Port of LONG BEACH

The Green Port

AIR EMISSIONS INVENTORY - 2014

September 2015

Prepared by:
STARCREST CONSULTING GROUP, LLC

Port of Long Beach
2014 Air Emissions Inventory

Prepared for:

September 2015

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Long Beach, CA

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EXECUTIVE SUMMARY

The Port of Long Beach (Port or POLB) annual activity-based emissions inventories serve as the primary tool to track the Port's efforts to reduce air emissions from goods movement-related sources through implementation of measures identified in the San Pedro Bay Ports Clean Air Action Plan (CAAP) and regulations promulgated at the state and federal levels. To quantify the annual air emissions, the Port relies on operational information provided by Port tenants and operators. Development of the annual air emissions estimates is coordinated with a technical working group (TWG) comprised of representatives from the Port, the Port of Los Angeles, and the air regulatory agencies: U.S. Environmental Protection Agency, Region 9 (EPA), California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD). The current annual emissions and activity levels are directly compared to the emissions and activity levels in 2005, the baseline year established in the CAAP - just before several of the strategies to reduce air emissions from goods movement-related sources were implemented. In order to maintain the consistency between the years compared, the 2005 emissions are recalculated whenever new estimation methodologies or data are introduced.

Although the Port does not typically report year-over-year comparisons, the 2014 air emissions inventory identifies key factors that affected emissions in 2014 compared to 2013. These factors include:

- Temporary period of terminal congestion in the latter part of 2014, which resulted in ships spending more time at anchorage, as well as increased activity levels for cargo-handling equipment[1];
- Increased cruise activity;
- Reduced turnover in the heavy-duty vehicle fleet coupled with continued deterioration of the existing engines.

[1] Although not reflected in this 2014 inventory, the prolonged congestion continued into the first half of 2015.

2014 Port of Long Beach Air Emissions Inventory Results

The results of the Port of Long Beach 2014 Air Emissions Inventory, including a comparison to the Port's 2005 air emissions inventory, are presented in Tables ES.1 and ES.2. To provide a valid comparison between the 2014 and 2005 emissions estimates, 2005 base year emissions are recalculated using the most up-to-date methodologies and data.

Table ES.1: 2005-2014 Air Emissions Comparison by Source Category

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2005 (tons)							
Ocean-going vessels	720	577	605	6,726	6,865	537	236
Harbor craft	45	41	45	1,107	5	294	70
Cargo handling equipment	47	44	47	1,289	11	398	65
Locomotives	43	40	43	1,273	76	179	66
Heavy-duty vehicles	205	196	205	5,273	37	1,523	318
Total	**1,060**	**898**	**945**	**15,667**	**6,993**	**2,931**	**755**
2014 (tons)							
Ocean-going vessels	92	87	73	4,461	211	380	168
Harbor craft	30	27	30	786	1	404	70
Cargo handling equipment	10	9	9	558	1	663	39
Locomotives	26	24	26	726	1	168	40
Heavy-duty vehicles	6	6	5	1,276	3	80	22
Total	**164**	**153**	**143**	**7,807**	**216**	**1,695**	**339**
Change between 2005 and 2014 (percent)							
Ocean-going vessels	-87%	-85%	-88%	-34%	-97%	-29%	-29%
Harbor craft	-33%	-35%	-33%	-29%	-87%	37%	1%
Cargo handling equipment	-79%	-79%	-81%	-57%	-88%	66%	-40%
Locomotives	-39%	-40%	-39%	-43%	-99%	-6%	-40%
Heavy-duty vehicles	-97%	-97%	-98%	-76%	-92%	-95%	-93%
Total	**-85%**	**-83%**	**-85%**	**-50%**	**-97%**	**-42%**	**-55%**

Table ES.2: 2005-2014 GHG Emissions by Source Category

	CO_2e	CO_2	N_2O	CH_4
2005 (metric tons)				
Ocean-going vessels	389,510	382,729	22	4
Harbor craft	44,746	44,131	2	1
Cargo handling equipment	103,710	102,803	3	3
Locomotives	60,579	59,979	2	5
Heavy-duty vehicles	387,056	382,263	14	22
Total	**985,603**	**971,905**	**43**	**36**
2014 (metric tons)				
Ocean-going vessels	293,640	288,276	18	3
Harbor craft	50,387	49,694	2	1
Cargo handling equipment	115,800	114,934	3	4
Locomotives	59,395	58,827	2	5
Heavy-duty vehicles	255,492	252,665	9	2
Total	**774,714**	**764,396**	**34**	**15**
Change between 2005 and 2014 (percent)				
Ocean-going vessels	-25%	-25%	-20%	-30%
Harbor craft	13%	13%	1%	-6%
Cargo handling equipment	12%	12%	8%	21%
Locomotives	-2%	-2%	25%	1%
Heavy-duty vehicles	-34%	-34%	-37%	-91%
Total	**-21%**	**-21%**	**-21%**	**-58%**

Table ES.3 compares vessel arrivals and container and cargo throughput at POLB in 2005 and 2014, including the average number of twenty-foot equivalent units (TEUs) per containership call.

Table ES.3: 2005-2014 Container Throughput and Vessel Call Comparison

Year	Container Throughput (TEU)	All Arrivals	Containership Arrivals	Average TEU per call
2005	6,709,818	2,690	1,332	5,037
2014	6,820,804	1,965	858	7,950
Change (%)	**2%**	**-27%**	**-36%**	**58%**

Emissions Metrics

To track operational efficiency improvements and the effectiveness of the emissions reduction strategies and measures, emissions are also estimated in total emissions per unit of cargo handled through the Port. Since Port operations are varied with a mix of containerized and non-containerized cargo, the metrics are based on TEU throughput and metric tons of cargo moved through the Port. Table ES.4 compares the tons of emissions per 10,000 TEU in 2005 and 2014, while Table ES.5 compares the tons of emissions per 100,000 metric tons in 2005 and 2014.

Table ES.4: 2005-2014 Emissions Efficiency Metric Comparison, tons per 10,000 TEU

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2005	1.58	1.34	1.41	23.35	10.42	4.37	1.13	1,619
2014	0.24	0.22	0.21	11.45	0.32	2.49	0.50	1,252
Change (%)	**-85%**	**-83%**	**-85%**	**-51%**	**-97%**	**-43%**	**-56%**	**-23%**

Table ES.5: 2005-2014 Emission Efficiency Metric Comparison, tons per 100,000 metric tons

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2005	1.35	1.14	1.20	19.94	8.90	3.73	0.96	1,383
2014	0.20	0.19	0.17	9.49	0.26	2.06	0.41	1,038
Change (%)	**-85%**	**-83%**	**-86%**	**-52%**	**-97%**	**-45%**	**-57%**	**-25%**

Progress towards CAAP Goals

In addition to identifying specific pollution-reduction strategies, the CAAP set emission reduction targets for 2014 and 2023. This is the first inventory to measure progress against a milestone year. As a result of the implementation of CAAP measures and regulations promulgated at the State level, the 2014 San Pedro Bay Emission Reduction Standards have not only been met, but exceeded. Table ES.6 summarizes the Port's 2014 cumulative air emissions reductions of DPM, NO_x, and SO_x compared to the established CAAP San Pedro Bay Emissions Reduction Standards for 2014 and 2023.

Table ES.6: 2005-2014 Emissions Reductions Compared to CAAP San Pedro Bay

Category	2005		2014
DPM (tons)			
Ocean-going vessels	605		73
Harbor craft	45		30
Cargo handling equipment	47		9
Locomotives	43		26
Heavy-duty vehicles	205		5
Total	**945**		**143**
Cumulative DPM Emissions Reduction Achieved in 2014			**85%**
CAAP San Pedro Bay DPM Emissions Reduction Standards		**2014**	**72%**
		2023	**77%**
NO_x (tons)			
Ocean-going vessels	6,726		4,461
Harbor craft	1,107		786
Cargo handling equipment	1,289		558
Locomotives	1,273		726
Heavy-duty vehicles	5,273		1,276
Total	**15,667**		**7,807**
Cumulative NOx Emissions Reduction Achieved in 2014			**50%**
CAAP San Pedro Bay NO_x Emissions Reduction Standards		**2014**	**22%**
		2023	**59%**
SO_x (tons)			
Ocean-going vessels	6,865		211
Harbor craft	5		0.6
Cargo handling equipment	11		1.4
Locomotives	76		0.7
Heavy-duty vehicles	37		2.9
Total	**6,993**		**216**
Cumulative SOx Emissions Reduction Achieved in 2014			**97%**
CAAP San Pedro Bay SO_x Emissions Reduction Standards		**2014**	**93%**
		2023	**93%**

SECTION 1 INTRODUCTION

The Port of Long Beach (Port or POLB) annual activity-based emissions inventories serve as the primary tool to track the Port's efforts to reduce air emissions from goods movement-related sources through implementation of measures identified in the San Pedro Bay Ports Clean Air Action Plan (CAAP) and regulations promulgated at the state and federal levels. To quantify the annual air emissions, the Port relies on operational information provided by Port tenants and operators. Development of the annual air emissions estimates is coordinated with a technical working group (TWG) comprised of representatives from the Port, the Port of Los Angeles, and the air regulatory agencies: U.S. Environmental Protection Agency, Region 9 (EPA), California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD). Through collaboration with the TWG, the ports seek the consensus of the air regulatory agencies regarding the methodologies and information used to develop the emissions estimates.

Emissions from the following goods movement-related source categories are evaluated:

- Ocean-going vessels (OGV)
- Harbor craft
- Cargo handling equipment (CHE)
- Rail locomotives
- Heavy-duty vehicles (HDV)

Exhaust emissions of the following pollutants, including greenhouse gases, are quantified in the inventory:

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Carbon dioxide equivalent (CO_2e)

Greenhouse gas emissions are presented in units of carbon dioxide equivalents, which weight each gas by its global warming potential (GWP) value relative to CO_2. To normalize these values into a single greenhouse gas value, CO_2e, the GHG emission estimates are multiplied by the following values and summed.[2]

- CO_2 – 1
- CH_4 – 25
- N_2O - 298

[2] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013*, April 2015.

Geographical Domain

For rail locomotives and on-road trucks, emissions are estimated 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. For OGV and harbor craft, the domain lies within the harbor and up to the study area boundary comprised of an over-water area bounded in the north by the south Ventura County line at the coast and in the south with the southern Orange county line at the coast. CHE and on-terminal HDV emissions are estimated for activities within Port terminals and facilities.

Figure 1.1: Port of Long Beach Emissions Inventory Domain

Emissions are estimated for activities within Port terminals and facilities.

Figure 1.2: Port of Long Beach Terminals

SECTION 2 OCEAN-GOING VESSELS

Source Description

Activity data obtained from the Marine Exchange of Southern California (MarEx) indicate that there were a total of 1,965 ocean-going vessels (OGVs, ships, or vessels) calls (arrivals not including shifts) to the Port in 2014. These vessels are grouped by the type of cargo they are designed to carry and fall into one of the following vessel categories or types:

- Auto carrier
- Containership
- General cargo
- Miscellaneous vessel
- Tanker
- Bulk carrier
- Cruise vessel
- Reefer vessel
- Roll-on roll-off vessel (RoRo)

Emissions from main engines (propulsion), auxiliary engines, and auxiliary boilers (boilers) are estimated. From an emissions contribution perspective, the three predominant vessel types, in order are: container, tanker, and cruise ships.

Emission Estimation Methodology and Enhancements

OGV emissions are estimated by vessel type, emission source, and operational mode (transit, maneuvering, hoteling at-berth, hoteling at-anchorage) using the general methodology described in Section 2 of the Port of Long Beach 2013 Air Emissions Inventory,[3] with the following updates/enhancements to estimate 2014 emissions:

- Emission factor adjustment (EFA) for MAN 2-stroke engines – based on tests with MAN Turbo Diesel A/S (MAN) and Mitsui Engineering & Shipbuilding Co., Ltd. (Mitsui)[4]
- Load adjustment factor (LAF) for MAN 2-stroke engines – replacing the dated Low Load Adjustment (LLA) factors
- Incorporated CARB shore power data – CARB provided vessel specific shore power times at berth
- Cruise diesel-electric ships – turned boilers on at berth during shore power events
- Tanker diesel-electric ships – assigned load for boilers at berth during shore power events
- Tanker (conventional) ships – updated at-berth auxiliary boiler defaults based on Vessel Boarding Program Data
- Enhanced anchorage transit resolution

These updates and enhancements are discussed at the end of this section.

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[3] *www.polb.com/emissions*
[4] *www.cleanairactionplan.org/civica/filebank/blobdload.asp?BlobID=2571*

Geographical Domain

The geographical domain or overwater boundary for OGVs includes the berths and waterways in the Port proper (see Figure 1.2) and all vessel movements within the forty nautical mile (nm) arc from Point Fermin as shown in Figure 1.1. The northern boundary is the Ventura County line and the southern boundary is the Orange County line. It should be noted that the overwater boundary extends further off the coast to incorporate the South Coast air quality modeling domain, although most of the vessel movements occur within the 40 nm arc.

Data and Information Acquisition

Sources of data and operational information were obtained from:

- Marine Exchange of Southern California
- Vessel Speed Reduction Program
- Jacobsen Pilot Service
- IHS Fairplay (Lloyd's) - Lloyd's Register of Ships
- Port Vessel Boarding Program
- CARB and terminal shore power reports
- Port tanker loading information

Emission Estimates

A summary of the 2014 OGV emissions estimates by vessel type are presented in Table 2.1[5] and Table 2.2

Table 2.1: 2014 Ocean-going Vessel Emissions by Vessel Type, tons

Vessel Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto Carrier	2.6	2.5	2.4	143.7	4.8	13.2	5.9
Bulk	4.4	4.2	3.9	242.4	9.6	19.6	7.3
Containership	39.6	37.2	33.2	2,129.5	83.6	178.3	89.1
Cruise	13.2	12.5	12.7	682.3	24.7	55.7	21.6
General Cargo	1.3	1.2	1.2	63.5	2.5	5.7	2.3
Miscellaneous	1.9	1.8	1.6	90.4	4.2	7.3	2.7
Reefer	0.0	0.0	0.0	1.2	0.0	0.1	0.0
RoRo	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Tanker	29.1	27.4	18.5	1,108.1	80.9	100.4	39.5
Total	**92.2**	**86.8**	**73.5**	**4,461.4**	**210.5**	**380.2**	**168.5**

[5] Note: In order for the total emissions to be consistently and concisely displayed for each pollutant in all the tables throughout this report, the individual values in each table column may not, in some cases, add up to the listed totals in the table. This is because there are fewer decimal places displayed (for readability) than are included in the calculated totals.

Table 2.2: 2014 Ocean-going Vessel GHG Emissions by Vessel Type, metric tons

Vessel Type	CO_2e	CO_2	N_2O	CH_4
Auto Carrier	6,673	6,561	0.4	0.1
Bulk	13,397	13,175	0.7	0.1
Containership	116,727	114,546	7.2	1.6
Cruise	34,301	33,821	1.6	0.4
General Cargo	3,545	3,491	0.2	0.0
Miscellaneous	5,883	5,786	0.3	0.0
Reefer	53	52	0.0	0.0
RoRo	22	22	0.0	0.0
Tanker	113,039	110,822	7.4	0.7
Total	**293,640**	**288,276**	**17.7**	**3.1**

Tables 2.3 and 2.4 present summaries of the emission estimates by emissions source.

Table 2.3: 2014 Ocean-going Vessel Emissions by Emissions Source, tons

Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auxiliary Engine	50.9	47.9	50.9	2,437.4	90.9	219.6	79.9
Auxiliary Boiler	18.6	17.5	0.0	270.4	83.6	27.4	13.7
Main Engine	22.6	21.3	22.5	1,753.6	36.0	133.2	74.9
Total	**92.2**	**86.8**	**73.5**	**4,461.4**	**210.5**	**380.2**	**168.5**

Table 2.4: 2014 Ocean-going Vessel GHG Emissions by Engine Type, metric tons

Engine Type	CO_2e	CO_2	N_2O	CH_4
Auxiliary Engine	125,854	124,245	5.3	1.4
Auxiliary Boiler	117,294	114,503	9.3	0.2
Main Engine	50,492	49,528	3.1	1.4
Total	**293,640**	**288,276**	**17.7**	**3.1**

Tables 2.5 and 2.6 present summaries of emission estimates by the various operational modes.

Table 2.5: 2014 Ocean-going Vessel Emissions by Mode, tons

Mode	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Transit	Auxiliary Engine	11.3	10.6	11.3	577.4	20.2	48.8	17.7
Transit	Auxiliary Boiler	0.7	0.7	0.0	10.1	3.1	1.0	0.5
Transit	Main Engine	19.8	18.7	19.7	1,574.0	33.6	114.2	59.1
Total Transit		**31.8**	**30.0**	**31.0**	**2,161.4**	**56.9**	**164.0**	**77.4**
Maneuvering	Auxiliary Engine	3.1	2.9	3.1	153.8	5.6	13.5	4.9
Maneuvering	Auxiliary Boiler	0.3	0.2	0.0	3.6	1.1	0.4	0.2
Maneuvering	Main Engine	2.8	2.6	2.8	179.6	2.3	19.0	15.8
Total Maneuvering		**6.2**	**5.8**	**5.9**	**337.0**	**9.0**	**32.8**	**20.9**
Hotelling at-berth	Auxiliary Engine	26.4	24.9	26.4	1,239.3	47.2	114.0	41.5
Hotelling at-berth	Auxiliary Boiler	15.4	14.5	0.0	223.6	69.2	22.7	11.3
Hotelling at-berth	Main Engine	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling at-berth		**41.8**	**39.4**	**26.4**	**1,462.9**	**116.3**	**136.6**	**52.8**
Hotelling at-anchorage	Auxiliary Engine	10.1	9.5	10.1	467.0	18.0	43.4	15.8
Hotelling at-anchorage	Auxiliary Boiler	2.3	2.1	0.0	33.0	10.2	3.3	1.7
Hotelling at-anchorage	Main Engine	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling at-anchorage		**12.3**	**11.6**	**10.1**	**500.0**	**28.2**	**46.8**	**17.5**
Total		**92.2**	**86.8**	**73.5**	**4,461.4**	**210.5**	**380.2**	**168.5**

Table 2.6: 2014 Ocean-going Vessel Greenhouse Gas Emissions by Mode, metric tons

Mode	Engine Type	CO_2e	CO_2	N_2O	CH_4
Transit	Auxiliary Engine	27,954	27,596	1.2	0.3
Transit	Auxiliary Boiler	4,375	4,271	0.3	0.0
Transit	Main Engine	47,157	46,293	2.8	1.1
Total Transit		**79,486**	**78,161**	**4.3**	**1.4**
Maneuvering	Auxiliary Engine	7,713	7,614	0.3	0.1
Maneuvering	Auxiliary Boiler	1,574	1,537	0.1	0.0
Maneuvering	Main Engine	3,335	3,235	0.3	0.3
Total Maneuvering		**12,622**	**12,386**	**0.8**	**0.4**
Hotelling at-berth	Auxiliary Engine	65,317	64,481	2.7	0.8
Hotelling at-berth	Auxiliary Boiler	97,016	94,708	7.7	0.2
Hotelling at-berth	Main Engine	0	0	0.0	0.0
Total Hotelling at-berth		**162,333**	**159,189**	**10.5**	**1.0**
Hotelling at-anchorage	Auxiliary Engine	24,871	24,553	1.0	0.3
Hotelling at-anchorage	Auxiliary Boiler	14,329	13,988	1.1	0.0
Hotelling at-anchorage	Main Engine	0	0	0.0	0.0
Total Hotelling at-anchorage		**39,199**	**38,540**	**2.2**	**0.3**
Total		**293,640**	**288,276**	**17.7**	**3.1**

Table 2.7 presents the numbers of arrivals, departures, and shifts associated with vessels at the Port in 2014.

Table 2.7: 2014 Total OGV Activities

Vessel Type	Arrival	Departure	Shift	Total
Auto Carrier	162	162	13	337
Bulk	201	207	230	638
Bulk - Heavy Load	6	7	2	15
Bulk - Self Discharging	7	7	4	18
Container - 1000	73	73	21	167
Container - 2000	67	67	11	145
Container - 3000	44	43	8	95
Container - 4000	186	184	13	383
Container - 5000	113	112	17	242
Container - 6000	7	7	2	16
Container - 7000	7	7	1	15
Container - 8000	169	167	35	371
Container - 9000	69	68	13	150
Container - 10000	45	44	14	103
Container - 11000	53	52	8	113
Container - 12000	2	2	0	4
Container - 13000	23	21	7	51
Cruise	234	234	1	469
General Cargo	60	68	52	180
Miscellaneous	4	4	2	10
Reefer	1	2	2	5
RoRo	1	1	2	4
Tanker - Aframax	90	89	147	326
Tanker - Chemical	122	128	208	458
Tanker - Handysize	0	0	2	2
Tanker - Panamax	90	90	156	336
Tanker - Suezmax	92	92	171	355
Tanker - ULCC	29	28	102	159
Tanker - VLCC	8	8	19	35
Total	**1,965**	**1,974**	**1,263**	**5,202**

Operational Profiles

Tables 2.8 and 2.9 summarize the hoteling durations while at-berth and at-anchorage in 2014.

Table 2.8: 2014 At-Berth Hotelling Times

Vessel Type	Min Hours	Max Hours	Avg Hours
Auto Carrier	4.2	47.3	12.8
Bulk - General	8.5	278.4	56.0
Bulk - Heavy Load	46.2	269.5	154.9
Bulk - Self Discharging	32.5	69.6	48.6
Container - 1000	10.5	87.7	31.2
Container - 2000	9.7	92.7	48.8
Container - 3000	21.1	151.5	46.1
Container - 4000	4.8	123.4	55.3
Container - 5000	6.8	202.8	58.5
Container - 6000	13.2	125.8	70.2
Container - 7000	58.4	145.8	84.9
Container - 8000	12.9	215.9	97.1
Container - 9000	70.0	308.2	96.4
Container - 10000	11.5	228.8	118.4
Container - 11000	26.4	239.8	104.4
Container - 12000	102.4	102.7	102.6
Container - 13000	39.6	273.6	128.7
Cruise	0.4	20.1	11.1
General Cargo	7.3	135.9	39.2
Miscellaneous	1,075.1	5,073.1	3,033.3
Reefer	9.1	9.3	9.2
RoRo	21.8	21.8	21.8
Tanker - Aframax	11.7	129.9	35.9
Tanker - Chemical	8.7	147.7	33.8
Tanker - Handysize	14.2	14.2	14.2
Tanker - Panamax	15.3	201.0	42.5
Tanker - Suezmax	12.7	50.6	27.0
Tanker - ULCC	12.8	47.2	29.2
Tanker - VLCC	16.8	48.0	30.8

Table 2.9: 2014 At-Anchorage Hotelling Times

Vessel Type	Min Hours	Max Hours	Avg Hours	Anchorage Activity Count
Auto Carrier	6.4	49.9	18.4	12
Bulk - General	2.2	518.5	67.2	180
Bulk - Heavy Load	6.2	6.2	6.2	1
Bulk - Self Discharging	3.3	116.8	46.9	3
Container - 1000	1.8	900.2	69.8	20
Container - 2000	4.3	57.6	27.4	8
Container - 3000	25.0	94.7	58.9	9
Container - 4000	4.5	142.8	34.6	12
Container - 5000	7.5	248.3	41.3	14
Container - 6000	0.0	0.0	0.0	0
Container - 7000	7.9	7.9	7.9	1
Container - 8000	0.5	112.3	44.3	30
Container - 9000	1.1	89.8	35.1	13
Container - 10000	3.3	117.3	44.4	12
Container - 11000	5.2	178.0	69.6	7
Container - 12000	0.0	0.0	0.0	0
Container - 13000	2.7	114.3	34.6	7
Cruise	0.0	0.0	0.0	0
General Cargo	1.8	325.2	49.7	38
Miscellaneous	12.6	12.6	12.6	1
Reefer	7.9	7.9	7.9	1
RoRo	3.8	7.6	5.7	2
Tanker - Aframax	2.7	401.7	45.1	132
Tanker - Chemical	1.7	218.3	29.5	146
Tanker - Handysize	25.7	25.7	25.7	1
Tanker - Panamax	0.6	244.4	34.7	132
Tanker - Suezmax	2.2	292.0	53.8	153
Tanker - ULCC	5.0	310.1	77.6	75
Tanker - VLCC	1.5	134.0	45.7	15

Table 2.10 presents the auxiliary engine load defaults by vessel type, by mode used to estimate emissions. Values in this table are based on Vessel Boarding Program and it should be noted that the cruise defaults are for non-diesel-electric ships. Diesel-electric cruise ship defaults are presented in Table 2.11.

Table 2.10: 2014 Average Auxiliary Engine Load Defaults (except Diesel-Electric Cruise Vessels), kW

Vessel Type	Transit	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	1,079	2,391	1,284	1,079
Bulk	313	822	210	313
Bulk - Heavy Load	462	1,223	272	462
Bulk - Self Discharging	305	807	179	305
Container - 1000	957	2,245	720	957
Container - 2000	985	2,188	1,039	985
Container - 3000	747	2,562	641	747
Container - 4000	1,403	2,472	1,136	1,403
Container - 5000	1,316	4,700	1,128	1,316
Container - 6000	1,162	2,591	804	1,162
Container - 7000	1,220	2,721	845	1,220
Container - 8000	1,457	3,249	1,008	1,457
Container - 9000	1,488	3,320	1,030	1,488
Container - 10000	1,375	1,675	1,075	1,375
Container - 12000	2,500	4,500	2,000	2,500
Container - 13000	2,600	5,200	1,700	2,600
Cruise	5,445	8,711	5,445	5,445
General Cargo	423	1,071	575	423
Miscellaneous	793	2,100	467	793
Reefer	630	1,889	1,091	630
RoRo	132	396	229	132
Tanker - Aframax	576	719	724	576
Tanker - Chemical	611	833	967	611
Tanker - Handysize	559	768	605	559
Tanker - Panamax	596	801	679	596
Tanker - Suezmax	860	1,288	2,509	860
Tanker - ULCC	1,080	1,486	1,171	1,080
Tanker - VLCC	1,080	1,486	1,171	1,080

Table 2.11: 2014 Diesel-Electric Cruise Vessel Auxiliary Engine Defaults, kW

Passenger Count	Transit	Maneuvering	Berth Hotelling
<1,500	3,500	3,500	3,000
1,500 < 2,000	7,000	7,000	6,500
2,000 < 2,500	10,500	10,500	9,500
2,500 < 3,000	11,000	11,000	10,000
3,000 < 3,500	11,500	11,500	10,500
3,500 < 4,000	12,000	12,000	11,000
4,000+	13,000	13,000	12,000

Table 2.12 presents the load defaults for the auxiliary boilers by vessel type and by mode. Based on recent Vessel Boarding Program data, it was identified that the auxiliary boilers are turned on for diesel-electric cruise ships because the heat recovery systems are not effective while the ship is on shore power. In addition, it was identified that the average load for the auxiliary boilers for tankers being loaded at-berth was ~875 kW. Finally, the auxiliary boiler at-berth load for diesel-electric tankers was adjusted for just providing the house load and not associated with cargo movements.

Table 2.12: 2014 Auxiliary Boiler Energy Defaults, kW

Vessel Type	Transit	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	351	351	351	351
Bulk	132	132	132	132
Bulk - Heavy Load	132	132	132	132
Bulk - Self Discharging	132	132	132	132
Container - 1000	241	241	241	241
Container - 2000	325	325	325	325
Container - 3000	474	474	474	474
Container - 4000	492	492	492	492
Container - 5000	628	628	628	628
Container - 6000	577	577	577	577
Container - 7000	551	551	551	551
Container - 8000	525	525	525	525
Container - 9000	705	705	705	705
Container - 10000	604	604	604	604
Container - 12000	600	600	600	600
Container - 13000	600	600	600	600
Cruise	1,393	1,393	1,393	1,393
General Cargo	135	135	135	135
Miscellaneous	137	137	137	137
Reefer	255	255	255	255
RoRo	243	243	243	243
Tanker - Aframax	371	371	5,030	371
Tanker - Chemical	371	371	821	371
Tanker - Handysize	371	371	2,586	371
Tanker - Panamax	371	371	3,293	371
Tanker - Suezmax	371	371	5,843	371
Tanker - ULCC	371	371	6,000	371
Tanker - VLCC	371	371	6,000	371
Tanker - All Diesel Electric	0	145	220	220

Note - Auxiliary boiler load used for all tankers while being loaded at-berth is 875 kW

Updates to the Emissions Estimation Methodology

In advance of the North American Emissions Control Area, 2014 was the start of CARB's final fuel standard for ships in California waters and required 0.1% S marine gas oil (MGO). It was assumed that all vessels that came to the Port complied with the CARB regulation. In addition, several tanker exemptions for auxiliary boilers expired at the end of 2013 so all tanker emissions were assumed to be in compliance with the CARB fuel requirements. Tables 2.13 and 2.14 present the emission factors corresponding to 0.1% S fuel used to estimate emissions.

Table 2.13: OGV Propulsion/Boiler Engine Emission Factors for 0.1% S MGO Fuel (g/kW-hr)

Engine	IMO Tier	Model Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
Slow speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	17.0	0.4	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	13.2	0.4	1.1	0.5	649	0.029	0.01
Slow speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	16.0	0.4	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	12.2	0.4	1.1	0.5	649	0.029	0.01
Slow speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	14.4	0.4	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	10.5	0.4	1.1	0.5	649	0.029	0.01
Slow speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	3.4	0.4	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	2.6	0.4	1.1	0.5	649	0.029	0.01
Gas turbine	na	all	0.01	0.01	0.00	5.7	0.6	0.2	0.1	922	0.075	0.002
Steamship	na	all	0.14	0.13	0.00	2.0	0.6	0.2	0.1	922	0.075	0.002

Table 2.14: OGV Auxiliary Engine Emission Factors for 0.1% S MGO Fuel (g/kW-hr)

Engine	IMO Tier	Model Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
High speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	10.9	0.5	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	13.8	0.5	1.1	0.4	686	0.029	0.008
High speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	9.8	0.5	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	12.2	0.5	1.1	0.4	686	0.029	0.008
High speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	7.7	0.5	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	10.5	0.5	1.1	0.4	686	0.029	0.008
High speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	2.0	0.5	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	2.6	0.5	1.1	0.4	686	0.029	0.008

The low load adjustment (LLA) regression equation variables are provided in Table 2.15 for reference. Starting in 2014, the LLA factors presented in Table 2.16 are only applied to 2-stroke non-MAN propulsion engines.

Table 2.15: Low Load Adjustment Factor Regression Equation Variables

Pollutant	Exponent	Intercept (b)	Coefficient (a)
PM	1.5	0.2551	0.0059
NO_x	1.5	10.4496	0.1255
CO	1.0	0.1548	0.8378
HC	1.5	0.3859	0.0667

Table 2.16: 2-Stroke non-MAN Propulsion Engines Low Load Adjustment Factors

Load	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
2%	7.29	4.63	1.00	9.68	21.18	1.00	4.63	21.18
3%	4.33	2.92	1.00	6.46	11.68	1.00	2.92	11.68
4%	3.09	2.21	1.00	4.86	7.71	1.00	2.21	7.71
5%	2.44	1.83	1.00	3.89	5.61	1.00	1.83	5.61
6%	2.04	1.60	1.00	3.25	4.35	1.00	1.60	4.35
7%	1.79	1.45	1.00	2.79	3.52	1.00	1.45	3.52
8%	1.61	1.35	1.00	2.45	2.95	1.00	1.35	2.95
9%	1.48	1.27	1.00	2.18	2.52	1.00	1.27	2.52
10%	1.38	1.22	1.00	1.96	2.18	1.00	1.22	2.18
11%	1.30	1.17	1.00	1.79	1.96	1.00	1.17	1.96
12%	1.24	1.14	1.00	1.64	1.76	1.00	1.14	1.76
13%	1.19	1.11	1.00	1.52	1.60	1.00	1.11	1.60
14%	1.15	1.08	1.00	1.41	1.47	1.00	1.08	1.47
15%	1.11	1.06	1.00	1.32	1.36	1.00	1.06	1.36
16%	1.08	1.05	1.00	1.24	1.26	1.00	1.05	1.26
17%	1.06	1.03	1.00	1.17	1.18	1.00	1.03	1.18
18%	1.04	1.02	1.00	1.11	1.11	1.00	1.02	1.11
19%	1.02	1.01	1.00	1.05	1.05	1.00	1.01	1.05
20%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Starting in 2014, the emissions from MAN 2-stroke propulsion (main) engines were adjusted as a function of engine load using test data from the San Pedro Bay Ports' (SPBP) *MAN Slide Valve Low-Load Emissions Test Final Report* (Slide Valve Test)[6] completed under the SPBP Technology Advancement Program (TAP) in conjunction with MAN and Mitsui. The following enhancements are incorporated into the emissions estimates for applicable propulsion engines based on the findings of the study and coordinated with the Technical Working Group[7]:

- Emission factor adjustment (EFA) is applied to pollutants for which test results were significantly different in magnitude than the base emission factors used in the inventory. A slide valve EFA (EFA_{SV}) is applied only to vessels equipped with slide valves (SV), which include 2004 or newer MAN 2-stroke engines and vessels identified in VBP as having slide valves. A conventional nozzle (C3) EFA (EFA_{C3}) is used for all other MAN 2-stroke engines, which would be older than 2004 vessels. EFAs were developed by compositing the test data into the E3 duty cycle load weighting, and comparing them to the E3-based EFs used in the inventories. The following EFAs are used:

  a. NO_x: $EFA_{SV} = 1.0$ $EFA_{C3} = 1.0$
  b. PM: $EFA_{SV} = 1.0$ $EFA_{C3} = 1.0$
  c. THC: $EFA_{SV} = 0.43$ $EFA_{C3} = 1.0$
  d. CO: $EFA_{SV} = 0.59$ $EFA_{C3} = 0.44$
  e. CO_2: $EFA_{SV} = 1.0$ $EFA_{C3} = 1.0$

- Load adjustment factor (LAF) were calculated and applied to the EF x EFA across all loads (0% to 100%). The LAF is pollutant based and valve specific (SV or C3), using the same criteria as stated above for EFA. The adjusted equation for estimating OGV MAN propulsion engine emissions is:

$$Ei = MCR\ (kW) \times\ engine\ load(\%) \times EF\ \left(\frac{g}{kW - hr}\right) \times EFA \times LAF_i \times FCF \times CF$$

Where,

Ei = Emission by load i, g
MCR = maximum continuous rating, kW
engine $load_i$ = % of MCR being used in mode i, %
EF = default emission factor (E3 duty cycle), g/kW-hr
EFA = emission factor adjustment, dimensionless
LAF_i = test-based EF_i (by valve type and pollutant) at load i / test-based composite EF (E3 duty cycle), dimensionless
FCF = fuel correction factor, dimensionless
CF = control factor for any emission reduction program, dimensionless

[6] As referenced in the Emission Estimating Methodology and Enhancements Section.
[7] Made up of POLB, Port of Los Angeles, CARB, South Coast Air Quality Management District, and EPA

Tables 2.17 and 2.18 present the LAFs used across the entire engine load range.

Table 2.17: Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1%	0.36	0.36	0.36	1.90	1.00	0.12	1.36	1.00	1.90	1.36
2%	0.37	0.37	0.37	1.86	1.00	0.12	1.32	1.00	1.86	1.32
3%	0.38	0.38	0.38	1.82	1.00	0.12	1.28	1.00	1.82	1.28
4%	0.38	0.38	0.38	1.78	1.00	0.12	1.24	1.00	1.78	1.24
5%	0.39	0.39	0.39	1.74	1.00	0.12	1.20	1.00	1.74	1.20
6%	0.40	0.40	0.40	1.70	1.00	0.12	1.17	1.00	1.70	1.17
7%	0.41	0.41	0.41	1.67	1.00	0.12	1.14	1.00	1.67	1.14
8%	0.41	0.41	0.41	1.63	1.00	0.12	1.11	1.00	1.63	1.11
9%	0.42	0.42	0.42	1.60	1.00	0.12	1.08	1.00	1.60	1.08
10%	0.43	0.43	0.43	1.57	1.00	0.12	1.05	1.00	1.57	1.05
11%	0.44	0.44	0.44	1.53	1.00	0.26	1.02	1.00	1.53	1.02
12%	0.45	0.45	0.45	1.50	1.00	0.39	0.99	1.00	1.50	0.99
13%	0.45	0.45	0.45	1.47	1.00	0.52	0.97	1.00	1.47	0.97
14%	0.46	0.46	0.46	1.45	1.00	0.64	0.94	1.00	1.45	0.94
15%	0.47	0.47	0.47	1.42	1.00	0.75	0.92	1.00	1.42	0.92
16%	0.48	0.48	0.48	1.39	1.00	0.85	0.90	1.00	1.39	0.90
17%	0.49	0.49	0.49	1.37	1.00	0.95	0.88	1.00	1.37	0.88
18%	0.49	0.49	0.49	1.34	1.00	1.04	0.86	1.00	1.34	0.86
19%	0.50	0.50	0.50	1.32	1.00	1.12	0.84	1.00	1.32	0.84
20%	0.51	0.51	0.51	1.30	1.00	1.20	0.82	1.00	1.30	0.82
21%	0.52	0.52	0.52	1.28	1.00	1.27	0.81	1.00	1.28	0.81
22%	0.53	0.53	0.53	1.26	1.00	1.34	0.79	1.00	1.26	0.79
23%	0.54	0.54	0.54	1.24	1.00	1.40	0.78	1.00	1.24	0.78
24%	0.54	0.54	0.54	1.22	1.00	1.46	0.76	1.00	1.22	0.76
25%	0.55	0.55	0.55	1.20	1.00	1.51	0.75	1.00	1.20	0.75

Table 2.17 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
26%	0.56	0.56	0.56	1.19	1.00	1.55	0.74	1.00	1.19	0.74
27%	0.57	0.57	0.57	1.17	1.00	1.59	0.73	1.00	1.17	0.73
28%	0.58	0.58	0.58	1.16	1.00	1.63	0.72	1.00	1.16	0.72
29%	0.59	0.59	0.59	1.14	1.00	1.66	0.71	1.00	1.14	0.71
30%	0.60	0.60	0.60	1.13	1.00	1.68	0.70	1.00	1.13	0.70
31%	0.60	0.60	0.60	1.12	1.00	1.70	0.70	1.00	1.12	0.70
32%	0.61	0.61	0.61	1.10	1.00	1.72	0.69	1.00	1.10	0.69
33%	0.62	0.62	0.62	1.09	1.00	1.74	0.69	1.00	1.09	0.69
34%	0.63	0.63	0.63	1.08	1.00	1.75	0.68	1.00	1.08	0.68
35%	0.64	0.64	0.64	1.07	1.00	1.75	0.68	1.00	1.07	0.68
36%	0.65	0.65	0.65	1.06	1.00	1.75	0.68	1.00	1.06	0.68
37%	0.66	0.66	0.66	1.05	1.00	1.75	0.67	1.00	1.05	0.67
38%	0.67	0.67	0.67	1.05	1.00	1.75	0.67	1.00	1.05	0.67
39%	0.68	0.68	0.68	1.04	1.00	1.74	0.67	1.00	1.04	0.67
40%	0.69	0.69	0.69	1.03	1.00	1.73	0.67	1.00	1.03	0.67
41%	0.70	0.70	0.70	1.03	1.00	1.72	0.67	1.00	1.03	0.67
42%	0.70	0.70	0.70	1.02	1.00	1.71	0.68	1.00	1.02	0.68
43%	0.71	0.71	0.71	1.02	1.00	1.69	0.68	1.00	1.02	0.68
44%	0.72	0.72	0.72	1.01	1.00	1.67	0.68	1.00	1.01	0.68
45%	0.73	0.73	0.73	1.01	1.00	1.65	0.69	1.00	1.01	0.69
46%	0.74	0.74	0.74	1.00	1.00	1.62	0.69	1.00	1.00	0.69
47%	0.75	0.75	0.75	1.00	1.00	1.60	0.70	1.00	1.00	0.70
48%	0.76	0.76	0.76	1.00	1.00	1.57	0.70	1.00	1.00	0.70
49%	0.77	0.77	0.77	0.99	1.00	1.54	0.71	1.00	0.99	0.71
50%	0.78	0.78	0.78	0.99	1.00	1.51	0.71	1.00	0.99	0.71

Table 2.17 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
51%	0.79	0.79	0.79	0.99	1.00	1.48	0.72	1.00	0.99	0.72
52%	0.80	0.80	0.80	0.99	1.00	1.45	0.73	1.00	0.99	0.73
53%	0.81	0.81	0.81	0.99	1.00	1.41	0.74	1.00	0.99	0.74
54%	0.82	0.82	0.82	0.99	1.00	1.38	0.75	1.00	0.99	0.75
55%	0.83	0.83	0.83	0.98	1.00	1.35	0.75	1.00	0.98	0.75
56%	0.84	0.84	0.84	0.98	1.00	1.31	0.76	1.00	0.98	0.76
57%	0.85	0.85	0.85	0.98	1.00	1.27	0.77	1.00	0.98	0.77
58%	0.86	0.86	0.86	0.98	1.00	1.24	0.78	1.00	0.98	0.78
59%	0.87	0.87	0.87	0.98	1.00	1.20	0.80	1.00	0.98	0.80
60%	0.88	0.88	0.88	0.98	1.00	1.16	0.81	1.00	0.98	0.81
61%	0.89	0.89	0.89	0.98	1.00	1.13	0.82	1.00	0.98	0.82
62%	0.90	0.90	0.90	0.98	1.00	1.09	0.83	1.00	0.98	0.83
63%	0.91	0.91	0.91	0.99	1.00	1.06	0.84	1.00	0.99	0.84
64%	0.92	0.92	0.92	0.99	1.00	1.02	0.85	1.00	0.99	0.85
65%	0.93	0.93	0.93	0.99	1.00	0.98	0.87	1.00	0.99	0.87
66%	0.94	0.94	0.94	0.99	1.00	0.95	0.88	1.00	0.99	0.88
67%	0.95	0.95	0.95	0.99	1.00	0.92	0.89	1.00	0.99	0.89
68%	0.97	0.97	0.97	0.99	1.00	0.88	0.91	1.00	0.99	0.91
69%	0.98	0.98	0.98	0.99	1.00	0.85	0.92	1.00	0.99	0.92
70%	0.99	0.99	0.99	0.99	1.00	0.82	0.93	1.00	0.99	0.93
71%	1.00	1.00	1.00	0.99	1.00	0.79	0.95	1.00	0.99	0.95
72%	1.01	1.01	1.01	0.99	1.00	0.76	0.96	1.00	0.99	0.96
73%	1.02	1.02	1.02	0.99	1.00	0.74	0.98	1.00	0.99	0.98
74%	1.03	1.03	1.03	0.99	1.00	0.71	0.99	1.00	0.99	0.99
75%	1.04	1.04	1.04	0.99	1.00	0.69	1.00	1.00	0.99	1.00

Table 2.17 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
76%	1.05	1.05	1.05	0.99	1.00	0.66	1.02	1.00	0.99	1.02
77%	1.06	1.06	1.06	0.99	1.00	0.64	1.03	1.00	0.99	1.03
78%	1.07	1.07	1.07	0.99	1.00	0.63	1.05	1.00	0.99	1.05
79%	1.09	1.09	1.09	0.99	1.00	0.61	1.06	1.00	0.99	1.06
80%	1.10	1.10	1.10	0.99	1.00	0.60	1.08	1.00	0.99	1.08
81%	1.11	1.11	1.11	0.99	1.00	0.58	1.09	1.00	0.99	1.09
82%	1.12	1.12	1.12	0.99	1.00	0.57	1.10	1.00	0.99	1.10
83%	1.13	1.13	1.13	0.98	1.00	0.57	1.12	1.00	0.98	1.12
84%	1.14	1.14	1.14	0.98	1.00	0.56	1.13	1.00	0.98	1.13
85%	1.15	1.15	1.15	0.98	1.00	0.56	1.15	1.00	0.98	1.15
86%	1.16	1.16	1.16	0.98	1.00	0.56	1.16	1.00	0.98	1.16
87%	1.18	1.18	1.18	0.97	1.00	0.56	1.18	1.00	0.97	1.18
88%	1.19	1.19	1.19	0.97	1.00	0.57	1.19	1.00	0.97	1.19
89%	1.20	1.20	1.20	0.96	1.00	0.58	1.20	1.00	0.96	1.20
90%	1.21	1.21	1.21	0.96	1.00	0.59	1.22	1.00	0.96	1.22
91%	1.22	1.22	1.22	0.95	1.00	0.61	1.23	1.00	0.95	1.23
92%	1.23	1.23	1.23	0.95	1.00	0.63	1.24	1.00	0.95	1.24
93%	1.25	1.25	1.25	0.94	1.00	0.65	1.25	1.00	0.94	1.25
94%	1.26	1.26	1.26	0.93	1.00	0.67	1.27	1.00	0.93	1.27
95%	1.27	1.27	1.27	0.93	1.00	0.70	1.28	1.00	0.93	1.28
96%	1.28	1.28	1.28	0.92	1.00	0.73	1.29	1.00	0.92	1.29
97%	1.29	1.29	1.29	0.91	1.00	0.77	1.30	1.00	0.91	1.30
98%	1.31	1.31	1.31	0.90	1.00	0.81	1.31	1.00	0.90	1.31
99%	1.32	1.32	1.32	0.89	1.00	0.85	1.32	1.00	0.89	1.32
100%	1.33	1.33	1.33	0.88	1.00	0.90	1.34	1.00	0.88	1.34

Table 2.18: Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1%	0.84	0.84	0.84	1.91	1.00	1.38	2.53	1.00	1.91	2.53
2%	0.83	0.83	0.83	1.86	1.00	1.36	2.45	1.00	1.86	2.45
3%	0.83	0.83	0.83	1.82	1.00	1.34	2.37	1.00	1.82	2.37
4%	0.82	0.82	0.82	1.77	1.00	1.33	2.30	1.00	1.77	2.30
5%	0.82	0.82	0.82	1.72	1.00	1.31	2.23	1.00	1.72	2.23
6%	0.81	0.81	0.81	1.68	1.00	1.29	2.16	1.00	1.68	2.16
7%	0.81	0.81	0.81	1.64	1.00	1.28	2.10	1.00	1.64	2.10
8%	0.80	0.80	0.80	1.60	1.00	1.26	2.03	1.00	1.60	2.03
9%	0.80	0.80	0.80	1.56	1.00	1.25	1.97	1.00	1.56	1.97
10%	0.79	0.79	0.79	1.52	1.00	1.24	1.91	1.00	1.52	1.91
11%	0.79	0.79	0.79	1.49	1.00	1.22	1.86	1.00	1.49	1.86
12%	0.78	0.78	0.78	1.45	1.00	1.21	1.80	1.00	1.45	1.80
13%	0.78	0.78	0.78	1.42	1.00	1.20	1.75	1.00	1.42	1.75
14%	0.78	0.78	0.78	1.39	1.00	1.19	1.70	1.00	1.39	1.70
15%	0.77	0.77	0.77	1.36	1.00	1.18	1.65	1.00	1.36	1.65
16%	0.77	0.77	0.77	1.33	1.00	1.17	1.61	1.00	1.33	1.61
17%	0.77	0.77	0.77	1.30	1.00	1.16	1.56	1.00	1.30	1.56
18%	0.77	0.77	0.77	1.28	1.00	1.15	1.52	1.00	1.28	1.52
19%	0.76	0.76	0.76	1.25	1.00	1.14	1.48	1.00	1.25	1.48
20%	0.76	0.76	0.76	1.23	1.00	1.13	1.44	1.00	1.23	1.44
21%	0.76	0.76	0.76	1.20	1.00	1.13	1.41	1.00	1.20	1.41
22%	0.76	0.76	0.76	1.18	1.00	1.12	1.37	1.00	1.18	1.37
23%	0.76	0.76	0.76	1.16	1.00	1.11	1.34	1.00	1.16	1.34
24%	0.75	0.75	0.75	1.14	1.00	1.10	1.31	1.00	1.14	1.31
25%	0.75	0.75	0.75	1.12	1.00	1.10	1.28	1.00	1.12	1.28

Table 2.18 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
26%	0.75	0.75	0.75	1.11	1.00	1.09	1.25	1.00	1.11	1.25
27%	0.75	0.75	0.75	1.09	1.00	1.08	1.22	1.00	1.09	1.22
28%	0.75	0.75	0.75	1.07	1.00	1.08	1.20	1.00	1.07	1.20
29%	0.75	0.75	0.75	1.06	1.00	1.07	1.17	1.00	1.06	1.17
30%	0.75	0.75	0.75	1.05	1.00	1.07	1.15	1.00	1.05	1.15
31%	0.75	0.75	0.75	1.03	1.00	1.06	1.13	1.00	1.03	1.13
32%	0.75	0.75	0.75	1.02	1.00	1.06	1.11	1.00	1.02	1.11
33%	0.75	0.75	0.75	1.01	1.00	1.05	1.09	1.00	1.01	1.09
34%	0.75	0.75	0.75	1.00	1.00	1.05	1.08	1.00	1.00	1.08
35%	0.76	0.76	0.76	0.99	1.00	1.04	1.06	1.00	0.99	1.06
36%	0.76	0.76	0.76	0.98	1.00	1.04	1.05	1.00	0.98	1.05
37%	0.76	0.76	0.76	0.98	1.00	1.03	1.04	1.00	0.98	1.04
38%	0.76	0.76	0.76	0.97	1.00	1.03	1.02	1.00	0.97	1.02
39%	0.76	0.76	0.76	0.96	1.00	1.02	1.01	1.00	0.96	1.01
40%	0.76	0.76	0.76	0.96	1.00	1.02	1.00	1.00	0.96	1.00
41%	0.77	0.77	0.77	0.95	1.00	1.01	0.99	1.00	0.95	0.99
42%	0.77	0.77	0.77	0.95	1.00	1.01	0.99	1.00	0.95	0.99
43%	0.77	0.77	0.77	0.94	1.00	1.01	0.98	1.00	0.94	0.98
44%	0.78	0.78	0.78	0.94	1.00	1.00	0.97	1.00	0.94	0.97
45%	0.78	0.78	0.78	0.94	1.00	1.00	0.97	1.00	0.94	0.97
46%	0.78	0.78	0.78	0.94	1.00	0.99	0.96	1.00	0.94	0.96
47%	0.79	0.79	0.79	0.94	1.00	0.99	0.96	1.00	0.94	0.96
48%	0.79	0.79	0.79	0.93	1.00	0.98	0.96	1.00	0.93	0.96
49%	0.79	0.79	0.79	0.93	1.00	0.98	0.96	1.00	0.93	0.96
50%	0.80	0.80	0.80	0.93	1.00	0.98	0.96	1.00	0.93	0.96

Table 2.18 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
51%	0.80	0.80	0.80	0.94	1.00	0.97	0.95	1.00	0.94	0.95
52%	0.81	0.81	0.81	0.94	1.00	0.97	0.95	1.00	0.94	0.95
53%	0.81	0.81	0.81	0.94	1.00	0.96	0.95	1.00	0.94	0.95
54%	0.82	0.82	0.82	0.94	1.00	0.96	0.95	1.00	0.94	0.95
55%	0.82	0.82	0.82	0.94	1.00	0.96	0.96	1.00	0.94	0.96
56%	0.83	0.83	0.83	0.94	1.00	0.95	0.96	1.00	0.94	0.96
57%	0.84	0.84	0.84	0.95	1.00	0.95	0.96	1.00	0.95	0.96
58%	0.84	0.84	0.84	0.95	1.00	0.95	0.96	1.00	0.95	0.96
59%	0.85	0.85	0.85	0.95	1.00	0.94	0.96	1.00	0.95	0.96
60%	0.86	0.86	0.86	0.95	1.00	0.94	0.97	1.00	0.95	0.97
61%	0.86	0.86	0.86	0.96	1.00	0.93	0.97	1.00	0.96	0.97
62%	0.87	0.87	0.87	0.96	1.00	0.93	0.97	1.00	0.96	0.97
63%	0.88	0.88	0.88	0.96	1.00	0.93	0.98	1.00	0.96	0.98
64%	0.89	0.89	0.89	0.97	1.00	0.93	0.98	1.00	0.97	0.98
65%	0.89	0.89	0.89	0.97	1.00	0.92	0.98	1.00	0.97	0.98
66%	0.90	0.90	0.90	0.98	1.00	0.92	0.99	1.00	0.98	0.99
67%	0.91	0.91	0.91	0.98	1.00	0.92	0.99	1.00	0.98	0.99
68%	0.92	0.92	0.92	0.98	1.00	0.91	0.99	1.00	0.98	0.99
69%	0.93	0.93	0.93	0.99	1.00	0.91	1.00	1.00	0.99	1.00
70%	0.94	0.94	0.94	0.99	1.00	0.91	1.00	1.00	0.99	1.00
71%	0.94	0.94	0.94	0.99	1.00	0.91	1.00	1.00	0.99	1.00
72%	0.95	0.95	0.95	1.00	1.00	0.91	1.01	1.00	1.00	1.01
73%	0.96	0.96	0.96	1.00	1.00	0.91	1.01	1.00	1.00	1.01
74%	0.97	0.97	0.97	1.00	1.00	0.91	1.01	1.00	1.00	1.01
75%	0.98	0.98	0.98	1.01	1.00	0.90	1.01	1.00	1.01	1.01

Table 2.18 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
76%	0.99	0.99	0.99	1.01	1.00	0.90	1.01	1.00	1.01	1.01
77%	1.00	1.00	1.00	1.01	1.00	0.90	1.01	1.00	1.01	1.01
78%	1.01	1.01	1.01	1.01	1.00	0.91	1.01	1.00	1.01	1.01
79%	1.03	1.03	1.03	1.02	1.00	0.91	1.01	1.00	1.02	1.01
80%	1.04	1.04	1.04	1.02	1.00	0.91	1.01	1.00	1.02	1.01
81%	1.05	1.05	1.05	1.02	1.00	0.91	1.01	1.00	1.02	1.01
82%	1.06	1.06	1.06	1.02	1.00	0.91	1.01	1.00	1.02	1.01
83%	1.07	1.07	1.07	1.02	1.00	0.92	1.01	1.00	1.02	1.01
84%	1.08	1.08	1.08	1.02	1.00	0.92	1.00	1.00	1.02	1.00
85%	1.10	1.10	1.10	1.02	1.00	0.92	1.00	1.00	1.02	1.00
86%	1.11	1.11	1.11	1.02	1.00	0.93	0.99	1.00	1.02	0.99
87%	1.12	1.12	1.12	1.02	1.00	0.93	0.99	1.00	1.02	0.99
88%	1.13	1.13	1.13	1.02	1.00	0.94	0.98	1.00	1.02	0.98
89%	1.15	1.15	1.15	1.01	1.00	0.95	0.97	1.00	1.01	0.97
90%	1.16	1.16	1.16	1.01	1.00	0.95	0.97	1.00	1.01	0.97
91%	1.17	1.17	1.17	1.01	1.00	0.96	0.96	1.00	1.01	0.96
92%	1.19	1.19	1.19	1.00	1.00	0.97	0.94	1.00	1.00	0.94
93%	1.20	1.20	1.20	1.00	1.00	0.98	0.93	1.00	1.00	0.93
94%	1.22	1.22	1.22	0.99	1.00	0.99	0.92	1.00	0.99	0.92
95%	1.23	1.23	1.23	0.99	1.00	1.01	0.91	1.00	0.99	0.91
96%	1.24	1.24	1.24	0.98	1.00	1.02	0.89	1.00	0.98	0.89
97%	1.26	1.26	1.26	0.97	1.00	1.03	0.87	1.00	0.97	0.87
98%	1.28	1.28	1.28	0.97	1.00	1.05	0.86	1.00	0.97	0.86
99%	1.29	1.29	1.29	0.96	1.00	1.07	0.84	1.00	0.96	0.84
100%	1.31	1.31	1.31	0.95	1.00	1.08	0.82	1.00	0.95	0.82

SECTION 3 HARBOR CRAFT

Source Description

Emissions from the following types of diesel-fueled harbor craft were quantified:

- Assist tugboats
- Crew, supply and work boats
- Ferry vessels
- Excursion vessels
- Government vessels
- Harbor tugboats
- Ocean tugboats

Emissions Estimation Methodology

The methodology to estimate emissions from harbor craft is similar to that used in CARB's emissions inventory for commercial harbor craft emissions operating in California[8] and described in Section 4 of the Port of Long Beach 2013 Air Emissions Inventory, which is available on the Port's website at *www.polb.com/emissions*. Harbor craft emissions are estimated for each individual engine, based on the engine's model year, power rating, and annual hours of operation.[9]

Geographical Domain

Emissions are estimated for harbor craft operating within the South Coast Air Basin over-water Boundary.

Data and Information Acquisition

Harbor craft owners and operators were contacted to obtain key operational parameters, including:

- Type of harbor craft
- Engine count
- Engine horsepower (or kilowatts) for main and auxiliary engines
- Engine model year
- Operating hours in calendar year 2014

[8] *www.polb.com/environment/air/emissions.asp*
[3]CARB, *Commercial Harbor Craft Regulatory Activities*, Appendix B: Emissions Estimation Methodology for Commercial Harbor Craft Operating in California. *www.arb.ca.gov/msei/chc-appendix-b-emission-estimates-ver02-27-2012.pdf.*

Emission Estimates

Tables 3.1 and 3.2 summarize the estimated harbor craft vessel emissions by vessel type and engine type.

Table 3.1: 2014 Harbor Craft Emissions by Vessel and Engine Type, tons

Harbor Craft	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Assist tugboat	Auxiliary	0.7	0.6	0.7	22.1	0.0	17.6	2.9
	Propulsion	8.0	7.4	8.0	212.2	0.2	113.0	18.1
Assist tugboat Total		**8.7**	**8.0**	**8.7**	**234.3**	**0.2**	**130.6**	**21.0**
Crew Boat	Auxiliary	0.1	0.1	0.1	2.5	0.0	1.9	0.5
	Propulsion	2.1	1.9	2.1	61.8	0.1	38.0	6.1
Crew boat Total		**2.2**	**2.0**	**2.2**	**64.3**	**0.1**	**39.9**	**6.6**
Excursion	Auxiliary	0.1	0.1	0.1	1.7	0.0	1.3	0.3
	Propulsion	0.4	0.3	0.4	12.5	0.0	9.7	1.3
Excursion Total		**0.5**	**0.4**	**0.5**	**14.2**	**0.0**	**11.0**	**1.6**
Ferry	Auxiliary	0.1	0.1	0.1	2.4	0.0	1.9	0.5
	Propulsion	5.0	4.6	5.0	142.0	0.1	93.2	13.8
Ferry Total		**5.1**	**4.7**	**5.1**	**144.4**	**0.1**	**95.1**	**14.3**
Government	Auxiliary	0.1	0.1	0.1	1.4	0.0	0.7	0.2
	Propulsion	1.6	1.5	1.6	31.7	0.0	9.0	2.4
Government Total		**1.7**	**1.6**	**1.7**	**33.1**	**0.0**	**9.7**	**2.6**
Ocean tugboat Total	Auxiliary	0.4	0.3	0.4	7.8	0.0	4.5	0.9
	Propulsion	10.4	9.6	10.4	264.1	0.1	95.0	19.7
Ocean tugboat Total		**10.8**	**9.9**	**10.8**	**271.9**	**0.2**	**99.5**	**20.6**
Harbor tugboat	Auxiliary	0.0	0.0	0.0	0.9	0.0	0.7	0.2
	Propulsion	0.4	0.4	0.4	12.2	0.0	9.1	1.3
Harbor tugboat Total		**0.4**	**0.4**	**0.4**	**13.1**	**0.0**	**9.8**	**1.5**
Work boat	Auxiliary	0.0	0.0	0.0	0.8	0.0	0.6	0.2
	Propulsion	0.2	0.2	0.2	9.7	0.0	8.3	1.1
Work boat Total		**0.2**	**0.2**	**0.2**	**10.5**	**0.0**	**8.9**	**1.3**
Harbor Craft Total		**29.6**	**27.2**	**29.6**	**785.8**	**0.6**	**404.5**	**69.5**

Table 3.2: 2014 Harbor Craft GHG Emissions by Vessel and Engine Type, metric tons

Harbor Craft	Engine Type	CO_2e	CO_2	N_2O	CH_4
Assist tugboat	Auxiliary	2,002	1,974	0.1	0.1
	Propulsion	13,520	13,334	0.6	0.3
Assist tugboat Total		**15,522**	**15,309**	**0.7**	**0.3**
Crew Boat	Auxiliary	187	184	0.0	0.0
	Propulsion	5,118	5,048	0.2	0.1
Crew boat Total		**5,305**	**5,232**	**0.2**	**0.1**
Excursion	Auxiliary	150	148	0.0	0.0
	Propulsion	1,091	1,076	0.1	0.0
Excursion Total		**1,241**	**1,223**	**0.1**	**0.0**
Ferry	Auxiliary	204	201	0.0	0.0
	Propulsion	11,219	11,065	0.5	0.2
Ferry Total		**11,423**	**11,266**	**0.5**	**0.2**
Government	Auxiliary	51	50	0.0	0.0
	Propulsion	1,512	1,491	0.1	0.0
Government Total		**1,563**	**1,541**	**0.1**	**0.0**
Ocean tugboat Total	Auxiliary	475	468	0.0	0.0
	Propulsion	12,722	12,547	0.6	0.3
Ocean tugboat Total		**13,197**	**13,016**	**0.6**	**0.3**
Harbor tugboat	Auxiliary	80	78	0.0	0.0
	Propulsion	1,019	1,005	0.1	0.0
Harbor tugboat Total		**1,098**	**1,083**	**0.1**	**0.0**
Work boat	Auxiliary	65	64	0.0	0.0
	Propulsion	973	960	0.0	0.0
Work boat Total		**1,038**	**1,024**	**0.1**	**0.0**
Harbor Craft Total		**50,387**	**49,694**	**2.2**	**1.1**

Operational Profiles

Tables 3.3 and 3.4 summarize the characteristics of main and auxiliary engines respectively, by vessel type operating at the Port in 2014. Averages of the model year, horsepower, or operating hours are used as default values when specific data is not available.

There are a number of companies that operate harbor craft in the harbors of both the Ports of Long Beach and Los Angeles. The activity hours for the vessels that are common to both ports reflect work performed during 2014 within the Port of Long Beach harbor only.

Table 3.3: 2014 Main Engine Characteristics by Harbor Craft Type

Harbor Craft Type	Vessel Count	Engine Count	Model year Minimum	Model year Maximum	Model year Average	Horsepower Minimum	Horsepower Maximum	Horsepower Average	Annual Hours Minimum	Annual Hours Maximum	Annual Hours Average
Assist tugboat	14	29	1980	2012	2003	600	2,540	1,908	65	2,197	1,462
Crew boat	17	41	2003	2012	2009	290	1,450	582	0	2,392	963
Excursion	8	14	1982	2013	2006	70	650	393	100	2,100	878
Ferry	12	26	1998	2013	2008	180	2,300	1,718	1,200	1,500	1,258
Government	4	7	1985	2003	1993	645	965	825	350	2,200	1,029
Ocean tugboat	10	20	1971	2012	1994	805	3,385	2,147	200	2,176	838
Harbor tugboat	12	25	2005	2012	2009	250	1,500	711	85	1,088	389
Work boat	4	7	2005	2013	2010	210	675	487	62	1,909	1,237
Total	**81**	**169**									

Table 3.4: 2014 Auxiliary Engine Characteristics by Harbor Craft Type

Harbor Craft Type	Vessel Count	Engine Count	Model year Minimum	Model year Maximum	Model year Average	Horsepower Minimum	Horsepower Maximum	Horsepower Average	Annual Hours Minimum	Annual Hours Maximum	Annual Hours Average
Assist tugboat	14	29	1980	2013	2007	67	425	181	9	4,068	1,732
Crew boat	17	19	1980	2012	2007	13	76	49	236	2,215	1,112
Excursion	8	6	2009	2012	2010	50	90	77	50	2,000	1,317
Ferry	12	18	2003	2013	2009	18	120	67	750	1,500	833
Government	4	7	1985	2003	1988	13	650	233	100	3,400	629
Ocean tugboat	10	21	1975	2012	1998	60	550	156	200	1,500	756
Harbor tugboat	12	21	2005	2012	2009	22	107	48	70	946	302
Work boat	4	8	1968	2013	1998	27	101	57	548	2,079	1,135
Total	**81**	**129**									

Harbor craft engines with known model year and horsepower are categorized by EPA marine engine standards. Engine information gathered from harbor craft operators does not identify the specific EPA certification standards or "tier" level, thus, the tier level is assumed for the engines based on emission standards by engine model year and horsepower.[10] The assumptions are consistent with CARB's harbor craft emission factors, which follow the same model year grouping as the EPA emissions standards for marine engines as shown in Table 3.5.

Table 3.5: Harbor Craft Marine Engine EPA Tier Levels

EPA Tier Level	Marine Engine Model Year	Horsepower
Tier 0	1999 and older	All
Tier 1	2000 to 2003	< 500
	2000 to 2006	> 500
Tier 2	2004 up to Tier 3 below	< 500
	2007 up to Tier 3 below	> 500
Tier 3	2009 and newer	0 to 120
	2013 and newer	> 120 to 175
	2014 and newer	> 175 to 500
	2013 and newer	> 500 to 750
	2012 to 2017	> 750 to 1,900
	2013 to 2016	> 1,900 to 3,300
	2014 to 2016	> 3,300

Table 3.6 lists the marine engine count by tier in 2014.

Table 3.6: 2014 Harbor Craft Engine Tier Count

Engine Tier	2014 Engine Count
Unknown	12
Tier 0	43
Tier 1	29
Tier 2	166
Tier 3	48
Total	**298**

[10] CFR (Code of Federal Regulation), 40 CFR, subpart 94.8 for Tier 1 and 2 and subpart 1042.101 for Tier 3.

SECTION 4 CARGO HANDLING EQUIPMENT

Source Description

Cargo handling equipment (CHE) typically operate at Port terminals or railyards to move cargo such as containers, general cargo, and bulk cargo to and from marine vessels, railcars, and on-road trucks. The majority of CHE are generally composed of off-road equipment not designed to operate on public roadways. This inventory includes CHE powered by engines fueled by diesel, gasoline, propane and electricity.

Emissions Estimation Methodology

The emissions calculation methodology used to estimate CHE emissions is consistent with CARB's latest methodology for estimating emissions from CHE[11] and is the same as described in Section 4 of the Port of Long Beach 2013 Air Emissions Inventory, which is available on the Port's website at www.polb.com/emissions.[12]. Emission factors for propane and gasoline-fueled CHE were updated based on CARB's latest methodology.

Geographical Domain

Emissions are estimated for CHE operating within Port terminals and facilities.

Data and Information Acquisition

The maintenance and/or CHE operating staff of each terminal were contacted to obtain equipment count and activity information on the CHE specific to their terminal or facility operations for the 2014 calendar year.

[11] CARB, Appendix B: Emission Estimation Methodology for Cargo Handling Equipment Operating at Ports and Intermodal Rail Yards in California at *http://www.arb.ca.gov/regact/2011/cargo11/cargoappb.pdf*, viewed 22 July 2015
[12] *http://www.polb.com/emissions*

Emission Estimates

A summary of CHE emissions by terminal type is presented in Tables 4.1 and 4.2.

Table 4.1: 2014 CHE Emissions by Terminal Type, tons per year

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	0.3	0.1
Break-Bulk	0.3	0.3	0.3	16.6	0.0	11.8	1.3
Container	9.3	8.5	8.2	535.1	1.3	626.8	36.1
Cruise	0.0	0.0	0.0	1.0	0.0	15.9	0.3
Dry Bulk	0.1	0.1	0.1	4.9	0.0	6.8	1.2
Liquid	0.0	0.0	0.0	0.5	0.0	1.0	0.1
Total	**9.8**	**9.0**	**8.7**	**558.2**	**1.4**	**662.6**	**39.0**

Table 4.2: 2014 CHE GHG Emissions by Terminal Type, metric tons

Terminal Type	CO_2e	CO_2	N_2O	CH_4
Auto	19	19	0.0	0.0
Break-Bulk	2,842	2,818	0.1	0.1
Container	112,110	111,270	2.5	4.1
Cruise	333	332	0.0	0.0
Dry Bulk	453	451	0.0	0.0
Liquid	44	44	0.0	0.0
Total	**115,800**	**114,934**	**2.6**	**4.2**

Tables 4.3 and 4.4 present the CHE emissions by equipment and engine type. Emissions from boom lifts are included in the miscellaneous propane category. Emissions from rail car movers are included under the miscellaneous diesel category.

Table 4.3: 2014 CHE Emissions by Equipment Type, tons

Port Equipment	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Bulldozer	Diesel	0.0	0.0	0.0	0.9	0.0	0.3	0.1
Crane	Diesel	0.0	0.0	0.0	0.6	0.0	0.5	0.0
Excavator	Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forklift	Diesel	0.3	0.3	0.3	10.4	0.0	7.0	0.7
Forklift	Gasoline	0.0	0.0	0.0	0.1	0.0	1.3	0.0
Forklift	Propane	0.0	0.0	0.0	5.5	0.0	14.0	1.4
Loader	Diesel	0.1	0.1	0.1	7.6	0.0	3.2	0.7
Man lift	Diesel	0.0	0.0	0.0	0.2	0.0	0.3	0.0
Material handler	Diesel	0.0	0.0	0.0	1.3	0.0	0.4	0.1
Miscellaneous	Diesel	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Miscellaneous	Propane	0.0	0.0	0.0	0.2	0.0	0.2	0.1
Rail pusher	Diesel	0.0	0.0	0.0	1.3	0.0	0.6	0.1
RTG crane	Diesel	1.7	1.6	1.7	113.7	0.1	25.6	6.4
Side handler	Diesel	0.0	0.0	0.0	10.8	0.0	2.5	0.6
Skid steer loader	Diesel	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Sweeper	Diesel	0.0	0.0	0.0	1.1	0.0	0.7	0.1
Sweeper	Propane	0.0	0.0	0.0	0.2	0.0	1.4	0.1
Top handler	Diesel	1.4	1.3	1.4	236.7	0.4	83.0	17.6
Tractor	Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tractor	Propane	0.0	0.0	0.0	0.6	0.0	14.2	0.2
Truck	Diesel	0.1	0.1	0.1	3.3	0.0	1.6	0.2
Yard tractor	Diesel	4.8	4.4	4.8	157.3	0.6	142.0	10.2
Yard tractor	Gasoline	1.1	0.9	0.0	6.1	0.1	363.6	0.5
Yard tractor	Propane	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		**9.8**	**9.0**	**8.7**	**558.2**	**1.4**	**662.6**	**39.0**

Table 4.4: 2014 CHE GHG Emissions by Equipment Type, metric tons

Port Equipment	Engine Type	CO_2e	CO_2	N_2O	CH_4
Bulldozer	Diesel	106	105	0.0	0.0
Crane	Diesel	28	28	0.0	0.0
Excavator	Diesel	6	6	0.0	0.0
Forklift	Diesel	1,200	1,188	0.0	0.1
Forklift	Gasoline	172	171	0.0	0.0
Forklift	Propane	509	509	0.0	0.0
Loader	Diesel	1,319	1,307	0.0	0.1
Man lift	Diesel	45	44	0.0	0.0
Material handler	Diesel	198	196	0.0	0.0
Miscellaneous	Diesel	11	11	0.0	0.0
Miscellaneous	Propane	6	6	0.0	0.0
Rail pusher	Diesel	262	260	0.0	0.0
RTG crane	Diesel	11,687	11,586	0.3	0.5
Side handler	Diesel	1,105	1,094	0.0	0.1
Skid steer loader	Diesel	6	5	0.0	0.0
Sweeper	Diesel	327	324	0.0	0.0
Sweeper	Propane	46	46	0.0	0.0
Top handler	Diesel	38,023	37,672	1.0	1.8
Tractor	Diesel	1	1	0.0	0.0
Tractor	Propane	209	209	0.0	0.0
Truck	Diesel	766	761	0.0	0.0
Yard tractor	Diesel	47,882	47,629	0.8	0.9
Yard tractor	Gasoline	11,888	11,775	0.3	0.7
Yard tractor	Propane	0	0	0.0	0.0
Total		**115,800**	**114,934**	**2.6**	**4.2**

Operational Profiles

Table 4.5 summarizes CHE data collected from the terminals for the 2014 calendar year. The average values shown in the following tables are population-weighted. For equipment without specific operational information available, default values associated with the specific type of CHE and engines are used.

Table 4.5: 2014 Engine Characteristics for All CHE Operating at the Port

Equipment	Engine Type	Count	Power (hp) Min	Power (hp) Max	Power (hp) Average	Model Year Min	Model Year Max	Model Year Average	Annual Operating Hours Min	Annual Operating Hours Max	Annual Operating Hours Average
Bulldozer	Diesel	3	92	285	192	1995	2012	2004	0	1,500	633
Crane	Diesel	2	177	334	256	1985	1991	1988	131	268	200
Crane	Electric	2	na	na	na	1980	2006	1993	0	0	0
Electric pallet jack	Electric	3	na	na	na	1997	2013	2008	4	142	58
Excavator	Diesel	3	322	371	338	2002	2005	2004	0	58	19
Forklift	Diesel	100	50	200	134	1979	2014	2006	0	2,306	498
Forklift	Electric	9	na	na	na	1995	2013	2003	0	537	207
Forklift	Gasoline	14	na	na	na	2012	2013	2013	74	999	403
Forklift	Propane	108	45	122	87	1981	2014	2002	0	1,500	314
Loader	Diesel	13	50	402	283	1985	2013	2006	169	2,300	1,112
Man Lift	Diesel	6	62	75	68	2008	2014	2011	192	872	366
Material handler	Diesel	4	322	717	460	2001	2008	2006	65	880	341
Material handler	Electric	1	na	na	na	1995	1995	1995	na	na	na
Miscellaneous	Diesel	2	13	13	13	2010	2010	2010	1,183	1,645	1,414
Miscellaneous	Electric	5	na	na	na	1994	2008	2001	na	na	na
Miscellaneous	Propane	1	na	na	na	1998	1998	1998	0	0	0
Rail pusher	Diesel	4	150	300	226	2003	2013	2011	662	1,389	952
RTG crane	Diesel	62	515	1,043	704	1998	2014	2005	0	4,070	2,396
Side handler	Diesel	14	152	240	211	2000	2011	2004	0	2,904	1,066
Skid steer loader	Diesel	2	49	70	60	2007	2008	2008	86	189	138
Sweeper	Diesel	8	39	230	170	2002	2014	2007	105	2,209	543
Sweeper	Electric	1	na	na	na	na	na	na	50	50	50
Sweeper	Propane	5	50	135	91	1982	2013	2001	20	600	192
Top handler	Diesel	167	174	375	295	1979	2014	2007	0	4,148	2,286
Tractor	Diesel	1	59	59	59	2009	2009	2009	80	80	80
Tractor	Propane	9	101	101	101	1986	1997	1995	44	895	621
Truck	Diesel	11	165	525	308	1990	2011	2005	33	1,547	737
Truck	Electric	5	na	na	na	2008	2009	2008	67	268	174
Yard tractor, offroad	Diesel	129	173	245	175	2001	2007	2004	72	3,420	1,721
Yard tractor, onroad	Diesel	417	173	250	208	2004	2014	2009	0	4,717	2,067
Yard tractor, gasoline	Gasoline	85	335	335	335	2011	2011	2011	60	5,558	1,447
Yard tractor, propane	Propane	8	173	173	173	2009	2009	2009	0	0	0
Total		**1,204**									

Table 4.6 is a summary of the CHE engines by fuel type. In 2014, 79% of CHE engines inventoried were diesel-powered, followed by 11% powered by propane and 8% by gasoline-fueled engines.

Table 4.6: 2014 CHE Engines by Fuel Type

Equipment	Electric	Propane	Gasoline	Diesel	Total
Forklift	9	108	14	100	231
RTG crane	0	0	0	62	62
Side handler	0	0	0	14	14
Top handler	0	0	0	167	167
Yard tractor	0	8	85	546	639
Sweeper	1	5	0	7	13
Other	16	10	0	52	78
Total	**26**	**131**	**99**	**948**	**1,204**
Percent of Total	**2%**	**11%**	**8%**	**79%**	

Table 4.7 summarizes the distribution of diesel-powered CHE equipped with off-road diesel engines by EPA non-road engine emission tier level and on-road diesel engines. On-road engines are generally lower in emissions than the off-road engines of the same model year.

Table 4.7: 2014 Count of Diesel-Powered CHE by Type and Engine Standard

Equipment Type	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	On-road	Total
Yard tractor	0	13	116	0	0	417	546
Forklift	6	28	26	30	10	0	100
Top handler	1	38	48	31	49	0	167
Other	6	4	11	11	13	6	51
RTG crane	0	27	20	5	10	0	62
Side handler	0	8	5	1	0	0	14
Sweeper	0	2	3	2	1	0	8
Total	**13**	**120**	**229**	**80**	**83**	**423**	**948**
Percent of Total	**1%**	**13%**	**24%**	**8%**	**9%**	**45%**	**100%**

Table 4.8 is a summary of the emission reduction technologies used on diesel-powered equipment. It should be noted that some equipment utilized more than one emission reduction technology. The majority of the emission reduction technologies were installed either voluntarily or in order to meet requirements of CARB's Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards regulation adopted in 2005[13].

Emission control technologies used on CHE operated at the Port include:

- CARB-verified Level 3 diesel particulate filters (DPF) reduce PM by at least 85%,
- Vycon REGEN®, flywheel system for RTG cranes captures and stores breaking energy generated when a container is lowered. The Vycon REGEN® is CARB-verified as a Level 1 device, reducing PM emissions by at least 25% and NO_x emissions by 30%,
- BlueCAT™ 3-way catalytic converter manufactured by NETT Technologies, Inc. is verified by CARB to reduce CO and NO_x emissions from liquid propane gas and compressed natural gas-fueled large spark ignited engines[14].

Table 4.8: 2014 CHE Emission Reduction Technologies by Equipment Type

Equipment	DOC Installed	On-Road Engines	ULSD Fuel	DPF Installed	Vycon Installed	BlueCAT
Forklift	1	0	100	60	0	0
RTG crane	0	0	62	30	6	0
Side handler	0	0	14	13	0	0
Top handler	1	0	167	97	0	0
Yard tractor	80	417	546	0	0	0
Sweeper	0	0	7	1	0	0
Other	0	6	52	14	0	8
Total	**82**	**423**	**948**	**215**	**6**	**8**

[13] CARB, *http://www.arb.ca.gov/regact/cargo2005/cargo2005.htm;* Final rule posted on October 23, 2006.
[14] CARB, *http://www.arb.ca.gov/msprog/offroad/orspark/documents/eog-09-013.pdf*

SECTION 5 RAILROAD LOCOMOTIVES

Source Description

Railroad locomotives are used to move trains transporting intermodal (containerized) freight and lesser amounts of dry bulk, liquid bulk, and car-load (box car freight) to, from, and around the Port. Railroad locomotive activities at the Port consist of two different types of operations: line haul, the movement of cargo over long distances; and switching, the short movement of rail cars, such as the assembling and disassembling of trains in and around the Port.

Class 1 rail operators Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) provide line haul service to and from the Port and also operate switching services at their off-port locations. Pacific Harbor Line (PHL) performs most of the switching operations within the Port.

Emissions Estimation Methodology

The methodology to estimate 2014 emissions from rail locomotives is generally the same as described in Section 5 of the Port of Long Beach 2013 Air Emissions Inventory, which is available on the Port's website at *www.polb.com/emissions*.

To validate inventory methods, new duty cycle information obtained for several switching locomotives used at the Port by PHL was compared with the default EPA average duty cycle. This comparison is further discussed at end of this section.

Geographical Domain

Generally, emissions from railroad locomotives are estimated for movements of cargo by rail locomotives within Port boundaries, to its first point of rest within the SoCAB boundaries, directly to or from port-owned properties such as terminals and on-port rail yards, or to and from the SoCAB boundary. The first point of rest is defined as the location where cargo is first off-loaded from the transport device after leaving the Port. The inventory does not include rail movements of cargo that occur solely outside the Port, such as off-port rail yard switching, and movements that neither begin or end at a Port property, such as east-bound line hauls that initiate in central Los Angeles intermodal yards. Please refer to Section 1 of this report for a description of the geographical domain of the emissions inventory with regard to locomotive operations.

Data and Information Acquisition

To estimate emissions associated with Port-related activities of locomotives, information was obtained from:

- Previous emissions studies
- Port cargo statistics
- Input from railroad operators
- Published information sources
- CARB MOU line-haul fleet compliance data

Emission Estimates

A summary of estimated emissions from locomotive operations related to the Port is presented in Tables 5.1 and 5.2. Locomotive emissions include operations within the Port and Port-related emissions outside the Port to the boundary of the SoCAB. The regional locomotive activity is associated with cargo movements having either their origin or termination at the Port. Movements of east-bound cargo loaded onto trains at one of the off-port rail yards are not included.

Table 5.1: 2014 Locomotive Estimated Emissions, tons

	PM_{10}	**$PM_{2.5}$**	**DPM**	**NO_x**	**SO_x**	**CO**	**HC**
On-Port Emissions							
Switching	0.2	0.2	0.2	21.3	0.03	8.7	1.1
Line Haul	7.3	6.6	7.3	198.6	0.2	44.5	11.1
On-Port Subtotal	7.5	6.8	7.5	219.9	0.23	53.2	12.2
Off-Port (Regional) Emissions							
Switching	0.1	0.1	0.1	6.9	0	3.1	0.1
Line Haul	18.4	16.6	18.4	499.7	0.4	112	28
Off-Port Subtotal	18.5	16.7	18.5	506.6	0.4	115.1	28.1
Total	**26.0**	**23.5**	**26.0**	**726.5**	**0.7**	**168.3**	**40.3**

Table 5.2: 2014 Locomotive GHG Estimated Emissions, metric tons

	CO_2e	CO_2	N_2O	CH_4
On-Port Emissions				
Switching	2,983	2,948	0.1	0.2
Line Haul	15,736	15,584	0.4	1.3
On-Port Subtotal	18,719	18,532	0.5	1.5
Off-Port (Regional) Emissions				
Switching	1,080	1,077	0.0	0.1
Line Haul	39,596	39,218	1.0	3.2
Off-Port Subtotal	40,676	40,295	1.0	3.3
Total	**59,395**	**58,827**	**1.5**	**4.8**

Operational Profiles

The goods movement rail system in terms of the activities that are carried out by locomotive operators is the same as described in detail in Section 5 of the Port's 2013 EI report available on the Port's website at *www.polb.com/emissions*.

Table 5.3 presents the CARB MOU compliance information submitted by BNSF and UP on pre-Tier 0 through Tier 3 locomotive fleet composition, showing a weighted average NO_x emission factor of 5.71 g/hp-hr.[15] The 2013 reports were used instead of the 2014 because of the timing of the inventory data collection phase and of the posting of the compliance reports by CARB. In the table, ULEL stands for ultra-low emission locomotive.

Table 5.3: CARB MOU Compliance Data, MWhrs and g NO_x/hp-hr

Tier	Number of Locomotives	Megawatt-Hours (MWhrs)	%MWhrs by Tier Level	Wt'd Avg NO_x (g/bhp-hr)	Tier Contribution to Fleet Average (g/bhp-hr)
BNSF					
Pre-Tier 0	156	1,261	0.6%	11.2	0.06
Tier 0	363	10,332	5%	7.8	0.37
Tier 1	967	41,453	19%	7.4	1.41
Tier 2	1,118	133,351	61%	4.7	2.88
Tier 3	407	31,101	14%	4.6	0.66
ULEL	0	0	0%	-	-
Total BNSF	**3,011**	**217,498**	**100%**		**5.4**
UP					
Pre-Tier 0	44	394	0.2%	12.7	0.03
Tier 0	2,352	54,575	29%	7.7	2.22
Tier 1	1,533	26,022	14%	6.8	0.94
Tier 2	1,535	77,486	41%	5.1	2.09
Tier 3	426	20,792	11%	4.6	0.51
ULEL	71	9,918	5%	2.5	0.13
Total UP	**5,961**	**189,187**	**100%**		**5.9**
			ULEL Credit Used		0
			UP Fleet Average		**5.9**
Both RRs, excluding ULELs and ULEL credits					
Pre-Tier 0	200	1,655	0%	11.6	0.05
Tier 0	2,715	64,907	16%	7.7	1.26
Tier 1	2,500	67,475	17%	7.2	1.22
Tier 2	2,653	210,837	53%	4.8	2.58
Tier 3	833	51,893	13%	4.6	0.60
Total both	**8,901**	**396,767**	**100%**		**5.71**

[15] Notes from railroads' MOU compliance submissions:
1. For more information on the U.S. EPA locomotive emission standards please visit. *http://www.epa.gov/oms/locomotives.htm.*
2. Number of locomotives is the sum of all individual locomotives that visited or operated within the SCAB at any time during 2013.

Emission factors for particulate matter (PM_{10}, $PM_{2.5}$, and DPM), HC, and CO were calculated using the tier-specific emission rates for those pollutants published by EPA[16] to develop weighted average emission factors using the MW-hr figures provided in the railroads' submissions. These results are presented in Table 5.4.

Table 5.4: Fleet MWhrs and PM, HC, CO Emission Factors, g/hp-hr

Engine Tier	MWhr	% of MWhr	EPA Tier-specific PM_{10} (g/hp-hr)	EPA Tier-specific HC (g/hp-hr)	EPA Tier-specific CO (g/hp-hr)	Fleet Composite PM_{10} (g/hp-hr)	Fleet Composite HC (g/hp-hr)	Fleet Composite CO (g/hp-hr)
Pre-Tier 0	1,655	0%	0.32	0.48	1.28	0.00	0.00	0.01
Tier 0	64,907	16%	0.32	0.48	1.28	0.05	0.08	0.21
Tier 1	67,475	17%	0.32	0.47	1.28	0.05	0.08	0.22
Tier 2	210,837	53%	0.18	0.26	1.28	0.10	0.14	0.68
Tier 3	51,893	13%	0.08	0.13	1.28	0.01	0.02	0.17
Totals	**396,767**	**100%**				**0.21**	**0.32**	**1.28**

Table 5.5 and 5.6 summarizes the emission factors for line haul locomotives, presented in units of g/hp-hr. The greenhouse gas emission factors are unchanged from the 2013 EI.

Table 5.5: 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	0.21	0.19	0.21	5.71	0.005	1.28	0.32

Table 5.6: GHG Emission Factors for Line Haul Locomotives, g/hp-hr

	CO_2	N_2O	CH_4
EF, g/bhp-hr	494	0.013	0.040

[16] EPA Office of Transportation and Air Quality, "Emission Factors for Locomotives" EPA-420-F-09-025 April 2009.

On-Port Line Haul Activity
As described in previous emissions inventories, estimates of the number of trains per year, locomotives per train, and on-port hours per train are multiplied together to calculate total locomotive hours per year. This activity information for 2014 is summarized in Table 5.7.

Table 5.7: 2014 Estimated On-Port Line Haul Locomotive Activity

Activity Measure	Inbound	Outbound	Total
Trains per Year	2,774	2,646	5,420
Locomotives per Train	3	3	N/A
Hours on Port per Trip	1	2.5	N/A
Locomotive Hours per Year	8,322	19,845	28,167

Out-of-Port Line Haul Activity
For out-of-port line haul estimates, the following table has updated values for the 2014 EI. Table 5.8 lists the estimated total of out-of-port horsepower-hours, calculated by multiplying the fuel use by the fuel consumption conversion factor of 20.8 hp-hr/gal.

Table 5.8: 2014 Gross Ton-Mile, Fuel Use, and Horsepower-hour Estimate

	Trains per year	MMGT per year	Distance miles	MMGT-miles per year
Alameda Corridor	5,028	37	21	777
Central LA to Air Basin Boundary	5,028	37	84	3,108
Million gross ton-miles				**3,885**
Estimated million gallons of fuel				**3.85**
Estimated million hp-hr				**80.1**

Updates to the Emissions Estimation Methodology

Although there were no changes to the overall emission estimation methodology, potential improvements were studied. To validate inventory methods, duty cycle information obtained for several switching locomotives used at the Port by PHL was compared with the default EPA average duty cycle. The comparison is depicted graphically in Figures 5.1 and 5.2, which illustrate the average percent of time in each throttle notch setting of the switching locomotives operating on the Port and of the locomotives tested by EPA. Figure 5.1 includes locomotive idling time, and shows that PHL's switchers have a similar pattern but idle somewhat more than the EPA average and have lower percentages of operating time in the throttle notch settings that are used when the locomotive is moving railcars. One reason for higher idling time might be the need to wait for passage of line haul locomotives, which have right-of-way priority on the tracks, in the busy port setting. Power demand is at its lowest level during idling, resulting in the lowest emission levels at these times.

Figure 5.1: Distribution of Time in Throttle Notch Setting including Idle, %

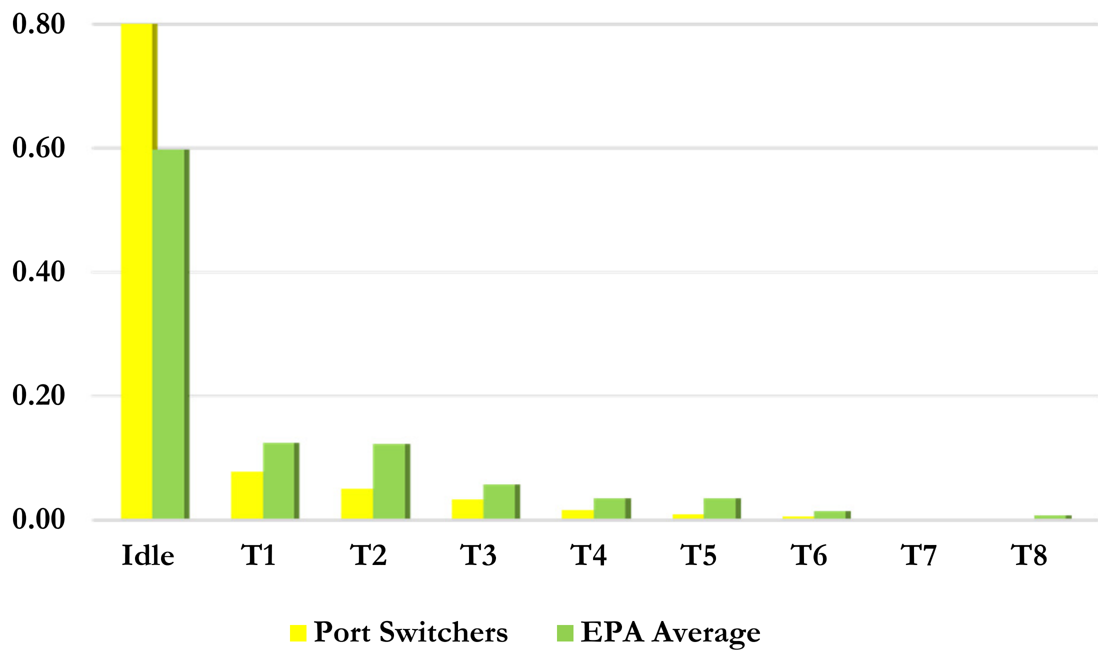
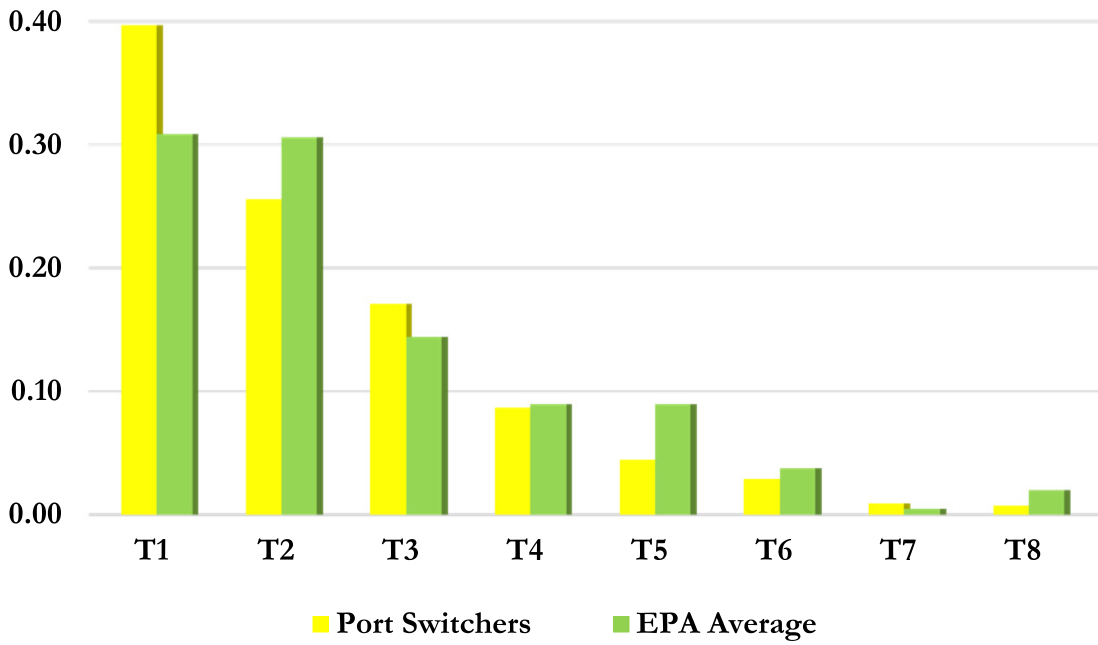


Figure 5.2 excludes idling time from the evaluation, showing that, while still similar in frequency distribution, the PHL switchers tend to spend comparatively more time in the first (lowest) notch setting than the EPA average and less time in notch position 2, as well as less time in most of the higher notch settings. Reasons for the lower operating percentages at higher notch settings may include speed being limited in the busy port setting, and the relatively flat terrain of the port area, requiring lower applications of power to make the required moves. Given the general similarity between the PHL duty cycle and the EPA average and the lack of readily available notch-specific emission factors for the types of locomotives employed by PHL, no changes to the emission factors have been made.

Figure 5.2: Distribution of Time in Throttle Notch Settings 1 through 9, %



SECTION 6 HEAVY-DUTY VEHICLES

Source Description

Heavy-duty vehicles, or trucks, are used to move cargo, particularly containerized cargo, to and from the marine terminals. Trucks also transfer containers between terminals and off-port railcar loading facilities, an activity known as drayage. 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.

The majority of trucks that service the Port's terminals are diesel-fueled vehicles. Alternative fuel trucks, primarily those fueled by liquefied natural gas (LNG), made approximately 8.2% of the terminal calls in 2014, according to the Port's Clean Trucks Program (CTP) activity records and the Port Drayage Truck Registry (PDTR). Vehicles using fuel other than diesel fuel do not emit diesel particulate matter, so the diesel particulate emission estimates presented in this inventory have been adjusted to take the alternative-fueled trucks into account.

Emissions Estimation Methodology

The methodology to estimate 2014 emissions from heavy-duty vehicles (HDV) is generally the same as described in Section 6.0 of the Port of Long Beach 2013 Air Emissions Inventory, which is available on the Port's website at *www.polb.com/emissions.*

HDV emission estimates are based on estimates of vehicle miles traveled (VMT) and CARB's on-road vehicle emissions model "EMFAC" to develop emission rates based on HDV model year information specific to the San Pedro Bay ports. The most recent version of the model, EMFAC2014, contains several updates based on CARB's current understanding of motor vehicle travel activities and their associated emission levels. Methodology changes resulting from the use of this updated version of the model are discussed in detail at the end of this section.

Geographical Domain

The two major geographical components of truck activities evaluated for this inventory are:

- **On-terminal operations**, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.
- **On-road operations**, consisting of travel on public roads within the SoCAB. This also includes travel on public roads within the Port boundaries and those of the adjacent POLA. The geographical domain for trucks is discussed in more detail in section 1.2.3

Data and Information Acquisition

For on-terminal truck activity, information is collected during in-person and/or telephone interviews with terminal personnel. For on-road operations, trip generation and travel demand models have been developed to estimate the volumes (number of trucks) and average speeds on roadway segments between defined intersections.

The model year distribution of HDV operating at the Port is developed using call data gathered from radio frequency identification (RFID) information gathered at the Port terminals and truck/engine model year data from the Port Drayage Truck Registry (PTDR).

Emission Estimates

Tables 6.1 and 6.2 summarize the vehicle miles traveled and emissions associated with overall HDV activity.

Table 6.1: 2014 HDV Emissions, tons

Activity Location	Vehicle Miles Traveled	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	2,272,636	0.2	0.2	0.2	110.6	0.1	17.2	5.2
On-Road	142,107,055	5.6	5.3	5.1	1,165.5	2.8	63.0	16.5
Total	**144,379,691**	**5.8**	**5.5**	**5.3**	**1,276.1**	**2.9**	**80.2**	**21.8**

Table 6.2: 2014 HDV GHG Emissions, metric tons

Activity Location	Vehicle Miles Traveled	CO_2e	CO_2	N_2O	CH_4
On-Terminal	2,272,636	15,541	15,417	0.4	0.3
On-Road	142,107,055	239,950	237,249	9.0	1.2
Total	**144,379,691**	**255,492**	**252,665**	**9.4**	**1.5**

Tables 6.3 and 6.4 show the vehicle miles traveled (VMT) and emissions associated with container terminal activity.

Table 6.3: 2014 HDV Emissions Associated with Container Terminals, tons

Activity Location	Vehicle Miles Traveled	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	2,234,859	0.2	0.2	0.2	109	0.1	17	5
On-Road	134,698,631	5.3	5.0	4.8	1,105	2.6	60	16
Total	**136,933,490**	**5.5**	**5.2**	**5.0**	**1,213.6**	**2.7**	**76.6**	**21**

Table 6.4: 2014 HDV GHG Emissions Associated with Container Terminals, metric tons

Activity Location	Vehicle Miles Traveled	CO_2e	CO_2	N_2O	CH_4
On-Terminal	2,234,859	15,307	15,184	0.4	0.3
On-Road	134,698,631	227,441	224,880	8.5	1.1
Total	**136,933,490**	**242,748**	**240,064**	**8.9**	**1.5**

Tables 6.5 and 6.6 summarize VMT and emissions associated with other Port terminals.

Table 6.5: 2014 HDV Emissions Associated with Other Port Terminals, tons

Activity Location	Vehicle Miles Traveled	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	37,776	0.003	0.003	0.003	1.6	0.00	0.27	0.08
On-Road	7,408,425	0.29	0.28	0.27	61	0.14	3.28	0.86
Total	**7,446,201**	**0.29**	**0.28**	**0.27**	**63**	**0.1**	**3.56**	**0.94**

Table 6.6: 2014 HDV GHG Emissions Associated with Other Port Terminals, metric tons

Activity Location	Vehicle Miles Traveled	CO_2e	CO_2	N_2O	CH_4
On-Terminal	37,776	235	233	0.0	0.0
On-Road	7,408,425	12,509	12,368	0.5	0.1
Total	**7,446,201**	**12,744**	**12,602**	**0.5**	**0.1**

Operational Profiles

To estimate the 2014 emissions from HDVs, operational profiles were developed for on-terminal truck activity using data and information collected from terminal operators. The on-road truck activity profiles were developed using trip generation and travel demand models to estimate the number of on-road VMT.

The model year distribution of HDVs was determined using RFID information collected at Port terminals to track the number of truck calls, and truck model year information from the PDTR. The distribution of the truck fleet's model years by calls is presented in Figure 6.1. The call weighted average age of the trucks in 2014 was approximately 5 years, older than the 4-year average in 2013 because there was very little turnover in the almost-new fleet.

Figure 6.1: 2014 Model Year Distribution of the Heavy-Duty Truck Fleet

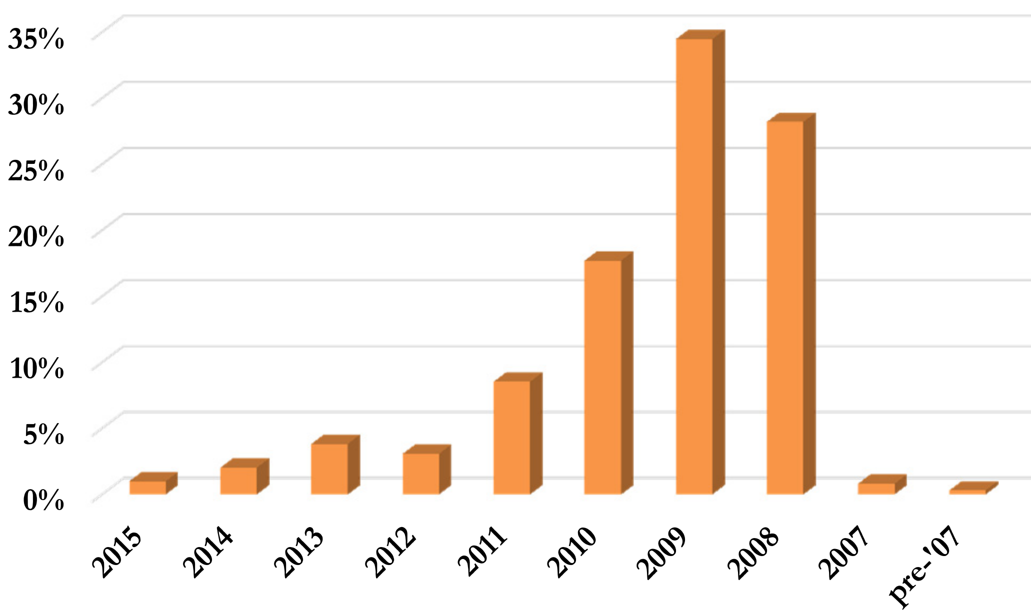


Table 6.7 shows the range and average of reported operating characteristics of on-terminal truck activities at Port container terminals, while Table 6.8 shows the same summary data for non-container terminals and facilities.

Table 6.7: 2014 Summary of Reported Container Terminal Operating Characteristics

	Speed (mph)	Distance (miles)	Gate In (hours)	Unload/Load (hours)	Gate Out (hours)
Maximum	15	1.5	0.08	0.50	0.08
Minimum	5	0.5	0.03	0.29	0.00
Average	7	0.8	0.06	0.39	0.03

Table 6.8: 2014 Summary of Reported Non-Container Facility Operating Characteristics

	Speed (mph)	Distance (miles)	Gate In (hours)	Unload/Load (hours)	Gate Out (hours)
Maximum	10	0.5	0.08	0.50	0.08
Minimum	5	0.0	0.00	0.00	0.00
Average	6	0.2	0.01	0.09	0.01

The total numbers of truck calls in 2014 were 3,005,347 associated with container terminals and 167,885 associated with non-container facilities. The total number of truck calls associated with container terminals is based on the trip generation model on which truck travel estimates are based, while non-container terminal truck calls were obtained from the terminal operators.

Table 6.9 provides the on-terminal operating parameters; listing total estimated VMT and hours of idling on-terminal and waiting at entry gates. The idling times are likely to be somewhat over-estimated because the idling estimates are based on the entire time that trucks are on terminal (except for driving time), which does not account for times that trucks are turned off while on terminal. No data source has been identified that would provide a reliable estimate of the average percentage of time the trucks' engines are turned off while on terminal.

Table 6.9: 2014 Estimated On-Terminal VMT and Idling Hours by Terminal

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	756,691	351,105
Container	405,138	300,102
Container	372,242	106,709
Container	293,023	281,302
Container	223,706	272,921
Container	184,061	154,611
Auto	5,656	9,721
Break Bulk	3,853	3,236
Break Bulk	2,996	959
Break Bulk	1,500	0
Break Bulk	776	155
Break Bulk	31	0
Dry Bulk	13,025	686
Dry Bulk	40	440
Liquid Bulk	5,550	4,440
Liquid Bulk	3,000	360
Liquid Bulk	1,350	0
Total	**2,272,636**	**1,486,746**

Table 6.10 summarizes the speed-specific emission factors used to estimate emissions.

Table 6.10: 2014 Speed-Specific Composite Exhaust Emission Factor

Speed Range (mph)	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4	Units
0 (Idle)	0.0113	0.0108	0.0104	39.444	0.0484	3.3618	1.2028	5,167	0.1662	0.0707	g/hr
5	0.0781	0.0747	0.0719	19.414	0.0176	5.028	1.3979	3,548	0.0631	0.1108	g/mi
10	0.07	0.067	0.0644	16.58	0.0176	4.0706	1.1279	3,163	0.0631	0.0894	g/mi
15	0.0595	0.0569	0.0547	12.989	0.0176	2.8562	0.7829	2,674	0.0631	0.0621	g/mi
20	0.0524	0.0501	0.0482	10.627	0.0176	2.0595	0.5589	2,350	0.0631	0.0443	g/mi
25	0.0475	0.0455	0.0437	9.42	0.0176	1.5144	0.4099	2,140	0.0631	0.0325	g/mi
30	0.0438	0.0419	0.0403	8.7245	0.0176	1.1234	0.3033	1,994	0.0631	0.024	g/mi
35	0.0408	0.039	0.0375	8.204	0.0176	0.8352	0.2246	1,879	0.0631	0.0178	g/mi
40	0.0384	0.0367	0.0353	7.7953	0.0176	0.6231	0.1665	1,787	0.0631	0.0132	g/mi
45	0.0364	0.0348	0.0335	7.4614	0.0176	0.4672	0.1236	1,710	0.0631	0.0098	g/mi
50	0.0348	0.0333	0.032	7.1837	0.0176	0.353	0.0921	1,644	0.0631	0.0073	g/mi
55	0.0336	0.0321	0.0309	6.952	0.0176	0.2697	0.069	1,588	0.0631	0.0055	g/mi
60	0.0331	0.0316	0.0304	6.8518	0.0176	0.2371	0.0599	1,562	0.0631	0.0047	g/mi
65	0.0331	0.0316	0.0304	6.8811	0.0176	0.2371	0.0599	1,562	0.0631	0.0047	g/mi
70	0.0331	0.0316	0.0304	6.893	0.0176	0.2371	0.0599	1,562	0.0631	0.0047	g/mi

Updates to the Emissions Estimation Methodology

The 2014 HDV emissions estimates reflect recent updates to CARB's on-road emissions factor model EMFAC2014, which replaces EMFAC2011, as a result of CARB's "current understanding of motor vehicle travel activities and their associated emission levels."[17]

CARB updates to EMFAC2014 include the effect of cold start-ups (after 30 minutes or more of non-operation) from model-year 2010 and newer trucks equipped with selective catalytic convertors (SCR). Under cold-start and warm-start conditions, HDVs equipped with SCR emit higher-than-normal amounts of NO_x until the catalyst in the convertor reaches optimum operating temperature. However, not all 2010+ trucks are equipped with SCR. Many 2010+ model year trucks have an exhaust gas recirculation (EGR) system which does not experience start-up emissions. Because the prevalence of EGR-equipped trucks decreases with each new model year, CARB has developed average emission factors for each model year of truck starting with 2010 which have been used to estimate start emissions for the HDVs in this EI. The start emissions contribute a very small amount of NO_x, approximately 1.8% of overall HDV NO_x emissions in the 2014 EI.

Another update in EMFAC2014 includes the use of truck body model year as the basis of analysis as opposed to engine model year, which had been used for previous EIs as a means of accounting for trucks that were equipped with engines one or more model years older than their body model year. CARB has accounted for the differences between body model year and engine model year such that body model year is the appropriate characteristic to match against CARB's model year-specific emission factors. The 2014 and previous-year estimates presented in this EI are based on body model year distributions.

[17] See: *http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-v1_0_7-release-notice.pdf*

SECTION 7 SUMMARY OF 2014 EMISSION RESULTS

The emission results for the Port of Long Beach 2014 Air Emissions Inventory are presented in this section. Table 7.1 summarizes the 2014 goods movement-related emissions associated with the Port in the South Coast Air Basin by category in tons per year.

Table 7.1: 2014 Emissions by Source Category, tons

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	92	87	73	4,461	211	380	168
Harbor craft	30	27	30	786	1	404	70
Cargo handling equipment	10	9	9	558	1	663	39
Locomotives	26	24	26	726	1	168	40
Heavy-duty vehicles	6	6	5	1,276	3	80	22
Total	**164**	**153**	**143**	**7,807**	**216**	**1,695**	**339**

Table 7.2 summarizes the 2014 total GHG emissions including the CO_2e in metric tons per year.

Table 7.2: 2014 GHG Emissions by Source Category, metric tons

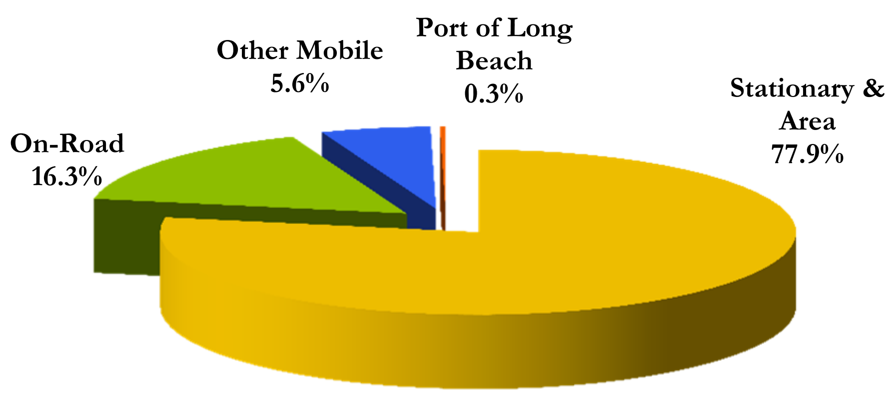
Category	CO_2e	CO_2	N_2O	CH_4
Ocean-going vessels	293,640	288,276	18	3
Harbor craft	50,387	49,694	2	1
Cargo handling equipment	115,800	114,934	3	4
Locomotives	59,395	58,827	2	5
Heavy-duty vehicles	255,492	252,665	9	2
Total	**774,714**	**764,396**	**34**	**15**

Table 7.3: 2014 Emissions Percent Contributions by Source Category

Source Category	DPM tons	DPM %	NO_x tons	NO_x %	SO_x tons	SO_x %	CO_2e metric tons	CO_2e %
Ocean-going vessels	73	51%	4,461	59%	211	97.4%	293,640	38%
Harbor craft	30	21%	786	10%	0.6	0.3%	50,387	7%
Cargo handling equipment	9	6%	558	8%	1.4	0.6%	115,800	15%
Rail locomotives	26	18%	726	9%	0.7	0.3%	59,395	8%
Heavy-duty vehicles	5	3%	1,276	14%	2.9	1.3%	255,492	33%
Total	**143**	**100%**	**7,807**	**100%**	**216**	**100%**	**774,714**	**100%**

The following figures and tables compare the Port's contribution of emissions to the total overall emissions in the SoCAB by major source category. The 2014 SoCAB emissions used for this comparison are based on the 2012 AQMP[18]. It should be noted that SoCAB PM_{10} and $PM_{2.5}$ emissions for on-road vehicles include brake and tire wear emissions whereas the Port's HDV emissions do not include brake and tire wear. Due to rounding, the percentages may not add up to 100%.

Figure 7.1: 2014 PM_{10} Emissions in the South Coast Air Basin, %



[18] SCAQMD, *Final 2012 Air Quality Management Plan Appendix III, Base & Future Year Emissions Inventories*, February 2013.

Figure 7.2: 2014 $PM_{2.5}$ Emissions in the South Coast Air Basin, %

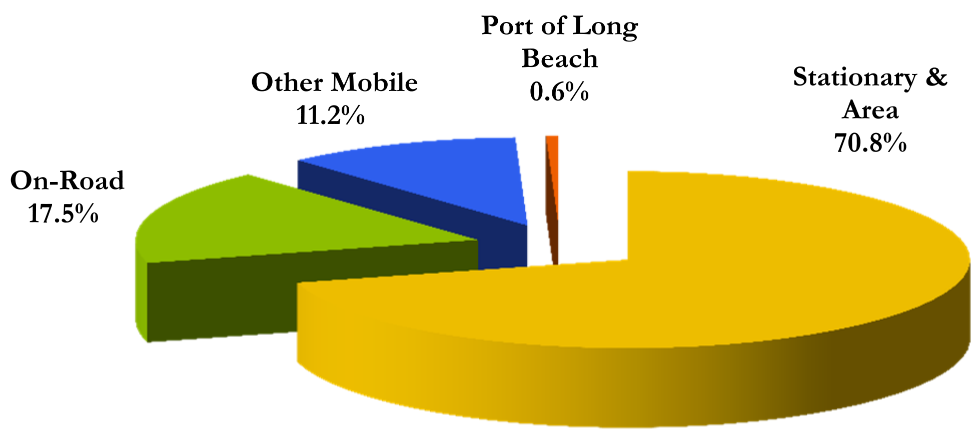


Figure 7.3: 2014 DPM Emissions in the South Coast Air Basin, %

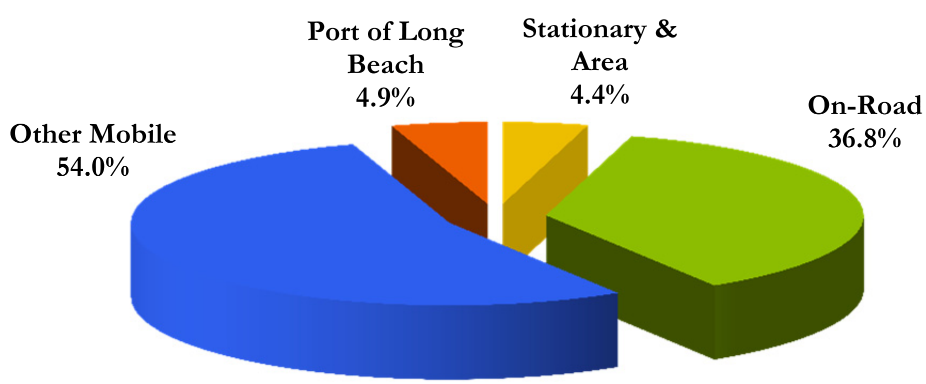


Figure 7.4: 2014 NO_x Emissions in the South Coast Air Basin, %

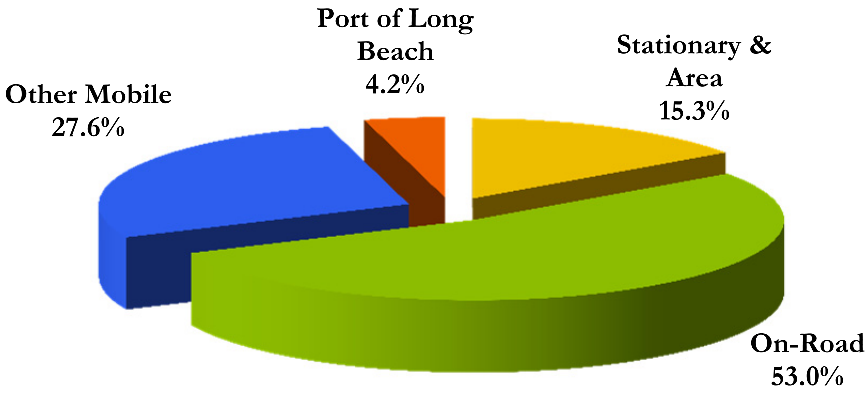


Figure 7.5: 2014 SO_x Emissions in the South Coast Air Basin, %

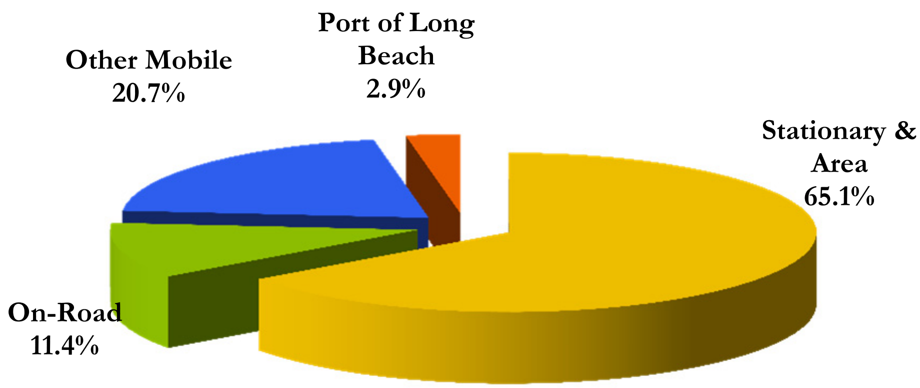


Table 7.4: 2014 PM_{10} Emissions Percentage Comparison, tons

Category	Subcategory	PM_{10}	Percent PM_{10} Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	3	3%	2%	0.00%
OGV	Bulk vessel	4	5%	3%	0.01%
OGV	Containership	40	43%	24%	0.07%
OGV	Cruise	13	14%	8%	0.02%
OGV	General cargo	1	1%	1%	0.00%
OGV	Miscellaneous	2	2%	1%	0.00%
OGV	Reefer	0	0%	0%	0.00%
OGV	RoRo	0	0%	0%	0.00%
OGV	Tanker	29	32%	18%	0.05%
OGV	**Subtotal**	**92**	**100%**	**56%**	**0.16%**
Harbor Craft	Assist tug	9	29%	5%	0.02%
Harbor Craft	Harbor tug	0	1%	0%	0.00%
Harbor Craft	Ferry	5	17%	3%	0.01%
Harbor Craft	Ocean tugboat	11	36%	7%	0.02%
Harbor Craft	Government	2	6%	1%	0.00%
Harbor Craft	Excursion	1	2%	0%	0.00%
Harbor Craft	Crewboat	2	7%	1%	0.00%
Harbor Craft	Work boat	0	1%	0%	0.00%
Harbor Craft	**Subtotal**	**30**	**100%**	**18%**	**0.05%**
CHE	RTG crane	2	17%	1%	0.00%
CHE	Forklift	0	4%	0%	0.00%
CHE	Top handler, side pick	1	14%	1%	0.00%
CHE	Other	0	4%	0%	0.00%
CHE	Yard tractor	6	59%	4%	0.01%
CHE	**Subtotal**	**10**	**100%**	**6%**	**0.02%**
Locomotives	Switching	0	1%	0%	0.00%
Locomotives	Line haul	26	99%	16%	0.05%
Locomotives	**Subtotal**	**26**	**100%**	**16%**	**0.05%**
HDV	On-Terminal	0.2	3%	0%	0.00%
HDV	On-road	5.6	93%	3%	0.01%
HDV	**Subtotal**	**6**	**100%**	**4%**	**0.01%**
Port	**Total**	**164**		**100%**	**0.3%**
SoCAB AQMP	**Total**	**56,695**			

Table 7.5: 2014 $PM_{2.5}$ Emissions Percentage Comparison, tons and %

			Percent $PM_{2.5}$ Emissions of Total		
Category	**Subcategory**	**$PM_{2.5}$**	**Category**	**Port**	**SoCAB AQMP**
OGV	Auto carrier	2	3%	2%	0.01%
OGV	Bulk vessel	4	5%	3%	0.02%
OGV	Containership	37	43%	24%	0.15%
OGV	Cruise	12	14%	8%	0.05%
OGV	General cargo	1	1%	1%	0.00%
OGV	Miscellaneous	2	2%	1%	0.01%
OGV	Reefer	0	0%	0%	0.00%
OGV	RoRo	0	0%	0%	0.00%
OGV	Tanker	27	31%	18%	0.11%
OGV	**Subtotal**	**87**	**100%**	**57%**	**0.34%**
Harbor Craft	Assist tug	8	30%	5%	0.03%
Harbor Craft	Harbor tug	0	1%	0%	0.00%
Harbor Craft	Ferry	5	17%	3%	0.02%
Harbor Craft	Ocean tugboat	10	37%	6%	0.04%
Harbor Craft	Government	2	6%	1%	0.01%
Harbor Craft	Excursion	0	1%	0%	0.00%
Harbor Craft	Crewboat	2	7%	1%	0.01%
Harbor Craft	Work boat	0	1%	0%	0.00%
Harbor Craft	**Subtotal**	**27**	**100%**	**18%**	**0.11%**
CHE	RTG crane	2	17%	1%	0.01%
CHE	Forklift	0	4%	0%	0.00%
CHE	Top handler, side pick	1	15%	1%	0.01%
CHE	Other	0	5%	0%	0.00%
CHE	Yard tractor	5	59%	3%	0.02%
CHE	**Subtotal**	**9**	**100%**	**6%**	**0.04%**
Locomotives	Switching	0.3	1%	0%	0.00%
Locomotives	Line haul	23.2	97%	15%	0.09%
Locomotives	**Subtotal**	**24**	**100%**	**16%**	**0.09%**
HDV	On-Terminal	0.2	3%	0%	0.00%
HDV	On-road	5.3	89%	3%	0.02%
HDV	**Subtotal**	**6**	**100%**	**4%**	**0.02%**
Port	**Total**	**153**		**100%**	**0.6%**
SoCAB AQMP	**Total**	**25,506**			

Table 7.6: 2014 DPM Emissions Percentage Comparison, tons and %

Category	Subcategory	DPM	Percent DPM Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	2	3%	2%	0.1%
OGV	Bulk vessel	4	5%	3%	0.1%
OGV	Containership	33	45%	23%	1.1%
OGV	Cruise	13	17%	9%	0.4%
OGV	General cargo	1	2%	1%	0.0%
OGV	Miscellaneous	2	2%	1%	0.1%
OGV	Reefer	0	0%	0%	0.0%
OGV	RoRo	0	0%	0%	0.0%
OGV	Tanker	18	25%	13%	0.6%
OGV	**Subtotal**	**73**	**100%**	**51%**	**2.5%**
Harbor Craft	Assist tug	9	29%	6%	0.3%
Harbor Craft	Harbor tug	0	1%	0%	0.0%
Harbor Craft	Ferry	5	17%	4%	0.2%
Harbor Craft	Ocean tugboat	11	36%	8%	0.4%
Harbor Craft	Government	2	6%	1%	0.1%
Harbor Craft	Excursion	1	2%	0%	0.0%
Harbor Craft	Crewboat	2	7%	2%	0.1%
Harbor Craft	Work boat	0	1%	0%	0.0%
Harbor Craft	**Subtotal**	**30**	**100%**	**21%**	**1.0%**
CHE	RTG crane	2	19%	1%	0.1%
CHE	Forklift	0	4%	0%	0.0%
CHE	Top handler, side pick	1	16%	1%	0.0%
CHE	Other	0	5%	0%	0.0%
CHE	Yard tractor	5	53%	3%	0.2%
CHE	**Subtotal**	**9**	**100%**	**6%**	**0.3%**
Locomotives	Switching	0	1%	0%	0.0%
Locomotives	Line haul	26	99%	18%	0.9%
Locomotives	**Subtotal**	**26**	**100%**	**18%**	**0.9%**
HDV	On-Terminal	0.2	4%	0%	0.0%
HDV	On-road	5.1	102%	4%	0.2%
HDV	**Subtotal**	**5**	**100%**	**3%**	**0.2%**
Port	**Total**	**143**		**100%**	**4.9%**
SoCAB AQMP	**Total**	**2,916**			

Table 7.7: 2014 NO_x Emissions Percentage Comparison, tons and %

Category	Subcategory	NO_x	Percent NO_x Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	144	3%	2%	0.1%
OGV	Bulk vessel	242	5%	3%	0.1%
OGV	Containership	2,130	48%	27%	1.2%
OGV	Cruise	682	15%	9%	0.4%
OGV	General cargo	63	1%	1%	0.0%
OGV	Miscellaneous	90	2%	1%	0.0%
OGV	Reefer	1	0%	0%	0.0%
OGV	RoRo	0	0%	0%	0.0%
OGV	Tanker	1,108	25%	14%	0.6%
OGV	**Subtotal**	**4,461**	**100%**	**57%**	**2.4%**
Harbor Craft	Assist tug	234	30%	3%	0.1%
Harbor Craft	Harbor tug	13	2%	0%	0.0%
Harbor Craft	Ferry	144	18%	2%	0.1%
Harbor Craft	Ocean tugboat	272	35%	3%	0.1%
Harbor Craft	Government	33	4%	0%	0.0%
Harbor Craft	Excursion	14	2%	0%	0.0%
Harbor Craft	Crewboat	64	8%	1%	0.0%
Harbor Craft	Work boat	11	1%	0%	0.0%
Harbor Craft	**Subtotal**	**786**	**100%**	**10%**	**0.4%**
CHE	RTG crane	114	20%	1%	0.1%
CHE	Forklift	16	3%	0%	0.0%
CHE	Top handler, side pick	248	44%	3%	0.1%
CHE	Other	18	3%	0%	0.0%
CHE	Yard tractor	163	29%	2%	0.1%
CHE	**Subtotal**	**558**	**100%**	**7%**	**0.3%**
Locomotives	Switching	28	4%	0%	0.0%
Locomotives	Line haul	698	96%	9%	0.4%
Locomotives	**Subtotal**	**726**	**100%**	**9%**	**0.4%**
HDV	On-Terminal	111	9%	1%	0.1%
HDV	On-road	1,165	91%	15%	0.6%
HDV	**Subtotal**	**1,276**	**100%**	**16%**	**0.7%**
Port	**Total**	**7,807**		**100%**	**4.2%**
SoCAB AQMP	**Total**	**184,770**			

Table 7.8: 2014 SO_x Emissions by Category Percentage Comparison, tons and %

Category	Subcategory	SO_x	Percent SO_x Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	5	2%	2%	0%
OGV	Bulk vessel	10	5%	4%	0%
OGV	Containership	84	40%	39%	1%
OGV	Cruise	25	12%	11%	0%
OGV	General cargo	3	1%	1%	0%
OGV	Miscellaneous	4	2%	2%	0%
OGV	Reefer	0	0%	0%	0%
OGV	RoRo	0	0%	0%	0%
OGV	Tanker	81	38%	37%	1%
OGV	**Subtotal**	**211**	**100%**	**97.4%**	**3%**
Harbor Craft	Assist tug	0.17	28%	0%	0%
Harbor Craft	Harbor tug	0.01	2%	0%	0%
Harbor Craft	Ferry	0.13	22%	0%	0%
Harbor Craft	Ocean tugboat	0.15	25%	0%	0%
Harbor Craft	Government	0.02	3%	0%	0%
Harbor Craft	Excursion	0.01	2%	0%	0%
Harbor Craft	Crewboat	0.06	10%	0%	0%
Harbor Craft	Work boat	0.01	2%	0%	0%
Harbor Craft	**Subtotal**	**1**	**100%**	**0%**	**0%**
CHE	RTG crane	0.1	9%	0%	0%
CHE	Forklift	0.0	1%	0%	0%
CHE	Top handler, side pick	0.5	33%	0%	0%
CHE	Other	0.0	3%	0%	0%
CHE	Yard tractor	0.7	53%	0%	0%
CHE	**Subtotal**	**1**	**100%**	**1%**	**0%**
Locomotives	Switching	0.0	5%	0%	0%
Locomotives	Line haul	0.6	95%	0%	0%
Locomotives	**Subtotal**	**1**	**100%**	**0%**	**0%**
HDV	On-Terminal	0.1	4%	0%	0%
HDV	On-road	2.8	95%	1%	0%
HDV	**Subtotal**	**3**	**100%**	**1%**	**0%**
Port	**Total**	**216**		**100%**	**3.2%**
SoCAB AQMP	**Total**	**6,716**			

Table 7.9: 2014 CO_2e Emissions by Category Percentage Comparison, metric tons and %

Category	Subcategory	CO_2e Emissions	Percent Emissions of Total Category	Percent Emissions of Total Port
OGV	Auto carrier	6,673	2%	1%
OGV	Bulk vessel	13,397	5%	2%
OGV	Containership	116,727	40%	15%
OGV	Cruise	34,301	12%	4%
OGV	General cargo	3,545	1%	0%
OGV	Miscellaneous	5,883	2%	1%
OGV	Reefer	53	0%	0%
OGV	RoRo	22	0%	0%
OGV	Tanker	113,039	38%	15%
OGV	**Subtotal**	**293,640**	**100%**	**38%**
Harbor Craft	Assist tug	15,521	31%	2%
Harbor Craft	Harbor tug	1,097	2%	0%
Harbor Craft	Ferry	11,424	23%	1%
Harbor Craft	Ocean tugboat	13,196	26%	2%
Harbor Craft	Government	1,561	3%	0%
Harbor Craft	Excursion	1,241	2%	0%
Harbor Craft	Crewboat	5,305	11%	1%
Harbor Craft	Work boat	1,038	2%	0%
Harbor Craft	**Subtotal**	**50,387**	**100%**	**7%**
CHE	RTG crane	11,687	10%	2%
CHE	Forklift	1,881	2%	0%
CHE	Top handler, side p	39,127	34%	5%
CHE	Other	3,336	3%	0%
CHE	Yard tractor	59,769	52%	8%
CHE	**Subtotal**	**115,800**	**100%**	**15%**
Locomotives	Switching	4,063	7%	1%
Locomotives	Line haul	55,332	93%	7%
Locomotives	**Subtotal**	**59,395**	**100%**	**8%**
HDV	On-Terminal	15,541	6%	2%
HDV	On-road	239,950	94%	31%
HDV	**Subtotal**	**255,492**	**100%**	**33%**
Port	**Total**	**774,714**		**100%**

SECTION 8 COMPARISON OF 2014 AND 2005 FINDINGS AND EMISSION ESTIMATES

This section compares the emissions estimates for 2014 and 2005 calendar year activity. Each source category is highlighted in a separate subsection that compares findings for that source category and presents the emissions comparisons. When there was a methodological change in 2014 for a source category, the 2005 emissions were recalculated using 2005 activity data with the new 2014 methodology to provide a valid basis for comparison. Due to rounding, the values may not add up to the whole number values for the percentage change or total emissions at the bottom of each table.

Additionally, although the Port does not typically report year-over-year comparisons, this section identifies key factors that affected emissions in 2014 compared to 2013. These factors include:

- Temporary period of terminal congestion in the latter part of 2014, which resulted in ships spending more time at anchorage as well as increased activity levels for cargo-handling equipment[19];
- Increased cruise activity;
- Reduced turnover in the heavy-duty vehicle fleet coupled with continued deterioration of the existing engines.

These factors are described in more detail under each source category subsection.

Table 8.1 compares the number of vessel calls and container cargo throughput as well as the average TEUs per containership call between 2005 and 2014. There was a 2% increase in TEU throughput when comparing 2014 and 2005. However, the number of overall vessel calls and containership calls at the Port decreased compared to 2005. The average numbers of TEUs per containership calls increased in 2014 by 58%, which shows improved efficiency due to larger containerships visiting in 2014 compared to 2005, resulting in more TEUs being handled per vessel call.

Table 8.1: 2005-2014 Container Throughput and Vessel Call Comparison

Year	Container Throughput TEUs	All Arrivals	Containership Arrivals	Average TEUs/Call
2005	6,709,818	2,690	1,332	5,037
2014	6,820,804	1,965	858	7,950
Change (%)	**2%**	**-27%**	**-36%**	**58%**

[19] Although not reflected in this 2014 inventory, the prolonged congestion continued into the first half of 2015.

Table 8.2 presents the total net change in emissions for all source categories in 2014 as compared to 2005. Goods movement-related emissions associated with the Port of Long Beach decreased for all pollutants in 2014 when compared to 2005 due to implementation of emission reduction strategies, and improvement in the terminals' operational efficiency.

Table 8.2: 2005-2014 Emissions Comparison, tons and %

EI Year	Container Throughput TEUs	Cargo Metric Tons	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e MT
2005	6,709,818	78,560,726	1,060	898	945	15,667	6,993	2,931	755	985,603
2014	6,820,804	82,293,724	164	153	143	7,807	216	1,695	339	774,714
Change	**1,110,986**	**3,732,995**	**-896**	**-745**	**-802**	**-7,860**	**-6,777**	**-1,236**	**-416**	**-210,889**
Change	**-2%**	**5%**	**-85%**	**-83%**	**-85%**	**-50%**	**-97%**	**-42%**	**-55%**	**-21%**

The following summarizes the comparison of 2005 and 2014 emissions by source category.

Ocean-Going Vessels
Emissions from OGV were reduced across all pollutants. These reductions are primarily attributed to the Port's vessel speed reduction program, the CARB low sulfur marine fuel regulation and implementation of shore power. The first year of enforcement by CARB requiring at least 50% of the calls for container, cruise and reefer to use shore power was 2014. Also in 2014, the phase 2 for fuel switch to 0.1% S requirement per CARB's Fuel Regulation was in place.

Harbor Craft
Harbor craft emissions decreased for PM, NO_x and SO_x emissions newer engines in 2014 as compared to 2005 and lower S content of the fuel used. The increase in CO emissions is related to the impact from the introduction of cleaner engines that do not have lower CO standards. The hydrocarbon emissions stayed the same between 2014 and 2005. The CO_2 emissions increased due to increased activity 2014 as compared to 2005.

Cargo Handling Equipment
Cargo handling equipment emissions decreased for all pollutants, except for CO. The decrease in emissions from cargo handling equipment can be attributed to the continued replacement and retrofit of existing equipment with cleaner engines as a result of the implementation of CAAP measures and the CARB CHE regulation. The increase in CO emissions from cargo handling equipment is attributed to the addition of several gasoline-fuel yard tractors that have higher CO emission rates compared to conventional diesel yard tractors and due to the continued decrease in DOC retrofits that had a reduction in CO emissions.

Locomotives
Emissions from rail locomotives decreased in 2014 as compared to 2005. The decreases in locomotive emissions were due in part to PHL's and UP's fleet turnover to the latest ultra-low emissions switching locomotives, to rail system efficiency improvements, use of cleaner fuels, and the turnover to cleaner locomotives, which occurred in part as a result of the implementation of the CARB/railroad MOU in 2010.

Heavy-Duty Vehicles

Truck emissions decreased significantly in 2014 compared with 2005 because of increasingly stringent on-road engine emission standards and the implementation of the Port's Clean Trucks Program that resulted in a newer fleet of trucks. Other factors include lower overall reported idling times, and decreased total vehicle miles travelled due to the increase in utilization of on-dock rail and changes in regional travel patterns.

Tables 8.3 and 8.4 compare emissions change by source category from 2005 to 2014.

Table 8.3: 2005-2014 Port Emissions Comparison by Source Category, tons and %

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2005							
Ocean-going vessels	720	577	605	6,726	6,865	537	236
Harbor craft	45	41	45	1,107	5	294	70
Cargo handling equipment	47	44	47	1,289	11	398	65
Locomotives	43	40	43	1,273	76	179	66
Heavy-duty vehicles	205	196	205	5,273	37	1,523	318
Total	**1,060**	**898**	**945**	**15,667**	**6,993**	**2,931**	**755**
2014							
Ocean-going vessels	92	87	73	4,461	211	380	168
Harbor craft	30	27	30	786	1	404	70
Cargo handling equipment	10	9	9	558	1	663	39
Locomotives	26	24	26	726	1	168	40
Heavy-duty vehicles	6	6	5	1,276	3	80	22
Total	**164**	**153**	**143**	**7,807**	**216**	**1,695**	**339**
% Change							
Ocean-going vessels	-87%	-85%	-88%	-34%	-97%	-29%	-29%
Harbor craft	-33%	-35%	-33%	-29%	-87%	37%	1%
Cargo handling equipment	-79%	-79%	-81%	-57%	-88%	66%	-40%
Locomotives	-39%	-40%	-39%	-43%	-99%	-6%	-40%
Heavy-duty vehicles	-97%	-97%	-98%	-76%	-92%	-95%	-93%
Total	**-85%**	**-83%**	**-85%**	**-50%**	**-97%**	**-42%**	**-55%**

Table 8.4 compares GHG emissions change by source category.

Table 8.4: 2005-2014 Port GHG Emissions Comparison by Source Category, metric tons and %

	CO_2e	CO_2	N_2O	CH_4
2005				
Ocean-going vessels	389,510	382,729	22	4
Harbor craft	44,746	44,131	2	1
Cargo handling equipment	103,710	102,803	3	3
Locomotives	60,579	59,979	2	5
Heavy-duty vehicles	387,056	382,263	14	22
Total	**985,603**	**971,905**	**43**	**36**
2014				
Ocean-going vessels	293,640	288,276	18	3
Harbor craft	50,387	49,694	2	1
Cargo handling equipment	115,800	114,934	3	4
Locomotives	59,395	58,827	2	5
Heavy-duty vehicles	255,492	252,665	9	2
Total	**774,714**	**764,396**	**34**	**15**
% Change				
Ocean-going vessels	-25%	-25%	-20%	-30%
Harbor craft	13%	13%	1%	-6%
Cargo handling equipment	12%	12%	8%	21%
Locomotives	-2%	-2%	25%	1%
Heavy-duty vehicles	-34%	-34%	-37%	-91%
Total	**-21%**	**-21%**	**-21%**	**-58%**

Ocean-Going Vessels

As discussed in section 2, the 2014 results reflect changes to the OGV emissions calculations methodology mainly related to slide valves in MAN propulsion engines; these methodological changes were also applied to the 2005 baseline year for consistent comparison. In addition, the auxiliary boiler at-berth loads for conventional tankers were updated with the 2014 Vessel Boarding Program data.

Table 8.5 compares overall OGV engines as well by engine type activity (in terms of kW-hrs) used for the 2005 and 2014 emission estimates.

Table 8.5: 2005-2014 OGV Engine Activity Comparison, kW-hrs

Year	All Engines	Main Eng	Aux Eng	Boiler
2005	507,488,985	153,369,455	229,580,036	124,539,494
2014	387,382,515	81,988,796	181,138,113	124,255,606
Change (%)	**-24%**	**-47%**	**-21%**	**-0.2%**

The various emission reduction strategies for ocean-going vessels that were in effect in 2014 are listed in Table 8.6 and summarized below:

- The percent of calls with IMO Tier I+ vessels (constructed in 2000 and newer) was 78% in 2014 as compared to 36% in 2005.
- The percent of vessel calls that switched to a cleaner fuel (0.1% S) for boilers, main and auxiliary engines at berth and within the CARB regulated boundary was 100% for the entire calendar year 2014 due to the CARB Fuel Regulation.
- In 2014, approximately 98% of the vessel calls complied with the VSR program (within 20 nm) as compared to 68% in 2005. For the 40 nm, 89% compliance rate in 2014 as compared to 0% in 2005.
- Approximately 26% of vessel calls used shore power in 2014 as compared with none in 2005.

Table 8.6: 2005-2014 OGV Emission Reduction Strategies

	Percent (%) of All Calls						
Year	Slide Valve	IMO Tier I+	Fuel Switch Aux Eng	Fuel Switch Main Eng	VSR 20 nm	VSR 40 nm	Shore Power
2005	14%	36%	14%	0%	68%	0%	0%
2014	41%	78%	100%	100%	98%	89%	26%

Although comparison with the previous year is normally not included in the emissions inventory reports, changes in OGV emissions between 2013 and 2014 are discussed below and shown in Table 8.7. Most notably, from 2013 to 2014, there was a 5% increase in OGV NO_x emissions.

Table 8.7: 2013-2014 OGV Emissions Comparison, tons and %

Year	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e MT
Change 2014-2013	-31.9	-26.0	-25.9	215.4	-413.4	-80.5	-49.9	25,300
% Change 2014-2013	-26%	-23%	-26%	5%	-66%	-17%	-23%	9%

The OGV emissions are dominated by containerships, tankers, and then cruise ships. The total calls, as well as the calls for containerships, tankers, and cruise ships are provided in Table 8.8. Note that total calls increased by 2%, containership and tanker calls are slightly down (while TEUs grew by 1%), and cruise ship calls increased by 89%.

Table 8.8: Containership, Tanker and Cruise Ship Arrival Calls Comparison

	Year	Arrivals	Change
Total Calls	2014	1,965	2%
	2013	1,921	
Container Calls	2014	858	-6%
	2013	911	
Tanker Calls	2014	431	-2%
	2013	439	
Cruise Calls	2014	234	90%
	2013	123	

Key drivers for the NO_x emissions increase between 2013 and 2014 are:

1. Increases in containership emissions are driven solely by the increase in anchorage emissions.
   a. Containership anchorage NO_x emissions increased by approximately 2,700% (~110 tons NO_x) from 2013 to 2014. This was due to the temporary period of increased congestion during the latter half of 2014. It should be noted that containership at-berth and transit emissions remained flat.

1. Slight rise in tanker calls translated into a slight reduction in overall emissions from vessel category.
    a. Total tanker NO_x emissions reduced by 5% (~38 tons NO_x) from 2013 to 2014, primarily driven by lower anchorage hotelling emissions.
2. Significant increases in cruise activity drove NO_x emissions increases between 2013 and 2014.
    a. Cruise ship at-berth NO_x emissions increased by 40% (~30 tons NO_x) from 2013 to 2014. The potential impacts from the increased cruise ship activity were significantly reduced by the use of shore power.
    b. Cruise ship transit NO_x emissions increased by 105% (~260 tons NO_x) from 2013 to 2014.
    c. Total cruise ship NO_x emissions increased by 90% (~320 tons NO_x) from 2013 to 2014.

Harbor Craft

As shown in Table 8.9, the harbor craft population count operating at the Port decreased by 12%. In addition, there was a 1% decrease in total engine count (most harbor craft are equipped with more than one engine), and a 13% increase in the overall activity (as measured by kilowatt hours) from 2005 to 2014.

Table 8.9: 2005-2014 Harbor Craft Engine and Activity Comparison, hours, kW-hr, and %

Year	Vessel Count	Engine Count	Total kW-hr	Total Hours
2005	92	301	67,684,712	285,586
2014	81	298	76,217,159	299,160
Change (%)	**-12%**	**-1%**	**13%**	**5%**

Table 8.10 compares the changes in propulsion and auxiliary engine average horsepower and usage hours in 2014 compared to 2005. Some of the changes in horsepower and hours may be attributed to improvement in data collection and better record keeping required with grant funded engine replacement projects. The engine power (HP) and hours (hrs) change impacts the activity (kilowatt hours) comparison.

Table 8.10: 2005-2014 Engine Power and Activity Change, %

Harbor Craft Type	Propulsion Engines HP	Propulsion Engines Hrs	Auxiliary Engines HP	Auxiliary Engines Hrs
Assist tugboat	-7%	4%	39%	25%
Crew boat	46%	49%	39%	105%
Excursion	-41%	-23%	-29%	-47%
Ferry	-3%	5%	37%	-3%
Government	43%	-72%	-64%	-5%
Ocean tugboat	8%	186%	3%	158%
Harbor tugboat	-31%	-53%	-38%	-65%
Work boat	39%	890%	214%	2843%

Table 8.11 summarizes the distribution of engines based on EPA's engine standards for 2005 and 2014. Since 2005, the percentage of Tier 2 engines increased significantly due to the introduction of newer vessels with newer engines into the fleet and replacements of existing higher-emitting engines with cleaner engines. In coming years, there will be an increase of Tier 3 engines as these are becoming more widely available and will be the Tier of choice when repowering a vessel. Over the years, with better data collection techniques and better record keeping required with grant funded repowers, the number of engines of unknown tier level has decreased significantly.

Table 8.11: 2005-2014 Harbor Craft Engine Tier Change, %

Engine Tier	2005 Engine Count	2014 Engine Count	Change
Unknown	102	12	-88%
Tier 0	86	43	-50%
Tier 1	94	29	-69%
Tier 2	19	166	774%
Tier 3	0	48	na
Total	**301**	**298**	

Cargo Handling Equipment

Between 2005 and 2014, there was a 4% decrease in the equipment count and a 10% increase in activity, measured as total kilowatt-hours.

Table 8.12: 2005-2014 CHE Count and Engine Activity Comparison

Year	Population	Activity (kW-hr)
2005	1,259	134,511,925
2014	1,204	147,412,729
Change (%)	**-4%**	**10%**

Tables 8.13 and 8.14 compare the CHE emission reduction technologies and fuels used in 2014 with those used in 2005. There was a significant increase in the number of CHE equipped with cleaner on-road engines in 2014. CHE equipped with DOCs continued to be replaced with newer equipment, thus the DOC count is less than it was in 2005. All of the DPFs installed are Tier 3 level.

Although not shown in the table, there are 85 gasoline yard tractors in 2014. The gasoline yard tractors replaced existing diesel yard tractors.

Table 8.13: 2005-2014 CHE Emission Reduction Technology Equipment Count Comparison

Equipment	2005 DOC	2014 DOC	2005 On-road Engine	2014 On-road Engine	2005 DPF	2014 DPF	2005 Vycon	2014 Vycon	2005 BlueCAT	2014 BlueCAT
Forklift	40	1	0	0	0	60	0	0	0	0
RTG crane	11	0	0	0	0	30	0	6	0	0
Side handler	42	0	0	0	0	13	0	0	0	0
Top handler	92	1	0	0	0	97	0	0	0	0
Yard tractor	514	80	53	417	0	0	0	0	0	0
Other	2	0	0	6	0	15	0	0	0	6
Total	**701**	**82**	**53**	**423**	**0**	**215**	**0**	**6**	**0**	**6**

Table 8.14: 2005-2014 CHE Equipment Count by Fuel Type Comparison

Equipment	2005 Emulsified Fuel	2014 Emulsified Fuel	2005 O2 Diesel	2014 O2 Diesel	2005 ULSD	2014 ULSD	2005 Propane Engine	2014 Propane Engine
Forklift	3	0	4	0	0	100	122	108
RTG crane	16	0	12	0	0	62	0	0
Side handler	4	0	8	0	0	14	0	0
Top handler	10	0	10	0	0	167	0	0
Yard tractor	151	0	81	0	0	546	0	8
Other	2	0	0	0	0	59	11	15
Total	**186**	**0**	**115**	**0**	**0**	**948**	**133**	**131**

The following tables and figures for CHE activities are included as additional comparisons between 2005 and 2014. Table 8.15 shows a comparison of CHE counts by equipment type. In total, there was a 4% decrease in equipment count from 2005 to 2014. Forklifts, RTG cranes, and side handler equipment counts went down from 2005 due to equipment retirement, and terminal efficiency improvements.

Table 8.15: 2005-2014 CHE Equipment Count and Change, %

Equipment	2005	2014	Change
Forklift	295	231	-22%
RTG crane	85	62	-27%
Side handler	43	14	-67%
Top handler	113	167	48%
Yard tractor	641	639	0%
Sweeper	15	14	-7%
Other	67	77	15%
Total	**1,259**	**1,204**	**-4%**

Table 8.16 shows the comparison of CHE activity by equipment type. Except for RTG cranes and top handlers, the average annual hours of activity were lower than in 2014 than 2005.

Table 8.16: 2005-2014 CHE Activity by Equipment Type, hours and %

Equipment	2005	2014	Change
Forklift	710	356	-50%
RTG crane	1,964	2,396	22%
Side handler	1,148	1,066	-7%
Top handler	1,999	2,286	14%
Yard tractor	2,186	1,309	-40%
Sweeper	502	262	-48%

Table 8.17 shows a comparison of the average model year and average age for CHE by equipment type. The average age of forklifts and RTG cranes is lower than in 2005. The average age of side handlers, top handlers, and yard tractors are higher in 2014 than 2005 even though the average model year of the equipment is newer.

Table 8.17: 2005-2014 CHE Average Model Year and Age Comparison, year

Equipment	MY 2005	MY 2014	Age 2005	Age 2014
Forklift	1993	2006	12	7
RTG crane	1995	2005	10	8
Side handler	1999	2004	6	9
Top handler	2001	2007	4	6
Yard tractor	2001	2008	4	5
Sweeper	1996	2004	9	9

Locomotives

Table 8.18 shows the various throughput comparisons for rail transportation in 2005 and 2014. From 2005 to 2014, there was hardly any change in total port throughput but a 40% increase in on-dock rail throughput, with the percentage of on-dock rail increasing from 16% of all container throughput to 22%.

Table 8.18: 2005-2014 Container Throughput Comparison, TEU and %

	2005	2014	Change
Total Port Throughput	6,709,818	6,820,804	2%
Total On-Dock Rail*	1,094,765	1,533,647	40%
% On-Dock	16%	22%	

*Based on average of 1.8 TEUs per container

Heavy-Duty Vehicles

The major methodological change for the emission calculations in this inventory was a change in CARB's emission factor model. EMFAC2014, which replaced the previously used EMFAC2011, "represents ARB's current understanding of motor vehicle travel activities and their associated emission levels."[20] Because the new model version contains numerous changes based on ARB's latest information, calendar year 2005 emissions have been re-estimated using the EMFAC2014 emission factors for comparison with 2014.

Along with the release of EMFAC2014, ARB published information on short-term emissions from model-year 2010 and newer trucks equipped with catalytic convertors when they start up from cold or after not running for more than approximately 30 minutes. When started under these cold-start and warm-start conditions, HDVs equipped with a catalytic convertor emit higher-than-normal amounts of NO_x until the catalyst in the convertor reaches optimum operating temperature. ARB's average emission factors for each model year of truck starting with 2010 have been used to estimate start emissions for the HDVs in this EI. The start emissions contribute a very small amount of NO_x, approximately 1.6% of overall HDV NO_x emissions in the 2014 EI. A further change resulting from the use of EMFAC2014 is the return to body model year as the basis of analysis as opposed to engine model year, which had been used for the past few EIs as a means of accounting for trucks that were equipped with engines one or more model years older than their body model year. The 2014 and 2005 estimates presented in this EI are based on body model year distributions.

Emissions from the HDV source category continue to be far lower than in 2005 due largely to the following factors affecting the overall age of the truck fleet and average idling times compared with 2005.

- Newer fleet of trucks due to the Port's Clean Trucks Program (CTP).
- The terminals optimized their gate systems and use radio frequency identification (RFID) readers to identify and help check in trucks complying with the CTP ban provisions, which helped reduce idling time.

[20] See *http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-v1_0_7-release-notice.pdf*

The average on-terminal total idling time report by the container terminals has continued to improve. Table 8.19 shows the decrease in total port-wide idling time. Table 8.20 compares the vehicle miles traveled by heavy-duty trucks in 2005 and 2014.

Table 8.19: 2005-2014 HDV Total Idling Time Comparison, hours and %

EI Year	Total Idling Hours
2005	3,854,273
2014	1,486,746
Change (%)	**-61%**

Table 8.20: 2005-2014 HDV Vehicle Miles Traveled Comparison, miles and %

Activity Location	2005 VMT	2014 VMT	Change %
On-Terminal	2,866,476	2,272,636	-21%
On-Road	213,716,895	142,107,055	-34%
	216,583,371	**144,379,691**	**-33%**

Compared to 2005, the average age of trucks visiting the Port has decreased from 11 to 5 years due to the Port's Clean Trucks Program launched in October 2008 requiring the progressive ban of pre-2007 trucks between 2008 and 2014.

Although comparison with the previous year is normally not included in the emissions inventory reports, changes in HDV emissions between 2013 and 2014 are discussed below. Most notably, from 2013 to 2014, emissions of most pollutants increased between 4% and 15%, reversing the downward trends seen in previous years. The units of grams per mile are used because they show the changes independent of changes in throughput or vehicle mileage, which can complicate the comparisons. The gram-per-mile figures have been calculated by dividing overall HDV emissions by overall miles traveled, and include idling emissions as well as emissions from driving at various speeds, on-terminal and on-road.

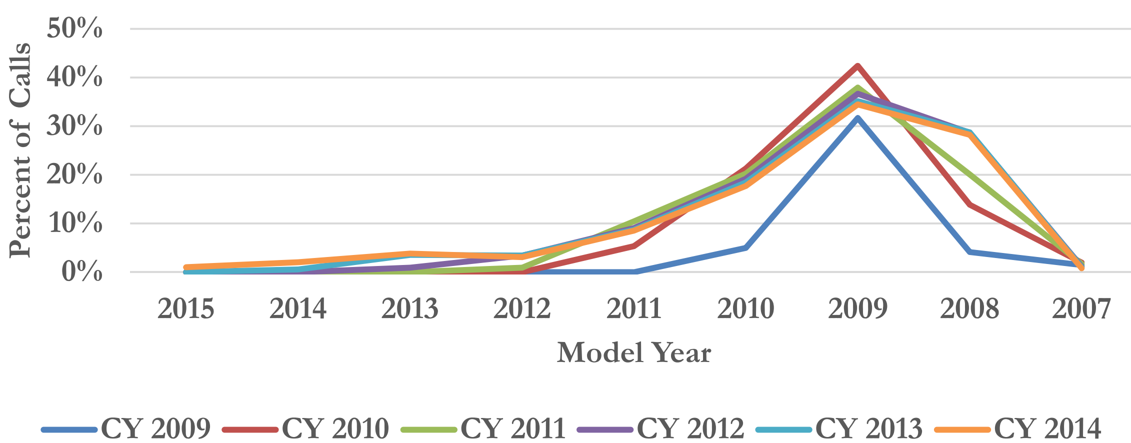
Table 8.21: Fleet Average Emissions, g/mile

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2005	0.857	0.820	0.857	22.08	0.153	6.38	1.33	1,621
2013	0.032	0.031	0.029	7.72	0.018	0.46	0.13	1,610
2014	0.036	0.035	0.033	8.02	0.018	0.50	0.14	1,605
% Change (2005-2014)	**-96%**	**-96%**	**-96%**	**-64%**	**-88%**	**-92%**	**-90%**	**-1%**
% Change (2013-2014)	**14%**	**14%**	**15%**	**4%**	**-1%**	**10%**	**9%**	**0%**

The increases between 2013 and 2014 occurred primarily because the fleet was, in general, a year older in 2014 than in 2013. With a large cohort of fairly new trucks brought into the fleet in response to the CTP, especially 2009 model year trucks, turnover has been low and new trucks brought into the fleet are subject to similar emission standards as the existing trucks. The EMFAC2014 model used to estimate gram-per-mile emission factors increases each model year's emissions in successive calendar years to account for the "deterioration" of emissions performance as a vehicle accumulates miles. This results in increasing emissions per mile of travel for the fleet as a whole. Increases in modeled emissions will continue to occur until fleet turnover reduces the 2009 model year peak shown below and evens out the model year distribution with a higher proportion of newer trucks.

Figure 8.1 illustrates the HDV model year distribution for calendar years 2009 through 2014, showing the peak of 2009 model year trucks that largely persists in each calendar year.

Figure 8.1: Model Year Distribution



To further illustrate the effect of deterioration on modeled emission factors, Table 8.22 lists the EMFAC2014 emission factors for NO_x and PM_{10} (other pollutants similar) for model year 2009 trucks in calendar years 2012, 2013, and 2014 at the 40 mph speed point. The NO_x emission factor increased by 7% and the PM_{10} emission factor increased by 13% between calendar year 2013 and calendar year 2014, the two most recent inventory years. These increases are typical of the year-to-year increases attributed to deterioration by the EMFAC2014 model, and show how the emissions from a fleet that is fairly static in model year composition will increase year to year.

Table 8.22: EMFAC2014 Emission Factors Illustrating Effect of Deterioration

						Emission factors g/mile	
Region	**Cal Yr**	**Veh Class**	**Mdl Yr**	**Speed**	**Fuel**	**NO_x**	**PM_{10}**
South Coast	2014	T7 POLA	2009	40	DSL	9.3479	0.0398
South Coast	2013	T7 POLA	2009	40	DSL	8.7109	0.0354
South Coast	2012	T7 POLA	2009	40	DSL	8.1379	0.0313
Change 2013-2014						**7%**	**13%**

SECTION 9 METRICS

To measure the effectiveness of emissions reduction strategies and progress towards the San Pedro Bay Emission Reduction Standards, the Port has established metrics to track emissions per unit of work by source category. Since port operations are varied with a mix of container and non-container cargo, the metrics listed in this section are based on TEU throughput and metric tons of cargo moved through the Port. Table 9.1 compares the amount of throughput in 2014 and 2005 in TEU and metric tons.

Table 9.1: 2005-2014 Container and Cargo Throughput and Change, %

Year	Throughput Container (TEU)	Cargo (metric tons)
2005	6,709,818	78,560,726
2014	6,820,804	82,293,724
Change (%)	**2%**	**5%**

Tables 9.2 and 9.3 show the port-wide tons of emissions per 10,000 TEU and per 100,000 metric tons of cargo in 2005 and 2014, respectively. The tons of emissions per 10,000 TEU of cargo decreased in 2014; an improvement from 2005.

Table 9.2: 2005-2014 Emission Efficiency Metric Comparison, annual tons per 10,000 TEU and %

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2005	1.58	1.34	1.41	23.35	10.42	4.37	1.13	1,619
2014	0.24	0.22	0.21	11.45	0.32	2.49	0.50	1,252
Change (%)	**-85%**	**-83%**	**-85%**	**-51%**	**-97%**	**-43%**	**-56%**	**-23%**

Table 9.3: 2005-2014 Emission Efficiency Metric Comparison, annual tons per 100,000 metric tons of cargo and %

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2005	1.35	1.14	1.20	19.94	8.90	3.73	0.96	1,383
2014	0.20	0.19	0.17	9.49	0.26	2.06	0.41	1,038
Change (%)	**-85%**	**-83%**	**-86%**	**-52%**	**-97%**	**-45%**	**-57%**	**-25%**

SECTION 10 CAAP PROGRESS

The Port's annual emissions inventories serve as the primary tool to track progress towards achieving the Clean Air Action Plan's San Pedro Bay Standards. These standards consist of the following emission reduction goals:

- Mass Emissions Reduction Standards:
  - By 2014, reduce emissions by 72% for DPM, 22% for NO_x, and 93% for SO_x from 2005 levels
  - By 2023, reduce emissions by 77% for DPM, 59% for NO_x, and 93% for SO_x from 2005 levels

The reduction of goods movement-related emissions in 2014 compared to 2005 can be attributed to a number of initiatives, including emissions reduction programs identified in the CAAP and implemented by the Port, such as the Clean Trucks Program, Green Flag Vessel Speed Reduction Program, and use of shore power for vessels at berth. CARB's OGV fuel switch program was also a significant factor for emission reductions.

Economic forecasts indicate that cargo volumes through the Port of Long Beach will increase in upcoming years. However, implementation of the CAAP and regulatory programs will continue to provide emissions benefits from goods movement-related sources and may offset impacts from the projected growth in trade.

The mass emissions reduction standards are represented as a percentage reduction of emissions from 2005 levels. Table 10.1 summarizes the standardized estimates of emissions by source category for calendar years 2005 and 2014 using the 2014 methodology.

Table 10.1: 2005-2014 Emissions Reductions Compared to CAAP San Pedro Bay Emissions Reduction Standards

Category	2005		2014
DPM (tons)			
Ocean-going vessels	605		73
Harbor craft	45		30
Cargo handling equipment	47		9
Locomotives	43		26
Heavy-duty vehicles	205		5
Total	**945**		**143**
Cumulative DPM Emissions Reduction Achieved in 2014			**85%**
CAAP San Pedro Bay DPM Emissions Reduction Standards		**2014**	**72%**
		2023	**77%**
NO_x (tons)			
Ocean-going vessels	6,726		4,461
Harbor craft	1,107		786
Cargo handling equipment	1,289		558
Locomotives	1,273		726
Heavy-duty vehicles	5,273		1,276
Total	**15,667**		**7,807**
Cumulative NOx Emissions Reduction Achieved in 2014			**50%**
CAAP San Pedro Bay NO_x Emissions Reduction Standards		**2014**	**22%**
		2023	**59%**
SO_x (tons)			
Ocean-going vessels	6,865		211
Harbor craft	5		0.6
Cargo handling equipment	11		1.4
Locomotives	76		0.7
Heavy-duty vehicles	37		2.9
Total	**6,993**		**216**
Cumulative SOx Emissions Reduction Achieved in 2014			**97%**
CAAP San Pedro Bay SO_x Emissions Reduction Standards		**2014**	**93%**
		2023	**93%**

APPENDIX A: REGULATORY AND SAN PEDRO BAY PORTS CLEAN AIR ACTION PLAN (CAAP) MEASURES

This appendix summarizes the regulatory initiatives and Port measures related to port activity. Almost all goods movement-related emissions in and around the port come from five emission source categories: OGVs, HDVs, CHE, harbor craft, and locomotives. 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 Los Angeles and Long Beach adopted the landmark CAAP in November 2006 to curb goods movement-related air pollution and subsequently approved an update to the CAAP (2010 CAAP Update).

San Pedro Bay Emissions Reduction Standards

The 2010 CAAP Update established the San Pedro Bay Standards, the most significant addition to the original CAAP, and a statement of the ports' commitments to significantly reduce the air quality impacts from local maritime industry operations. Achievement of the standards listed below will require diligent implementation of all of the current CAAP measures, additional aggressive actions to find further emissions and health risk reductions, and identification of new strategies that will emerge over time.

Health Risk Reduction Standard
To complement the CARB's Air Pollution Reduction Programs including the Diesel Risk Reduction Plan, the Ports of Long Beach and Los Angeles have developed the following standard for reducing overall goods movement-related health risk impacts, relative to 2005 emissions level:

- By 2020, reduce the population-weighted cancer risk attributed to port-related DPM pollution by 85% in highly-impacted communities located proximate to port sources and throughout the residential areas in the port region.

Emission Reduction Standard
Consistent with the ports' commitment to meet their fair-share of mass emission reductions of air pollutants, the Ports of Long Beach and Los Angeles have developed the following standards for reducing air pollutant emissions from goods movement-related activities, relative to 2005 emission levels:

- By 2014, reduce emissions of NO_x by 22%, of SO_x by 93%, and of DPM by 72% to support attainment of the national fine particulate matter ($PM_{2.5}$) standards.

- By 2023, reduce emissions of NO_x by 59%, of SO_x by 93%, and of DPM by 77% to support attainment of the national and federal 8-hour ozone standards and national fine particulate matter ($PM_{2.5}$) standards.

Regulatory Programs by Source Category

The following tables summarize current regulatory programs and CAAP measures by major source category that help reduce emissions from goods movement-related operations at the Port.

Table A.1: OGV Emission Regulations, Standards and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Implementation Year	Impact
IMO	**NOx Emission Standard for Marine Engines** *www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-%28NOx%29-%E2%80%93-Regulation-13.aspx*	NO_x	2011 – Tier 2 2016 – Tier 3	Sets NOx emission standard for auxiliary and propulsion engines over 130 kW output power on newly built vessels
IMO	**Low Sulfur Fuel Requirements for Marine Engines** *www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-%28SOx%29-%E2%80%93-Regulation-14.aspx*	DPM PM SO_x	2012 ECA– 1% 2015 ECA– 0.1%	Significantly reduces emissions due to low sulfur content in fuel by creating Emissions Control Area (ECA)
IMO	**Energy Efficiency Design Index (EEDI) for International Shipping** *www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Technical-and-Operational-Measures.aspx*	CO_2 and other pollutants	2013	Promotes use of more energy efficient (less polluting) equipment and engines
EPA	**Emission Standards for Marine Diesel Engines above 30 Liters per Cylinder (Category 3 Engines); Aligns with IMO Annex VI marine engine NO_x standards and low sulfur requirement** *www.epa.gov/otaq/oceanvessels.htm#engine-fuel*	DPM PM NO_x SO_x	2011 – Tier 2 2016 – Tier 3	Auxiliary and propulsion on US-Flagged new built vessels; Use of low sulfur fuel

Table A.1 (continued): OGV Emission Regulations, Standards and Policies

Agency	Regulation, Standard, or Policy	Targeted Pollutants	Implementation Year	Impact
CARB	**Regulation to Reduce Emissions from Diesel Auxiliary Engines on Ocean-Going Vessels While At-Berth at a California Port** *www.arb.ca.gov/regact/2007/shorepwr07/shorepwr07.htm* and *http://www.arb.ca.gov/ports/shorepower/forms/regulatoryadvisory/regulatoryadvisory12232013.pdf*	All	2014 – 50% 2017 –70% 2020 – 80%	Vessels must use Shore power (or equivalent) requirement to reduce at-berth emissions. Compliance levels based on fleet percentage visiting the port.
CARB	**Ocean-going Ship Onboard Incineration** *www.arb.ca.gov/ports/shipincin/shipincin.htm*	DPM PM HC	2007	Vessels operators cannot incinerate within 3 nm of the California coast
SPBP CAAP	**CAAP Measure – OGV 1** **Vessel Speed Reduction (VSR) Program** *www.cleanairactionplan.org/reports/documents.asp*	All	2008	Vessel operators within 20 nm and 40 nm of Point Fermin
SPBP CAAP	**CAAP Measure – OGV 2** **Reduction of At-Berth OGV Emissions** *www.cleanairactionplan.org/reports/documents.asp*	All	2014	Shore power requirements. Vessel operators and terminals
SPBP CAAP	**CAAP Measure – OGV 5 and 6** **Cleaner OGV Engines and OGV Engine Emissions Reduction Technology Improvements** *www.cleanairactionplan.org/reports/documents.asp*	DPM PM NO_x	2012	Vessel operators who choose to participate in technology demonstrations and/or Green Ship Incentive Program

Table A.2: Harbor Craft Emission Regulations, Standards and Policies

Agency	Regulation, Standard, or Policy	Targeted Pollutants	Implementation Year	Impact
EPA	**Emission Standards for Harbor Craft Engines** *www.epa.gov/otaq/marine.htm*	All	2009 – Tier 3 2014 – Tier 4 for 800 hp or greater	Commercial marine diesel engines with displacement less than 30 liters per cylinder
CARB	**Low Sulfur Fuel Requirement for Harbor Craft** *www.arb.ca.gov/regact/carblohc/carblohc.htm*	DPM PM NO_x SO_x	2006 – 15 ppm	Use of low sulfur diesel fuel in commercial harbor craft operating in SCAQMD
CARB	**Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft** *www.arb.ca.gov/regact/2010/chc10/chc10.htm*	DPM PM NO_x	2009 to 2020 - Depending on engine model year	Most harbor craft homeported in SCAQMD must meet more stringent emissions limits according to a compliance schedule
SPBP CAAP	**CAAP Measure – HC 1 Performance Standards for Harbor Craft** *www.cleanairactionplan.org/reports/documents.asp*	All	2009 to 2020 - Depending on engine model year	Modernization of harbor craft operating in San Pedro Bay Ports.

Table A.3: Cargo Handling Equipment Emission Regulations, Standards and Policies

Agency	Regulation, Standard, or Policy	Targeted Pollutants	Implementation Year	Impact
EPA	**Emission Standards for Non-Road Diesel Powered Equipment** *www.epa.gov/otaq/standards/nonroad/nonroadci.htm*	All	2008-2015	All non-road (also known as off-road) equipment.
CARB	**Regulation for Cargo Handling Equipment Operating at Ports and Intermodal Railyards** *www.arb.ca.gov/regact/2011/cargo11/cargo11.htm*	All	2007-2017	All cargo handling equipment operating at ports and intermodal railyards.
CARB	**New Emission Standards, Test Procedures, for Large Spark Ignition (LSI) Engine Forklifts and Other Industrial Equipment** *www.arb.ca.gov/regact/2008/lsi2008/lsi2008.htm*	All	2007 – Phase 1 2010 – Phase 2	Emission standards for large spark-ignition engines 25 hp or greater.
CARB	**Fleet Requirements for Large Spark Ignition Engines** *www.arb.ca.gov/regact/2010/offroadlsi10/lsifinalreg.pdf*	All	2009-2013	More stringent emissions requirements for fleets of large spark ignition engine equipment fleets.
SPBP CAAP	**CAAP Measure – CHE1 Performance Standards for CHE** *www.cleanairactionplan.org/reports/documents.asp*	All	2007-2014	Turnover to Tier 4 cargo handling equipment per lease renewal agreement

Table A.4: Railroad Locomotives Emission Regulations, Standards and Policies

Agency	Regulation, Standard, or Policy	Targeted Pollutants	Implementation Year	Impact
EPA	**Emission Standards for New and Remanufactured Locomotives and Locomotive Engines- Latest Regulation** *www.epa.gov/otaq/standards/nonroad/locomotives.htm*	DPM NO_x	2011/2013 – Tier 3 2015 – Tier 4	All new and remanufactured locomotive engines.
EPA	**Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel** *www.epa.gov/otaq/fuels/dieselfuels/regulations.htm*	SOx PM	2010	All locomotive engines
CARB	Low Sulfur Fuel Requirement for Intrastate Locomotives *www.arb.ca.gov/msprog/offroad/loco/loco.htm#intrastate*	SO_x NO_x PM	2007	Intrastate locomotives, mainly switchers
CARB	**Statewide 1998 and 2005 Memorandum of Understanding (MOUs)** *www.arb.ca.gov/msprog/offroad/loco/loco.htm#intrastate*	NO_x	2010	UP and BNSF locomotives
SPBP CAAP	**CAAP Measure – RL1 Pacific Harbor Line (PHL) Rail Switch Engine Modernization** *http://www.cleanairactionplan.org/reports/documents.asp*	PM	2010	PHL switcher engines
SPBP CAAP	**CAAP Measure – RL2 Class 1 Line-haul and Switcher Fleet Modernization** *http://www.cleanairactionplan.org/reports/documents.asp*	All	2023 – Tier 3	Class 1 locomotives at ports
SPBP CAAP	**CAAP Measure – RL3 New and Redeveloped Near-Dock Rail Yards** *http://www.cleanairactionplan.org/reports/documents.asp*	All	2020 – Tier 4	New near-dock rail yards

Table A.5: Heavy-Duty Vehicles Emission Regulations, Standards and Policies

Agency	Regulation, Standard, or Policy	Targeted Pollutants	Implementation Year	Impact
CARB/EPA	**Emission Standards for New 2007+ On-Road Heavy-Duty Vehicles** *www.arb.ca.gov/msprog/onroadhd/reducstd.htm*	NO_x PM	2007 2010	All new on-road diesel heavy-duty vehicles
CARB	**Heavy-Duty Vehicle On-Board Diagnostics (OBD and OBDII) Requirement** *www.arb.ca.gov/msprog/obdprog/section1971_1_clean2013.pdf*	NOx PM	2010+	All new on-road heavy-duty vehicles
CARB	**Ultra-Low Sulfur Diesel Fuel Requirement** *www.arb.ca.gov/regact/ulsd2003/ulsd2003.htm*	All	2006 - ULSD	All on-road heavy-duty vehicles
CARB	**Drayage Truck Regulation** (amended in 2011 and 2014) *www.arb.ca.gov/msprog/onroad/porttruck/finalregdrayage.pdf*	All	Phase in started in 2009	All drayage trucks operating at California ports
CARB	**Low NOx Software Upgrade Program** *www.arb.ca.gov/msprog/hdsoftware/hdsoftware.htm*	NO_x	Starting 2005	1993 to 1998 on-road heavy-duty vehicles that operate in California
CARB	**Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Regulation** *www.arb.ca.gov/cc/hdghg/hdghg.htm*	CO_2	Phase 1 starting in 2012	Heavy-duty tractors that pull 53-foot+ trailers in CA
CARB	**Assembly Bill 32 requiring GHG reductions targets and Governor's Executive Order B – 30-15** *www.arb.ca.gov/cc/ab32/ab32.htm* *and* *www.gov.ca.gov/news.php?id=18938*	CO_2	GHG emissions reduction goals in 2020	All sectors identified in Climate Change Scoping Plan, including Goods Movement Sector.

Table A.5 (continued): Heavy-Duty Vehicles Emission Regulations, Standards and Policies

Agency	Regulation, Standard, or Policy	Targeted Pollutants	Implementation Year	Impact
SPBP CAAP	**CAAP Measure – HDV1 Performance Standards for On-Road Heavy-Duty Vehicles; Clean Truck Program** *www.cleanairactionplan.org/reports/documents.asp*	All	Phase-in starting in 2008	On-road heavy-duty vehicles that operate at POLB must have 2007 or newer engines by 2012.

Air Quality Management Plan (AQMP)

As part of the State Implementation Plan (SIP) process, the 2016 AQMP is currently being developed by the SCAQMD to demonstrate attainment of the 2008 8-hour ozone standard by 2031, and show early action measures to attain the 1997 8-hour ozone standard by 2023.[22] Based on air quality monitoring data collected in calendar year 2014, and the 1st quarter of 2015, there were multiple days when South Coast Air Basin did not the attain the 24-hour $PM_{2.5}$ National Ambient Air Quality standard of 35 µg/m^3. SCAQMD staff is proposing a formal request to the EPA to reclassify the Air Basin as a Serious Non-attainment Area for 24 - hour $PM_{2.5}$. If approved, SCAQMD will develop a Serious Area 24 - hour $PM_{2.5}$ SIP as part of the 2016 AQMP.

[22] SCAQMD, *http://www.aqmd.gov/home/about/groups-committees/aqmp-advisory-group*