



# Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories

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# Why Do a Port Emissions Inventory?

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- ▶ **Assess impacts of port growth**
- ▶ **Development of a well-informed port emissions reduction strategy**
- ▶ **SIP development**
- ▶ **NEPA and CEQA analyses**
- ▶ **Inform voluntary initiatives such as a collaborative regional air toxics assessment**
- ▶ **development of a port environmental management system**

# Previous Methodology

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## ► Current Methodologies and Best Practices – EPA

- Current Methodologies and Best Practices for Preparing Port Emission Inventories – 2006 – **Now updated April 2009**

## ► Starcrest Inventories

- 2005 Puget Sound Air Maritime Emissions Inventory -- 2007
- 2005 Port of Los Angeles Air Emissions Inventory -- 2007
- 2005 Port of Long Beach Air Emissions Inventory -- 2007
- 2006 Port of San Diego Air Emissions Inventory - 2007

## ► Older EPA Guidance Documents

- Commercial Marine Activity for Deep Sea Ports in the United States -- 1999
- Commercial Marine Activity for Great Lakes and Inland River Ports in the United States – 1999
- Commercial Marine Emission Inventory Development -- 2002

# Port Inventory Development Methodology Options

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## ► Detailed Inventory

- Requires details on deep sea vessel and land based equipment characteristics, activities, port geometry and ship paths
- Used by larger sea ports
- Resource Intensive

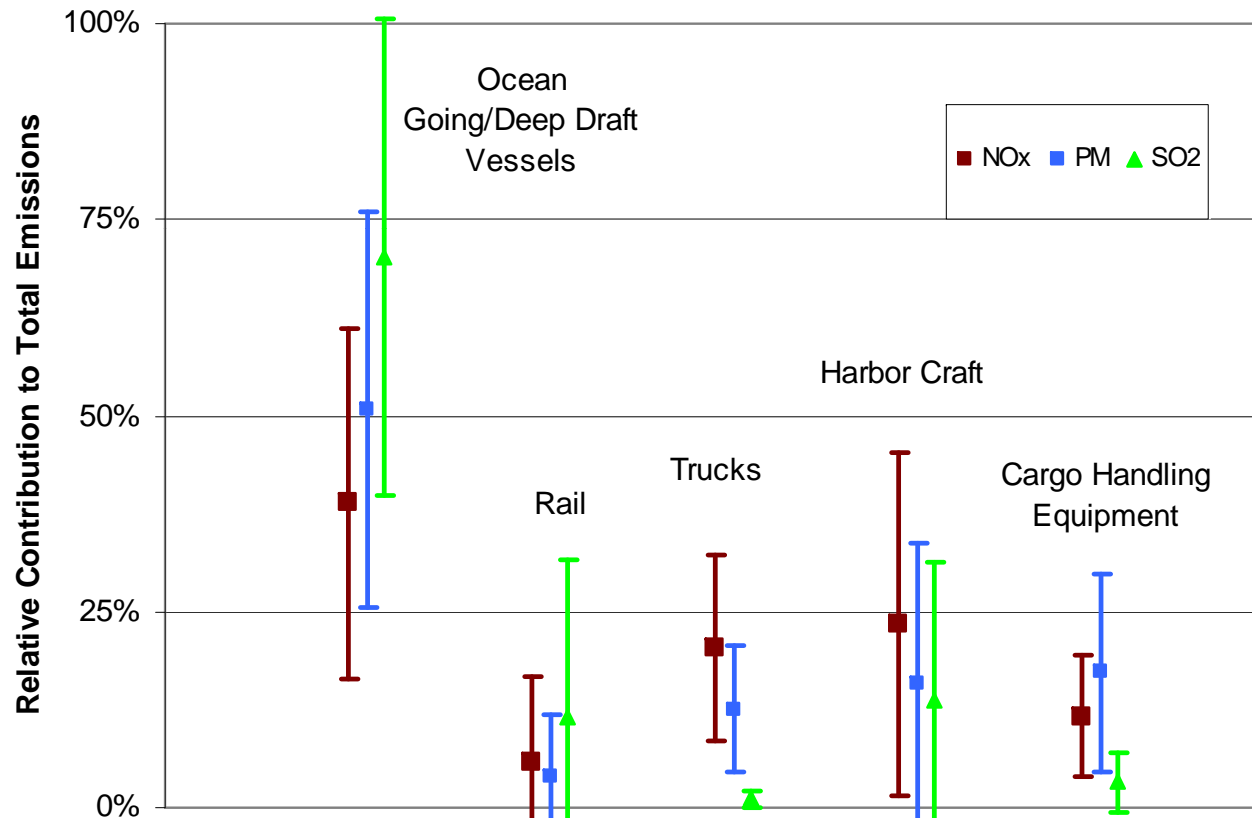
## ► Mid-Tier Inventory

- Requires port-specific activity information by ship type then applies “typical” port emission rate averages for each ship type
- Used by mid-sized and smaller ports in a non-attainment or maintenance areas

## ► Streamlined Inventory

- Provides a “back of the envelope” estimate of port emissions and requires only a low amount of resources
- Used by smaller sea and Great Lake ports

# Emission Contribution by Mode



# Detailed Inventory Preparation

## Deep Sea Vessels

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

Where **E** = Emissions (grams [g])

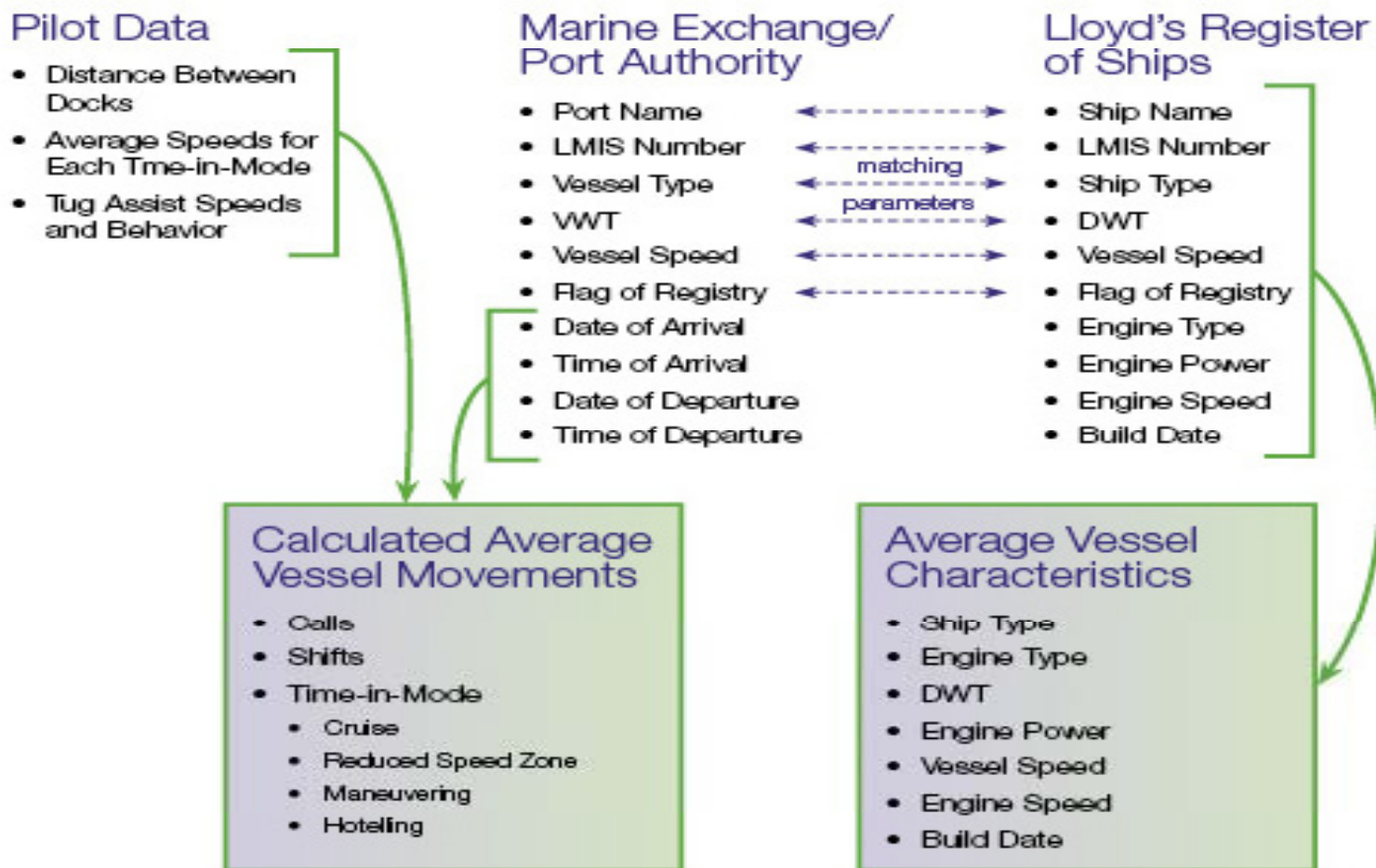
**P** = Maximum Continuous Rating Power (kW)

**LF** = Load Factor (percent of vessel's total power)

**A** = Activity (hrs)

**EF** = Emission Factor (g/kWh)

# Data Sources for OGVs



# OGV Ship Types

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**Auto Carrier**

**Barge Carrier**

**Bulk Carrier**

**Container Ship**

**General Cargo**

**Miscellaneous**

**Ocean Going Tug**

**Passenger**

**Reefer**

**RoRo**

**Tanker**

# Marine Engine Types

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## ▀ Engine Size

### – Category 1

- < 5 liters/cylinder
- Mostly small harbor craft and recreational propulsion

### – Category 2

- > 5 liters/cylinder and < 30 liters per cylinder
- OGV Auxiliaries, Harbor craft, smaller OGV propulsion

### – Category 3

- > 30 liters per cylinder
- OGV propulsion

# Marine Engine Types

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## ► Engine Speed

- Slow Speed
  - Direct Drive
  - Mostly 2 stroke
- Medium Speed
  - Geared Drive
  - Mostly 4 stroke
  - > 300 rpm
- High Speed
  - Geared Drive
  - 4 stroke
  - > 1400 rpm

## ► Other Engine Types

- Steam Turbine
- Gas Turbine

## ► Electric Drive

- Auxiliary Engines used for both propulsion and auxiliary power

# Activity

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## ▶ Cruise

- From open ocean to RSZ
- At service speed

## ▶ Reduced Speed Zone

- From pilot pick-up or other point to breakwater
- At reduced speed, usually 9 to 12 knots

## ▶ Maneuvering

- From breakwater to berth
- At slow speeds – 3 to 8 knots – slower coming in than out

## ▶ Hotelling

- Time at berth or anchorage with propulsion engine off
- Auxiliaries usually running unless cold ironing

# Propulsion Load Factors

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$$LF = (AS/MS)^3$$

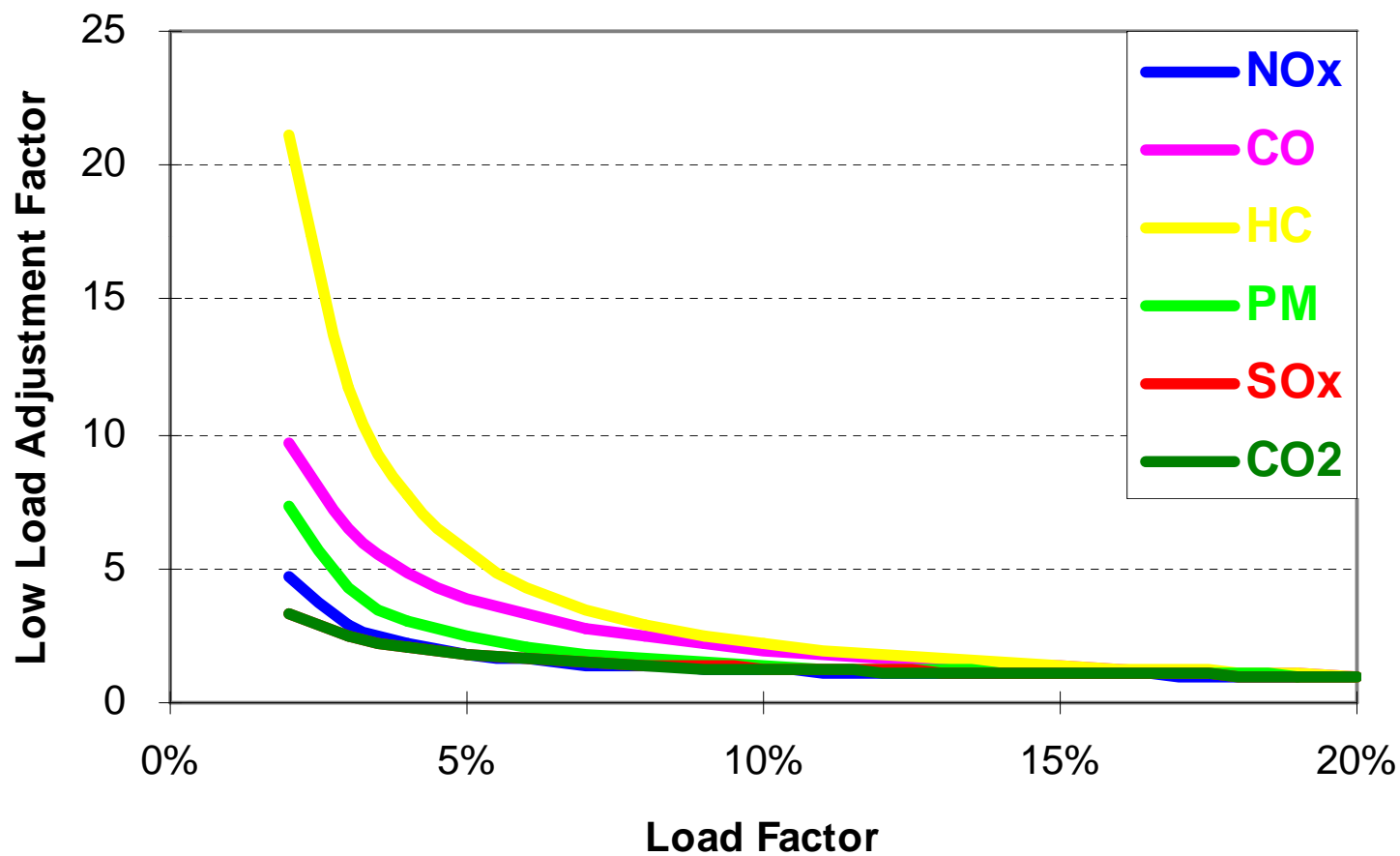
Where **LF** = Load Factor (percent)

**AS** = Actual Speed (knots)

**MS** = Maximum Speed (knots))

Minimum value 2%

# Low Load Adjustment Factors



# New IMO Regulations

Area	Year	Fuel Sulfur	NOx
Emission Control Area	Today to Jul 2010	15,000 ppm	Tier 3 Aftertreatment*
	2010	10,000 ppm	
	2015	1,000 ppm	
	2016		
Global	Today to Jan 2012	45,000 ppm	Tier 2 Engine Controls*
	2012	35,000 ppm	
	2020	5,000 ppm	
	2011		

- \* Today's Tier 1 NOx standards range from approximately 10 to 17 g/kW-h, depending on engine speed. The Tier 2 standards represent a 20% NOx reduction below Tier 1, and the Tier 3 standards represent an 80% NOx reduction below Tier 1.

# NOx Emission Reductions for IMO Regulations

Analysis Year	Global		Emission Control Area	
	Main	Auxiliary	Main	Auxiliary
2005	9.8%	9.4%	9.8%	9.4%
2010	12.5%	12.3%	12.5%	12.3%
2015	19.8%	19.4%	19.8%	19.4%
2020	24.3%	25.2%	40.4%	41.6%
2025	26.8%	28.3%	57.2%	58.9%
2030	28.5%	30.5%	68.2%	70.1%

# Trucks

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## ► General Approach

- Emissions = Emission Factors x Activity Levels
- Activity levels: miles of travel, hours of operation, fuel use

## ► Vehicle Types

- Assume all port trucks are diesel Class 8b heavy-duty trucks

## ► Activity Patterns

- movements within ports
- movements beyond ports

# Trucks Emissions Calculation

**1** Analyze and categorize waterborne cargo data

- ▶ Quantify volume and weight of cargo handled, by port and by commodity.
- ▶ Waterborne cargo activity will be used to estimate truck activity at each port.

**2** Classify ports

- ▶ Based on factors that are likely to exhibit a strong correlation with mode split and activity patterns.
- ▶ For example, physical size of the port, cargo throughput, availability of on-dock and near-dock rail terminals (to determine mode splits), and commodities handled.

**3** Develop equations to relate waterborne cargo activity to truck movements

- ▶ Determine availability of on-dock rail terminals
- ▶ Mode split analysis
- ▶ Estimate number of truck trips

# Trucks and Rail Emissions Calculation (cont.)

## 4 Estimate trip distances

- ▶ Land-side boundary: first intermodal point
- ▶ Accounts for drayage movements to off-dock rail facilities, and short-haul truck movements to cross-docking facilities and local customers.
- ▶ Operations of off-dock rail facilities are assumed to be beyond port boundaries.

## 5 Estimate idling times

- ▶ Based on activity patterns for each port category.

## 6 Develop emission factors

- ▶ Both cruise and idling emission factors
- ▶ Use of MOBILE or MOVES to develop truck EF
- ▶ Use correction factors from E55/E59 data to account for high percentages of time spent on creep and transient modes while at ports.
- ▶ Use VIUS to estimate fleet age distribution

## 7 Calculate emissions

- ▶ Emissions = Emission Factors x Activity Levels
- ▶ Activity levels: miles of travel, hours of operation, fuel use

# Cargo Handling Equipment

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- ▶ Cranes
- ▶ Excavators
- ▶ Forklifts
- ▶ Container Handling Equipment
- ▶ Other, General
- ▶ Industrial Equipment
- ▶ Sweepers/Scrubbers
- ▶ Tractor/Loader/Backhoe
- ▶ Yard Truck

# CHE Emission Methodologies

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## ► Case 1:

- Develop port specific estimates of each CHE type, population, and activity if possible,
- Then use NONROAD/OFFROAD to estimate emissions

## ► Case 2:

- Scale to other ports by port size and cargo tons by cargo type
- Use activity profiles and load factors from typical port inventories
- Calculate by hand or use NONROAD to estimate emissions

# CHE Emission Calculation Inputs

$$Emissions_{Pollutant,CHE} = \langle EF_{Pollutant,CHE} \rangle \cdot N_{CHE} \cdot LF_{CHE} \cdot Activity_{CHE} \cdot HP_{CHE}$$

CHE Type	Average HP	Average Age (Years)	Average Operating Hours
Car loader	150	20	500
Crane	274	9	534
Forklift	127	10	1,029
Gantry Crane	453	5	2,641
Generator	141	13	692
Reach Stacker	274	5	2,810
Side Handler	184	6	1,228
Skid Steer Loader	85	8	679
Top Handler	282	7	1,955
Tractor	131	11	553
Yard Tractor	206	5	1,861

# Questions?

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## ► New Best Practices Document

<http://www.epa.gov/sectors/sectorinfo/sectorprofiles/ports.html>

## ► Contact Information

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