2001 to 2006, despite a 63% increase in TEU throughput, emissions efficiency improved for all pollutants from 52% to 98%.

Table 9.13: Harbor Craft Emissions Efficiency Comparison, tons/10,000 TEU & %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	0.06	0.06	0.06	1.49	0.00	0.41	0.10
2005	0.07	0.07	0.07	1.78	0.01	0.49	0.12
2001	0.16	0.15	na	3.43	0.03	0.85	0.28
2006-2005	**-18%**	**-18%**	**-18%**	**-16%**	**-91%**	**-17%**	**-16%**
2006-2001	**-61%**	**-61%**	**na**	**-56%**	**-98%**	**-52%**	**-65%**

In the figure below, the light blue column represents TEU change from 2005 to 2006 (13%) and the dark blue column represents TEU changed from 2001 to 2006 (63%).

Figure 9.7: Harbor Craft Emissions Efficiency Comparison, %



9.3 Cargo Handling Equipment

Table 9.14 shows a 32% increase between 2005 and 2006 in equipment activity (measured as a product of horsepower, annual activity and load factor) and a 13% increase in total number of equipment. Between 2001 and 2006, equipment activity increased by 104% and the equipment count increased by 72%.

Table 9.14: CHE Count and Activity Comparison

	Total Population	Total Hp-hr
CY 2006	1,926	318,299,748
CY 2005	1,702	241,366,009
CY 2001	1,121	155,825,843
2006-2005	**13%**	**32%**
2006-2001	**72%**	**104%**

Table 9.15 summarizes the various engine power types for CHE, which include electric, liquefied natural gas (LNG), propane, gasoline, and diesel. Electric powered equipment has doubled and propane powered equipment has more than tripled at the port since 2001.

Table 9.15: CHE Engine Power Matrix

Equipment	Electric	LNG	Propane	Gasoline	Diesel
2006					
Forklifts	0	0	355	8	191
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	103
Side handlers	0	0	0	0	43
Top handlers	0	0	0	0	134
Yard tractors	0	2	58	0	897
Sweepers	0	0	0	2	10
Other	19	0	0	0	104
Total	**88**	**2**	**413**	**10**	**1,482**
2005					
Forklifts	0	0	263	8	151
Wharf gantry cranes	67	0	0	0	0
RTG cranes	0	0	0	0	98
Side handlers	0	0	0	0	41
Top handlers	0	0	0	0	127
Yard tractors	0	0	53	0	848
Sweepers	0	0	0	3	8
Other	12	0	0	0	103
Total	**79**	**0**	**316**	**11**	**1,376**
2001					
Forklifts	0	0	116	4	80
Wharf gantry cranes	44	0	0	0	0
RTG cranes	0	0	0	0	34
Side handlers	0	0	0	0	37
Top handlers	0	0	0	0	74
Yard tractors	0	0	0	0	590
Sweepers	0	0	0	1	3
Other	0	0	0	0	70
Total	**44**	**0**	**116**	**5**	**888**

Table 9.16 summarizes the various emissions controls for diesel powered CHE by equipment counts and by percent total diesel equipment (found in the total equipment count column). It should be noted that emission controls can be used in combination with each other, therefore they cannot be added across to come up with total equipment count (control equipment counts are greater than total equipment counts).

Table 9.16: CHE Diesel Power Equipment Emissions Control Matrix

	Control Equipment Counts				Total	Percent of Total Diesel Powered Equipment			
Equipment	DOC Installed	On-Road Engines	USLD Fuel	Emulsified Fuel	Equipment Count	DOC Installed	On-Road Engines	USLD Fuel	Emulsified Fuel
2006									
Forklifts	4	4	191	15	191	2%	2%	100%	8%
RTG cranes	10	0	103	28	103	10%	0%	100%	27%
Side handlers	13	0	43	10	43	30%	0%	100%	23%
Top handlers	54	0	134	42	134	40%	0%	100%	31%
Yard tractors	531	216	897	128	897	59%	24%	100%	14%
Sweepers	0	1	10	0	10	0%	10%	100%	0%
Other	0	5	104	0	104	0%	5%	100%	0%
Total	**612**	**226**	**1,482**	**223**	**1,482**	**41%**	**15%**	**100%**	**15%**
2005									
Forklifts	3	0	27	15	151	2%	0%	18%	10%
RTG cranes	0	0	36	28	98	0%	0%	37%	29%
Side handlers	14	0	16	10	41	34%	0%	39%	24%
Top handlers	48	0	79	36	127	38%	0%	62%	28%
Yard tractors	520	164	483	129	848	61%	19%	57%	15%
Sweepers	0	0	0	0	8	0%	0%	0%	0%
Other	0	1	65	0	103	0%	1%	63%	0%
Total	**585**	**165**	**706**	**218**	**1,376**	**43%**	**12%**	**51%**	**16%**
2001									
Forklifts	0	0	0	0	80	0%	0%	0%	0%
RTG cranes	0	0	0	0	34	0%	0%	0%	0%
Side handlers	0	0	0	0	37	0%	0%	0%	0%
Top handlers	0	0	0	0	74	0%	0%	0%	0%
Yard tractors	0	0	0	0	590	0%	0%	0%	0%
Sweepers	0	0	0	0	3	0%	0%	0%	0%
Other	0	0	0	0	70	0%	0%	0%	0%
Total	**0**	**0**	**0**	**0**	**888**	**0%**	**0%**	**0%**	**0%**

It should be noted that in 2006, all equipment with diesel engines used ULSD.

The cargo handling equipment emission estimating methodology used in 2006 stayed the same as the 2005 methodology with the exception of the following:

- The load factor for yard tractors changed from 0.65 in 2005 to 0.39 in 2006 based on a 2006 in-field study conducted by ports in consultation with CARB's staff

The cargo handling equipment emission estimating methodology used in 2006 stayed the same as the 2001 methodology with the exception of the following:

- The load factor for yard tractors changed from 0.57 in 2001 to 0.39 in 2006 based on a 2006 in-field study conducted by ports in consultation with CARB's staff

Because there was a change in methodology, the 2005 and 2001 emissions were re-calculated using the 2005 and 2001 activity with the 2006 emissions methodology in order to make a meaningful comparison. The resulting 2005 and 2001 cargo handling equipment emissions based on 2006 methodology are used to compare to the 2006 emissions below. Table 9.17 shows the emissions estimate comparisons for calendar year 2006, 2005 and 2001 for cargo handling equipment in tons per year and as a percent change.

Table 9.17: CHE Emissions Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	52	49	51	1,853	2	977	95
2005	47	43	46	1,520	9	765	80
2001	48	44	na	1,258	8	647	97
2006-2005	**11%**	**12%**	**11%**	**22%**	**-78%**	**28%**	**18%**
2006-2001	**10%**	**10%**	**na**	**47%**	**-74%**	**51%**	**-3%**

There was a significant reduction in SO_x emissions due to the early introduction and use of 15 ppm ULSD in all cargo handling equipment with diesel engines. With the exception of 2006-2001 hydrocarbon emissions, which decreased 3%, the other pollutants increased in emissions from 11% to 28% since 2005 and 8% to 51% since 2001. DPM emissions did not increase as much as the other pollutants due to the use of emission reduction technologies such as DOCs, on-road engines, ULSD and emulsified fuel which reduce DPM emissions. There was an increase in the propane engine population which reduces DPM, but increases HC, CO and NO_x emissions compared to diesel engines.

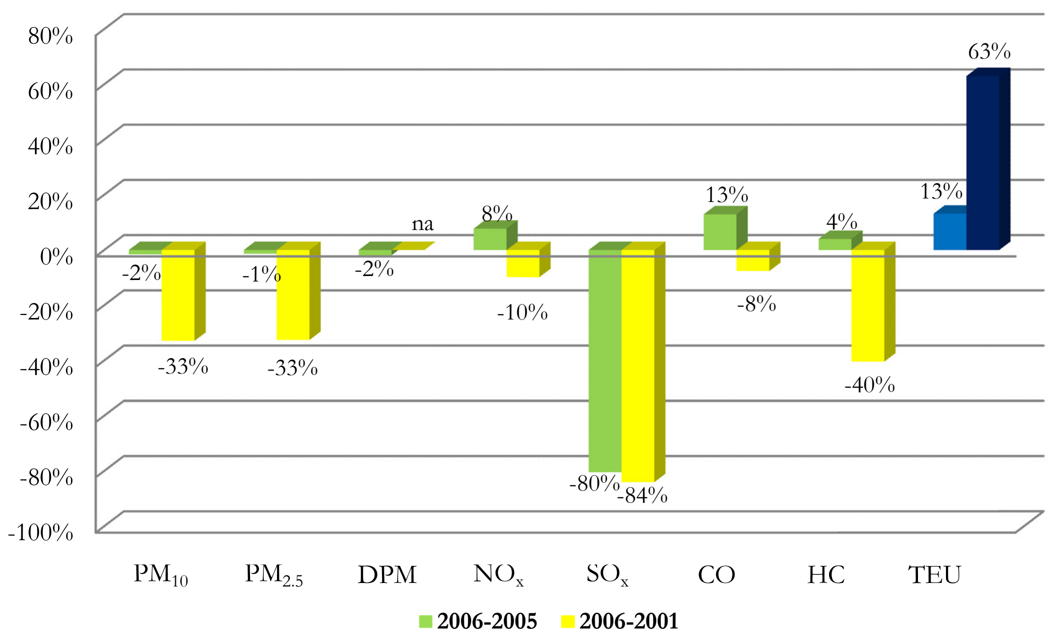
Table 9.18 shows the emissions efficiency changes for 2006-2005 and 2006-2001. From 2005 to 2006, there was a 13% increase in TEU throughput, but emissions efficiency improved 80% for SO_x and 1% to 2% for PM. There was a loss in emissions efficiency by 8% for NO_x 13% for CO and 4% for HC. From 2001 to 2006, despite a 63% increase in TEU throughput, emissions efficiency improved from 8% to 84% for all pollutants.

Table 9.18: CHE Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	0.06	0.06	0.06	2.2	0.002	1.15	0.112
2005	0.06	0.06	0.06	2.0	0.012	1.02	0.107
2001	0.09	0.08	na	2.4	0.015	1.25	0.187
2006-2005	**-2%**	**-1%**	**-2%**	**8%**	**-80%**	**13%**	**4%**
2006-2001	**-33%**	**-33%**	**na**	**-10%**	**-84%**	**-8%**	**-40%**

In the figure below, the light blue column represents TEU change from 2005 to 2006 (13%) and the dark blue column represents TEU changed from 2001 to 2006 (63%).

Figure 9.8: CHE Emissions Efficiency Comparison, %



9.4 Rail Locomotives

Tables 9.19 show the various throughput comparisons for rail locomotives for 2005 and 2006. From 2005 to 2006, there was a 30% increase in total on-dock rail and a 18% increase in near-dock rail. The off-dock rail emissions are not included in the Port's emissions inventory, but are shown in this table for completeness.

Table 9.19: TEU Throughput Comparison

	2005	2006	% Change
Total Port Throughput	7,484,615	8,469,980	13%
Total On-Dock Rail	1,891,198	2,466,759	30%
% On-Dock of Total	25.3%	29.1%	
Near-Dock Rail[1]	555,694	653,321	18%
% Near-Dock of Total	7.4%	7.7%	
Off-Dock Rail[2]	868,416	858,960	-1%

(1) Intermodal Container Transfer Facility (ICTF) - Emissions from rail cargo movements to/from this location are included in the Port's emissions inventory.

(2) Rail cargo movements to/from these off-port rail yards are not included in the Port's emissions inventory.

The methodology used in 2006 to estimate rail locomotive emissions was the same as that used in 2005. The 2005 emissions estimates listed below are slightly different from the emissions listed in the 2005 report because the emissions in the report were estimated using excel spreadsheets and the 2005 emissions below were estimated using a database. Table 9.20 shows the emissions estimate comparisons for calendar year 2006, 2005, and 2001 for locomotive engines in tons per year and as a percent change. From 2005 to 2006, emissions increased from 23% to 38% depending on pollutant. From 2001 to 2006, the emissions increased from 47% to 139% for the various pollutants. The emissions increases are directly due to the increased throughput in 2006 from the previous years.

Table 9.20: Rail Emission Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	72	65	72	2,081	131	320	115
2005	56	52	56	1,685	95	233	89
2001	34	31	na	1,413	55	145	57
2006-2005	30%	25%	30%	23%	38%	37%	29%
2006-2001	112%	110%	na	47%	139%	121%	101%

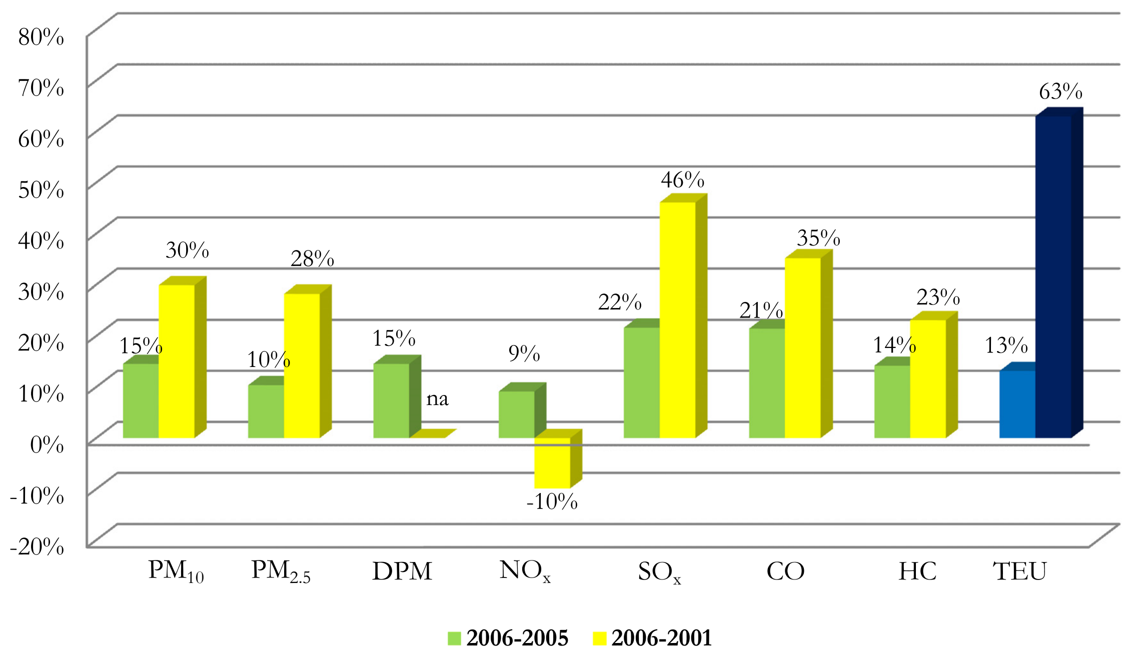
Table 9.21 and Figure 9.9 show the emissions efficiency changes for 2006-2005 and 2006-2001. From 2005 to 2006, there was a 13% increase in TEU throughput and there were losses in emissions efficiency from 9% to 22%. From 2001 to 2006, TEU throughput increased 63% and there were losses in emissions efficiency from 28% to 46% for all pollutants, except NO_x which improved by 10%.

Table 9.21: Rail Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	0.09	0.08	0.09	2.5	0.16	0.38	0.14
2005	0.07	0.07	0.07	2.3	0.13	0.31	0.12
2001	0.07	0.06	na	2.7	0.11	0.28	0.11
2006-2005	**15%**	**10%**	**15%**	**9%**	**22%**	**21%**	**14%**
2006-2001	**30%**	**28%**	**na**	**-10%**	**46%**	**35%**	**23%**

In the figure below, the light blue column represents TEU change from 2005 to 2006 (13%) and the dark blue column represents TEU changed from 2001 to 2006 (63%).

Figure 9.9: Rail Emissions Efficiency Comparison, %



9.6 HDV Findings and Emissions Comparison

Table 9.22 shows a decrease in total idling time from 2005 to 2006. This is due to mainly to three factors:

- The terminals modernized their gate system with optical character recognition (OCR) and added several queuing lines at the in and out gates which increased the efficiency at the gates and thus reduced idling time.
- Assembly Bill 2650 (known as the Lowenthal Bill), introduced in 2004, required that each marine terminal in California operate in a manner that does not cause the engines on trucks to idle or queue for more than 30 minutes while waiting to enter the gate into the marine terminal.
- Since July 2005, all marine terminals at the Ports of Long Beach and Los Angeles, offer off-peak shifts on nights and weekends. As part of the program, a Traffic Mitigation Fee is required for cargo movement through the ports during peak daytime hours. In 2006, this program diverted approximately 36% of the container moves at the two ports to off-peak hours

Table 9.22: HDV Idling Time Comparison, hours

EI Year	Total Idling Hours
2006	2,962,463
2005	3,017,252
2001	4,404,847

From 2005 to 2006, there was a 13% increase in total TEU throughput at the Port and a 15% increase in the total vehicle miles travelled by heavy-duty trucks. This had an impact on the heavy-duty vehicle emissions which, with the exception of SO_x , increased from 14% to 17% for the various pollutants in 2006 from 2005. The SO_x emissions show a 14% reduction from 2005 due to the use of ULSD by HDV starting during the third quarter of 2006. Table 9.23 presents the emission changes between 2006, 2005 and 2001.

Table 9.23: HDV Emissions Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	404	372	404	8,579	40	2,808	599
2005	346	319	346	7,498	47	2,433	525
2001	280	257	na	6,104	43	2,226	469
2006-2005	**17%**	**17%**	**17%**	**14%**	**-14%**	**15%**	**14%**
2006-2001	**44%**	**45%**	**na**	**41%**	**-6%**	**26%**	**28%**

Table 9.24 and Figure 9.10 show the emissions efficiency changes for 2006-2005 and 2006-2001. From 2005 to 2006, there was a 13% increase in TEU throughput and there was a loss in emissions efficiency from 1% to 3% for all pollutants, except for SO_x which improved by 24%. From 2001 to 2006, TEU throughput increased 63% and the emissions efficiency improved from 11% to 43% for all pollutants.

Table 9.24: HDV Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2006	0.48	0.44	0.48	10.1	0.05	3.32	0.71
2005	0.46	0.43	0.46	10.0	0.06	3.25	0.70
2001	0.54	0.50	na	11.8	0.08	4.29	0.90
2006-2005	**3%**	**3%**	**3%**	**1%**	**-24%**	**2%**	**1%**
2006-2001	**-12%**	**-11%**	**na**	**-14%**	**-43%**	**-23%**	**-22%**

In the figure below, the light blue column represents TEU change from 2005 to 2006 (13%) and the dark blue column represents TEU changed from 2001 to 2006 (63%).

Figure 9.10: HDV Emissions Efficiency Comparison, %