

U.S. EPA's New Program to Control Pollution from Locomotives and Marine Diesels

Office of Transportation and Air Quality
GRPE, June 2008



Overview

- This Rule's Context in EPA's National Clean Diesel Campaign
- A Comprehensive 3-Part Program
- Key Elements of the Program
 - Locomotives
 - Marine Diesels
- A Collaborative Process Enabled a Strong Final Rule

Reconciling Diesels with the Environment: EPA's National Clean Diesel Campaign

Tier 2 Light-Duty

final rule 1999

fully phased in 2009

Diesels held to same stringent standards as gasoline vehicles



These standard-setting rulemakings are key enablers for collaborative partnerships with industry and state & local governments



Heavy-Duty Highway

sales 800,000 / yr

40B gallons / yr

final rule 2000

fully phased in 2010



Locomotive/Marine

sales 40,000 marine engines,

1,000 locomotives / yr

6B gallons / yr

final rule 2008

fully phased in 2017



Nonroad Diesel

sales over 650,000 / yr

12B gallons / yr

final rule 2004

fully phased in 2015

Note: sales and diesel fuel usage vary year-to-year; these figures are for comparison purposes only

1
standards for remanufactured existing engines
starts 2008

2
Tier 3 for newly-built engines
starts 2012 engine-based
2009 for marine <75 kW

3
Tier 4 for newly-built engines
starts 2014 (marine), 2015 (locomotive)
aftertreatment-based

Clean Locomotives and Marine Diesels A Comprehensive 3-Part Program

What the Rule Covers-- Locomotives



Line-Haul
(>2300 hp)



Switch (<2300 hp)

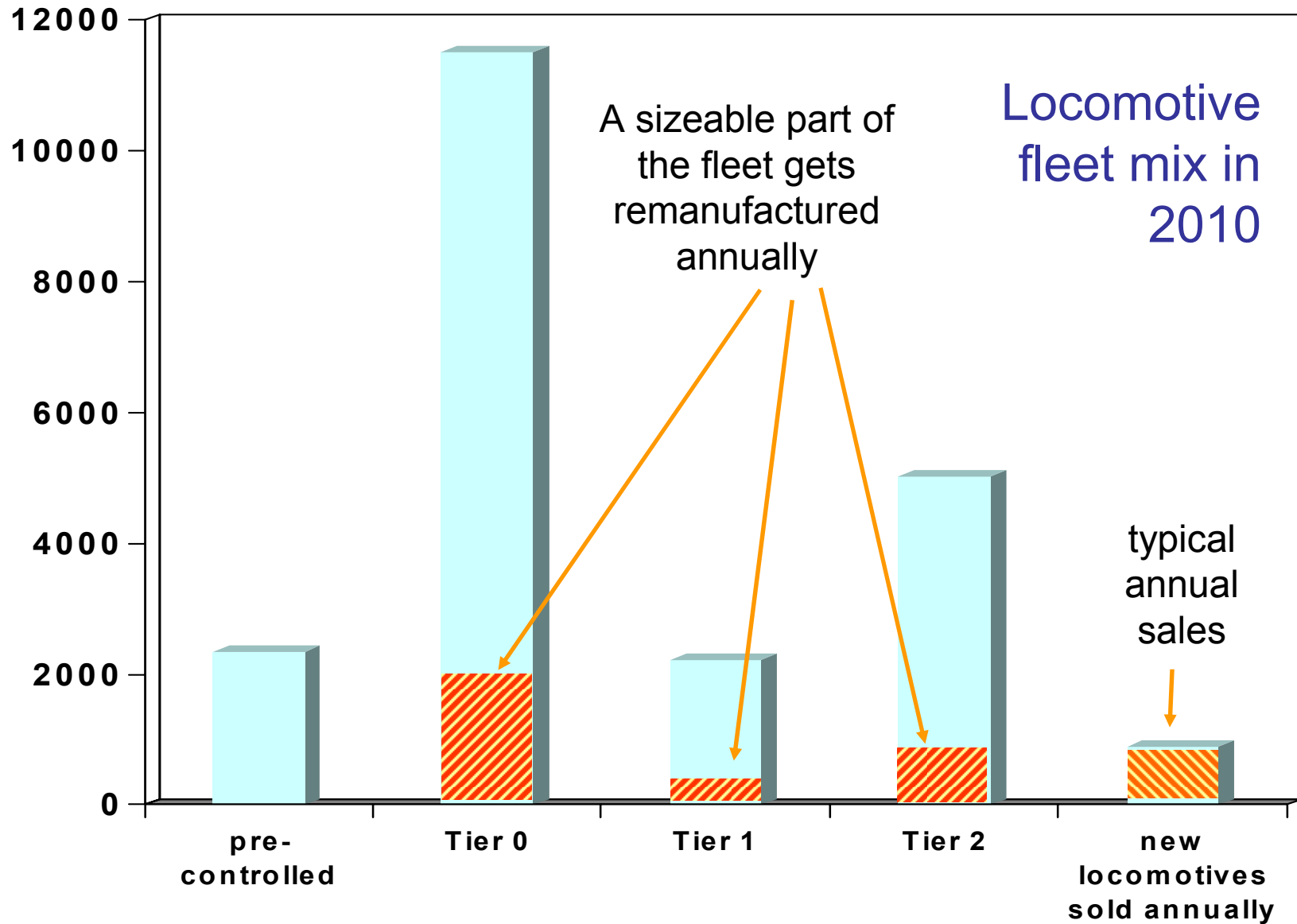


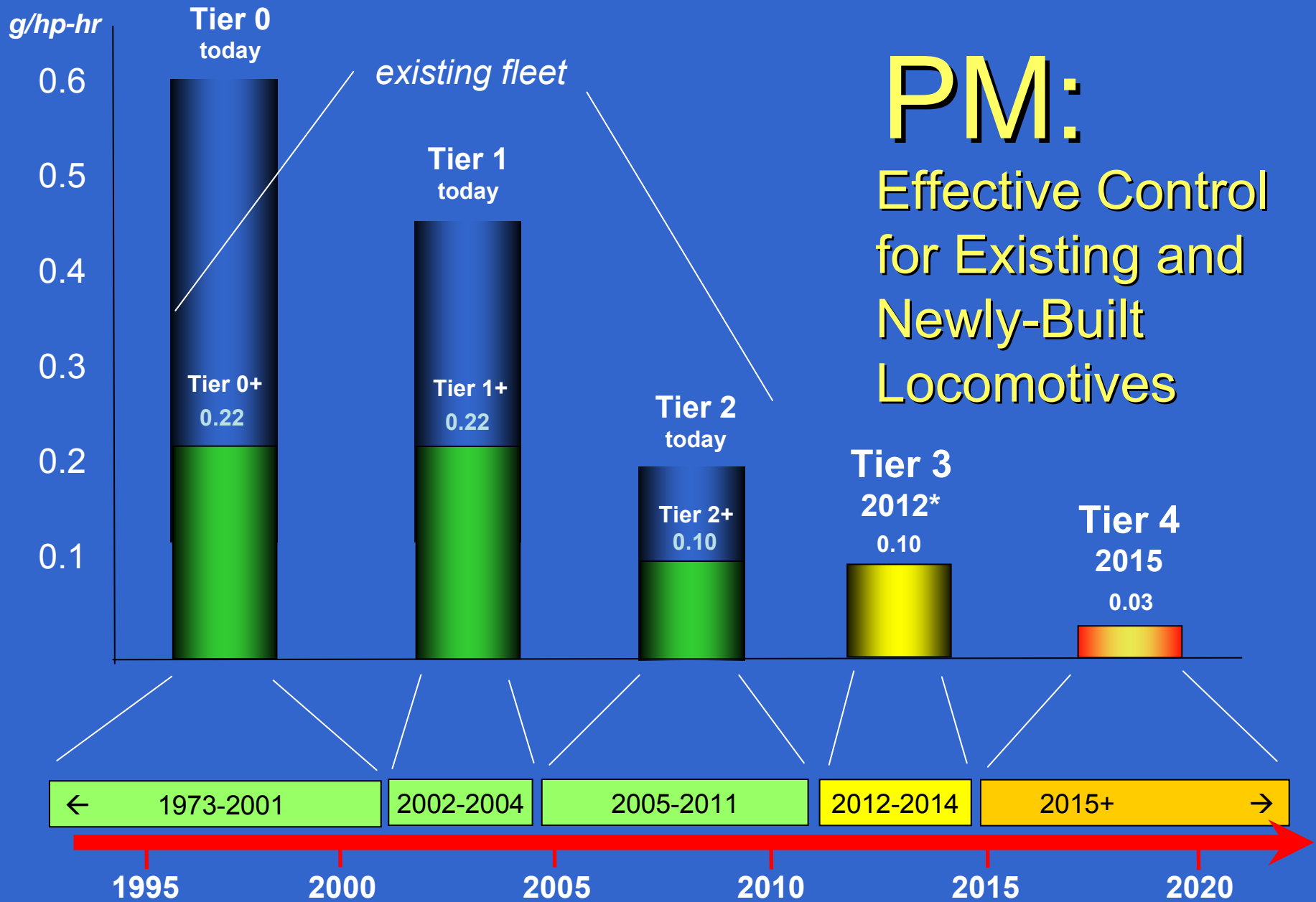
Passenger



Sales ~700-1200 / year
Typically rebuilt
every 5-7 years

The Significance of Locomotive Remanufacturing



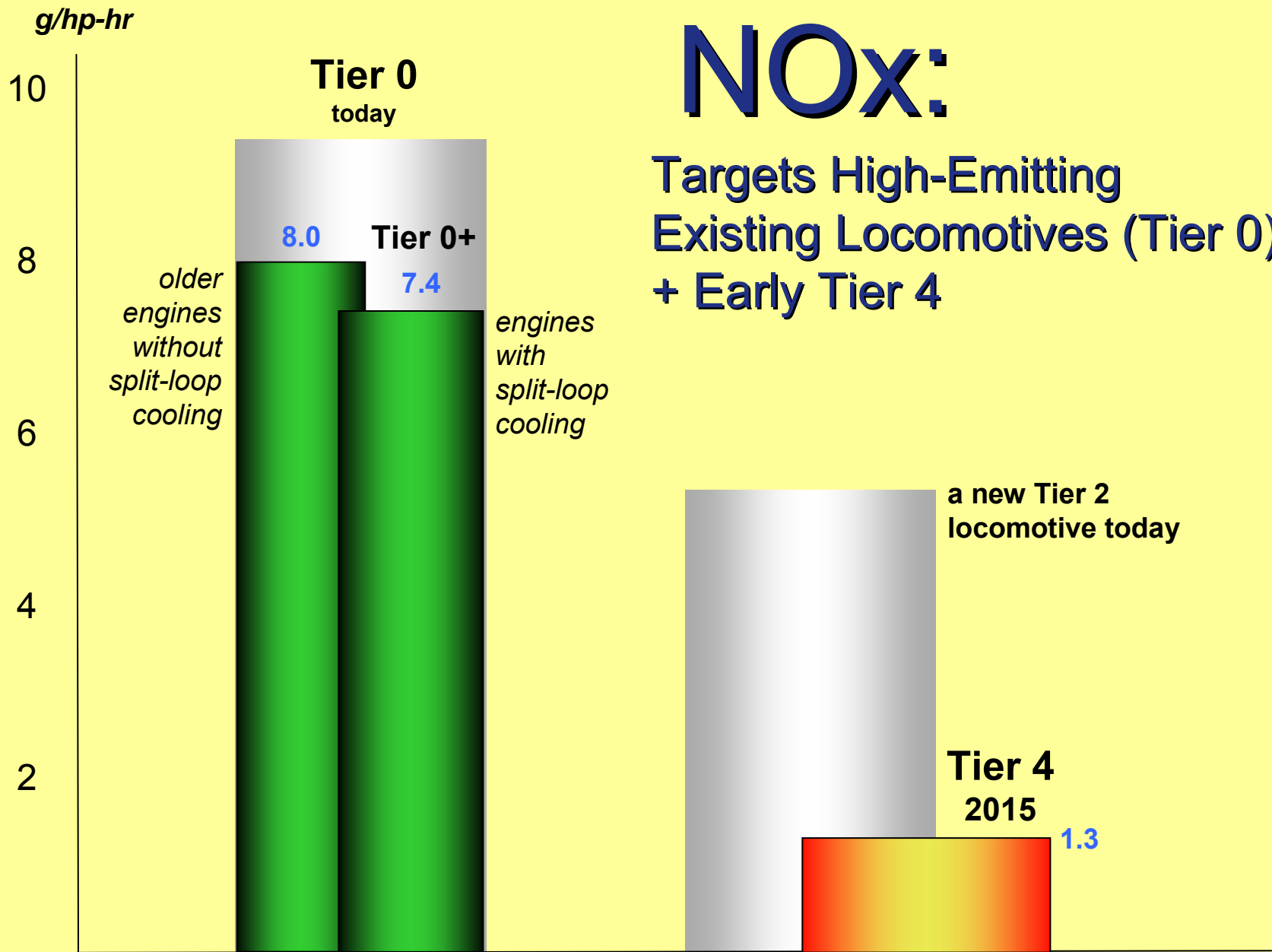


PM:

Effective Control for Existing and Newly-Built Locomotives

Additionally for all tiers:
Idle emissions controls

* for switchers: Tier 3 in 2011; equivalent standards apply to switchers in all tiers



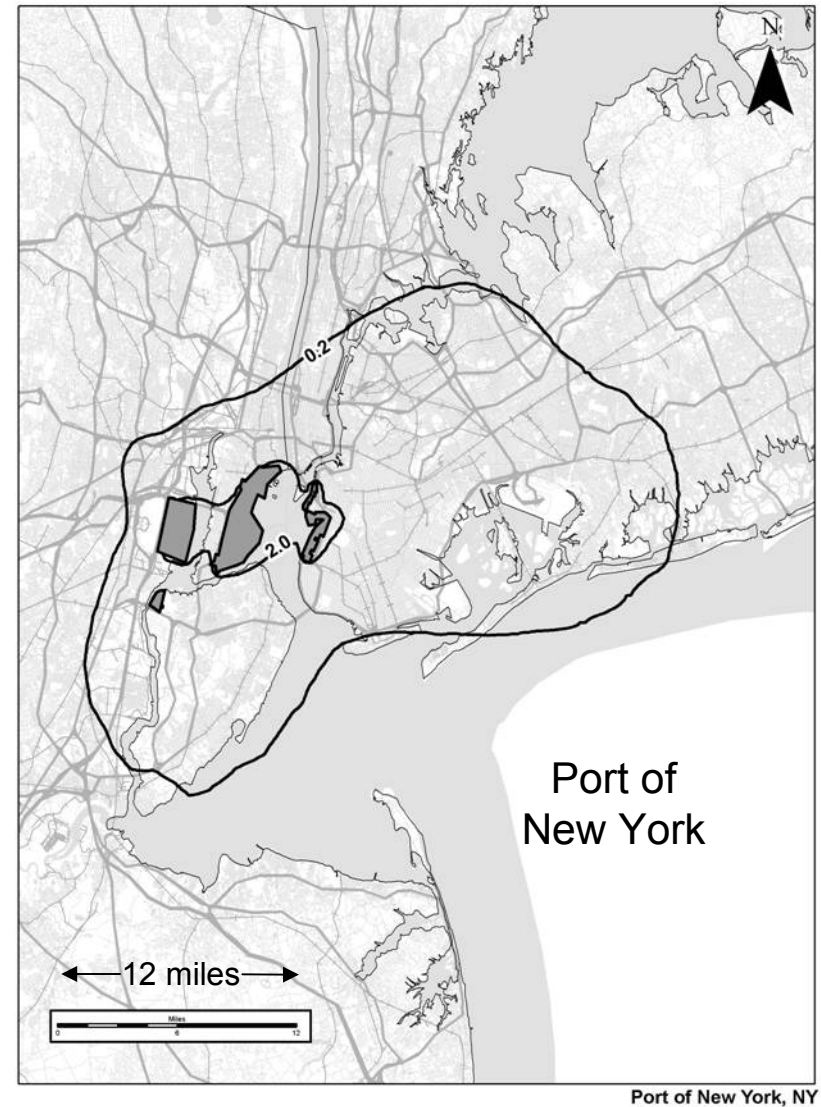
Encouraging Low-Emission Switchers

- Stringent new standards alone could prove counterproductive
 - Added cost could drive RRs to continue maintaining old switchers
- Streamlined certification using “nonroad” engines – no limit on sales
- Standards allow for traditional “medium-speed” engines too
- Revised credit calculations to properly credit replacing old switchers with refurbished ones

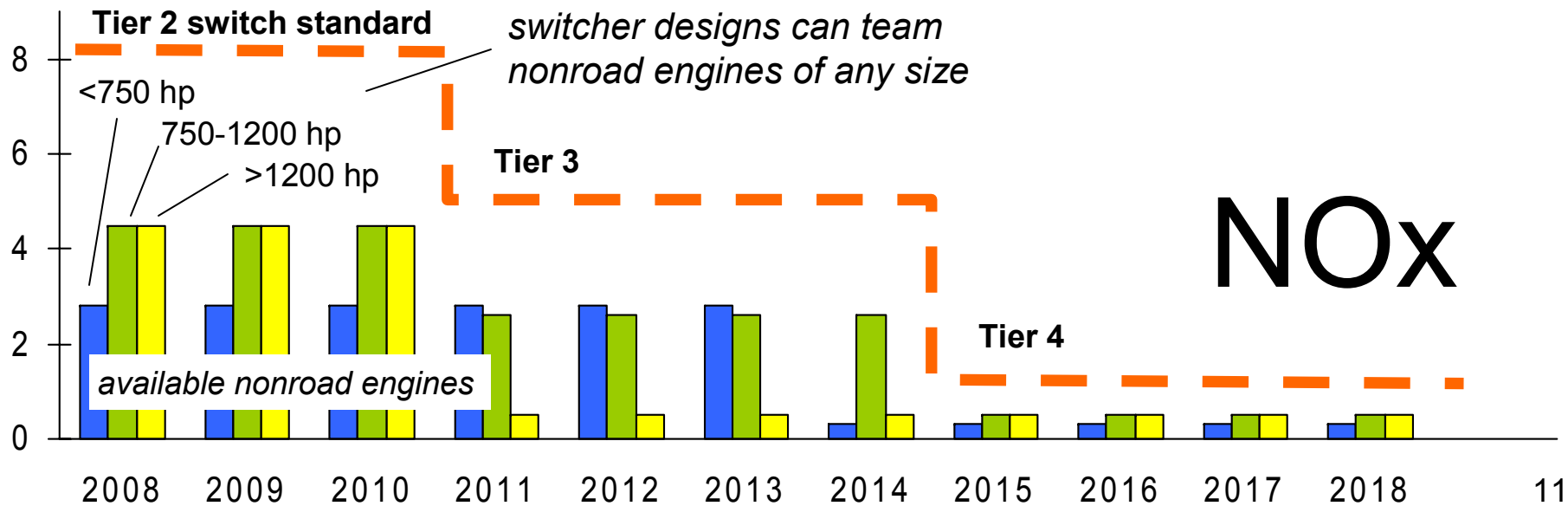


Environmental Justice and Neighborhood Impacts

- Rulemaking analyzed 47 ports, 37 railyards
 - >13 million people living nearby are exposed to diesel PM levels $>0.2 \mu\text{g}/\text{m}^3$ above urban background levels.
 - including high % of low-income households, African-Americans, Hispanics.
- Finding under Executive Order 12898—
 - The rule will have no disproportionate adverse impacts on minority or low-income populations.
- In fact, this rule has large health benefits for communities near ports, railyards, etc
- Some provisions are especially helpful--
 - Example: requirement for locomotive idle reduction controls, starting 2008



Streamlined Switch Locomotive Program Using Clean Nonroad Engines Certified Below Locomotive Levels



Diversity In Vessel Applications Calls for Targeted Diesel Emissions Standards

<75 hp
<10,000/year



gen sets



sailboats

Recreational
~15,000/year

cruisers



yachts



Category 1 Commercial (<7 liter/cylinder)
~15,000/year (about half are aux engines)



workboats



police boats



fishing vessels

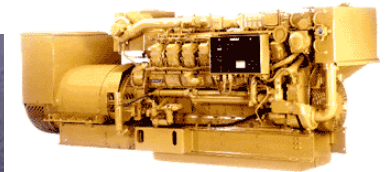
Category 2 (7 to 30 liter/cyl) <300/year



tugboats



ferries



auxiliary power for
ocean-going vessels



Great Lakes freighters

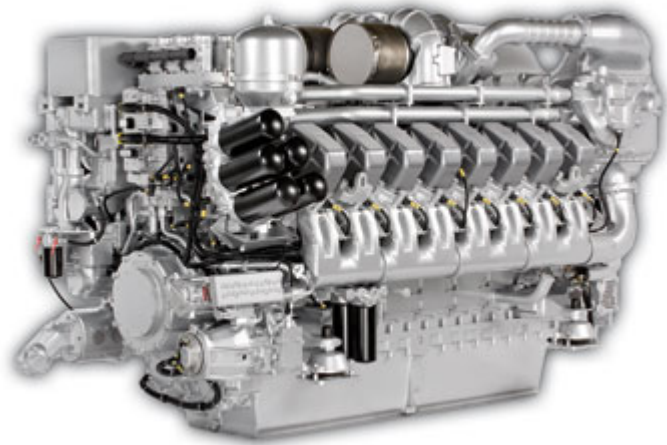
**Category 3
(>30 liter/cyl)**



ocean-going ships

Covered in separate initiative

Diversity In Marine Diesel Engines Calls for Targeted Emissions Standards



Category 1 Commercial
<7 liters/cylinder



Category 2
7–30 liters/cylinder
many derived from locomotive engines

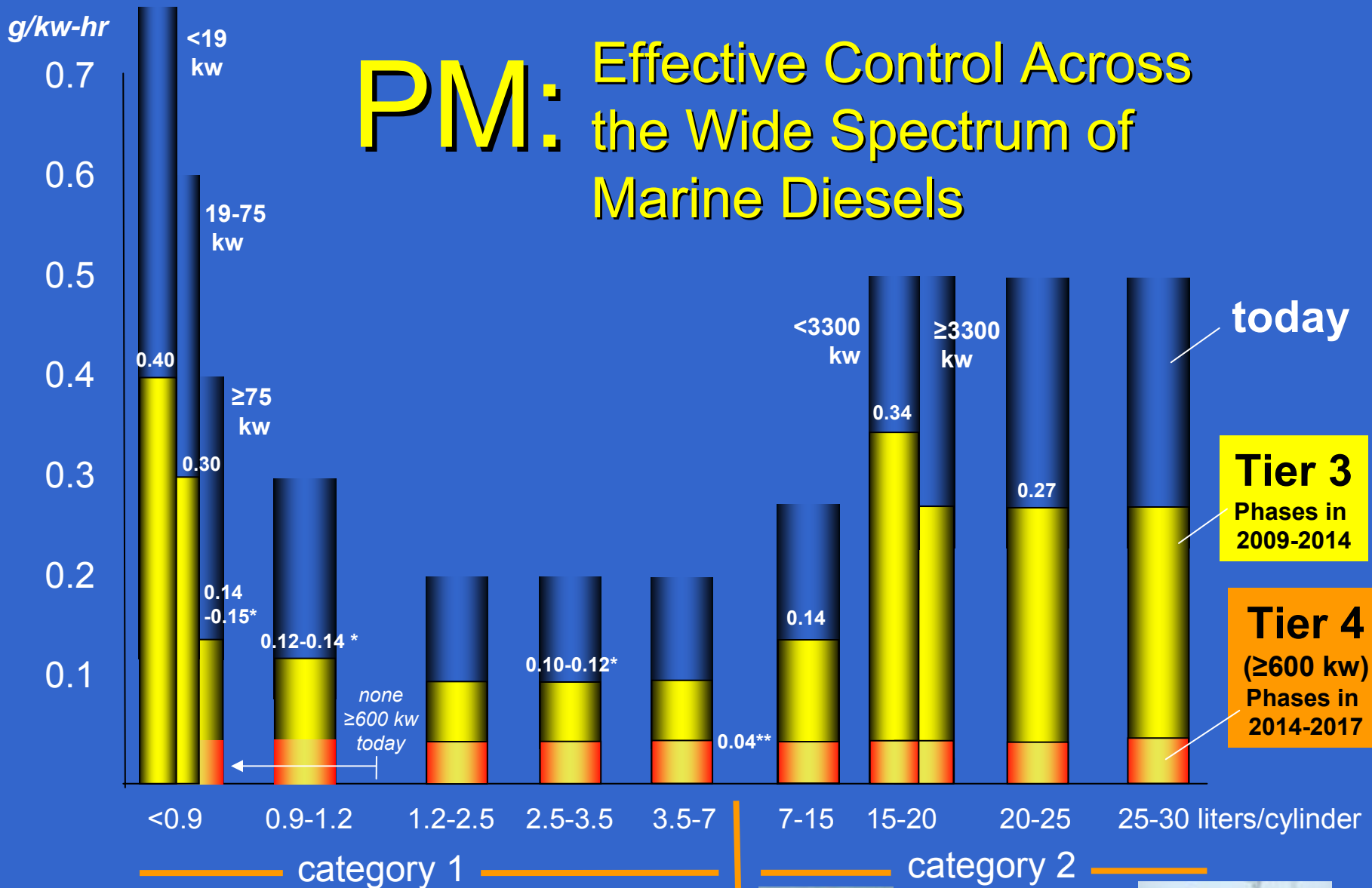


Recreational
high power-to-weight ratios
to enable vessel planing

<75 kW
marinized
nonroad engines



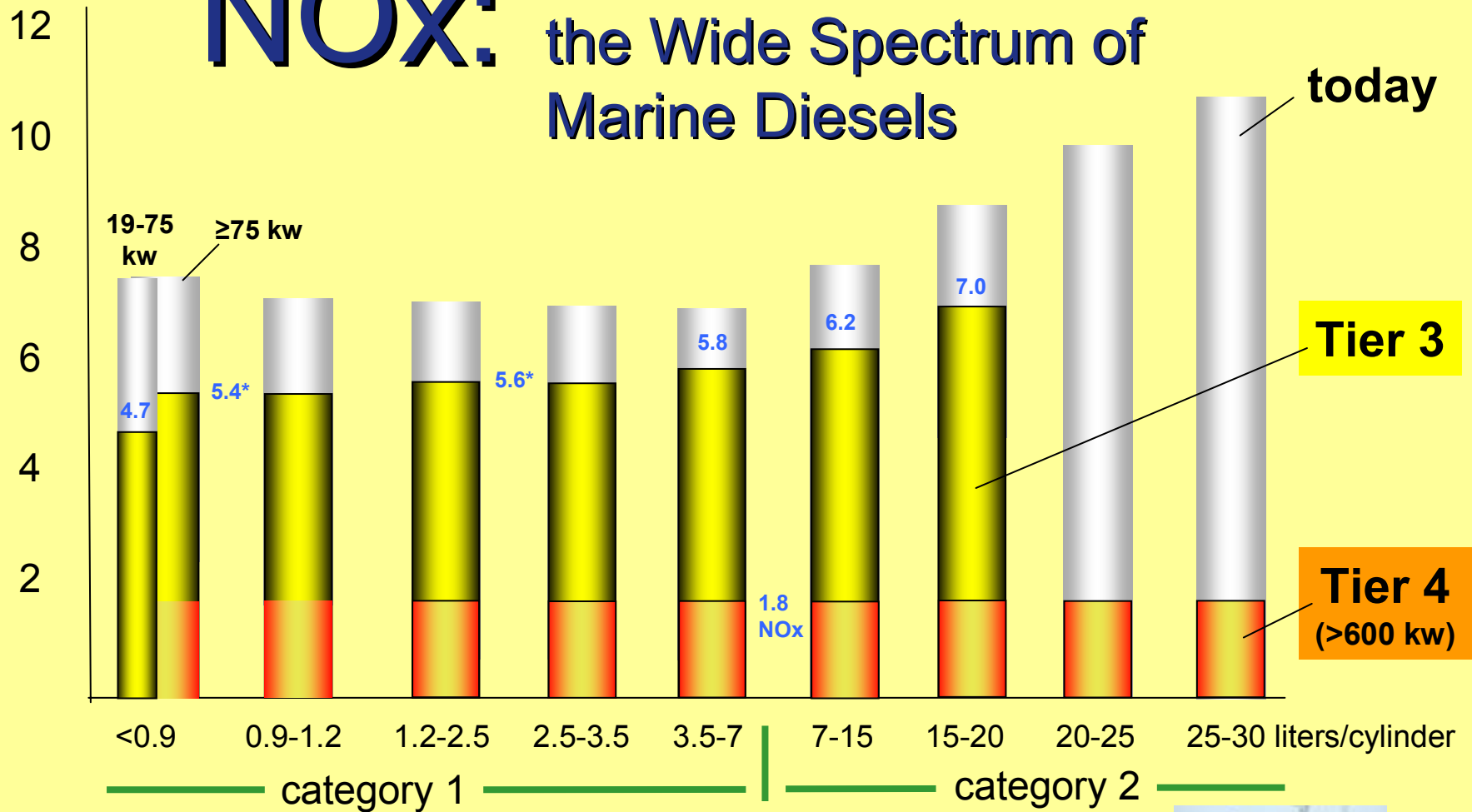
PM: Effective Control Across the Wide Spectrum of Marine Diesels



* higher #s are for hi-power density (≥35 kw/L) engines.
 ** 0.06 for the very largest (>3700 kw) engines.

NO_x+HC
g/kw-hr

NO_x: Effective Control Across the Wide Spectrum of Marine Diesels



Indicated standards are NO_x+HC, except Tier 4 (NO_x).
 For ≥2000 kw: no Tier 3 NO_x (early Tier 4 instead).
 * 5.8 for hi-power density (≥35 kw/L) engines.

How Does the New Program for Existing Marine Engines Work?

- Existing marine diesels are considered “new” and subject to EPA standards when they are remanufactured (starting November 2008)
- Requirement: At the time of remanufacture, engine must be certified to the remanufacture standard if a certified remanufacture system is available
 - If a remanufacture system has not been certified, there is no requirement
- Standard: 25% reduction in PM emissions from measured baseline, no NOx increase
 - Expected to be met through “better” versions of parts normally replaced at rebuild
 - Systems subject to a cost cap of \$45K/ton PM
 - Simplified certification for locomotive kits that can be used on marine engines
 - Program allows certified fuel-based systems as an alternative if an engine system has also been certified



Program for Existing Marine Engines Likely To Have Large Impact

- Program applies to existing commercial marine diesel engines >600 kW manufactured from 1973 up through Tier 2
 - These engines produce the vast majority of marine diesel emissions
 - Are routinely remanufactured multiple times
- Certification is voluntary; the program is market driven
 - There is a clear market incentive for engine manufacturers to certify reasonable-cost systems
 - If a competitor certifies and you don't, your parts can't be used
- EPA will review this market-driven approach in ~2012
 - If remanufacture systems have not been certified, we may consider changes to the program
 - We may also consider extending the program to more engines



Hitting the Ground Running

Some Parts of the New Program Start Within Months

May 2008

- Publication in the Federal Register

July

- Streamlined switcher certification
- Non-OEM parts verification program
- New test and compliance flexibilities
- Remanufacture kits begin to certify to new standards

October November

- Remanufactured locomotives must use new kits

- Remanufactured marine diesels subject to standards for 1st time ever

January 2009

- Marine diesels <75 kW start Tier 3

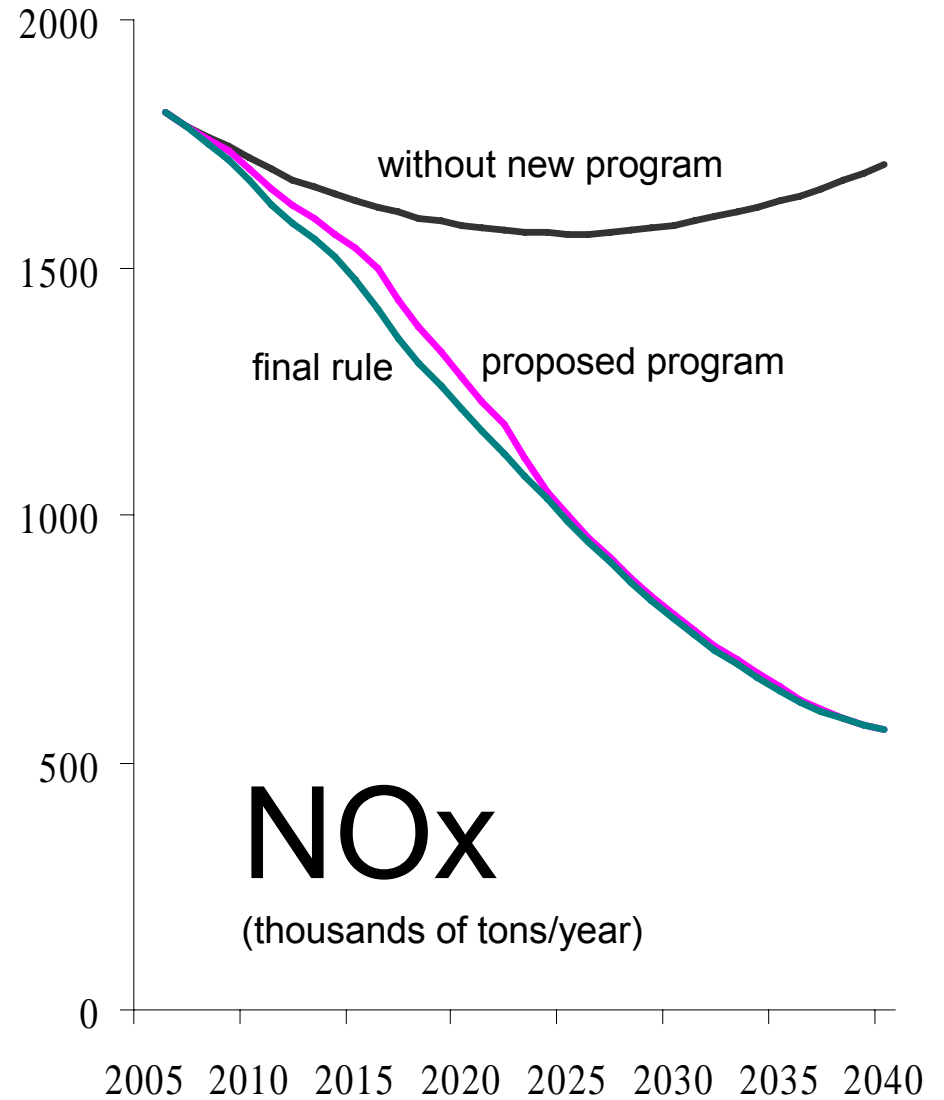
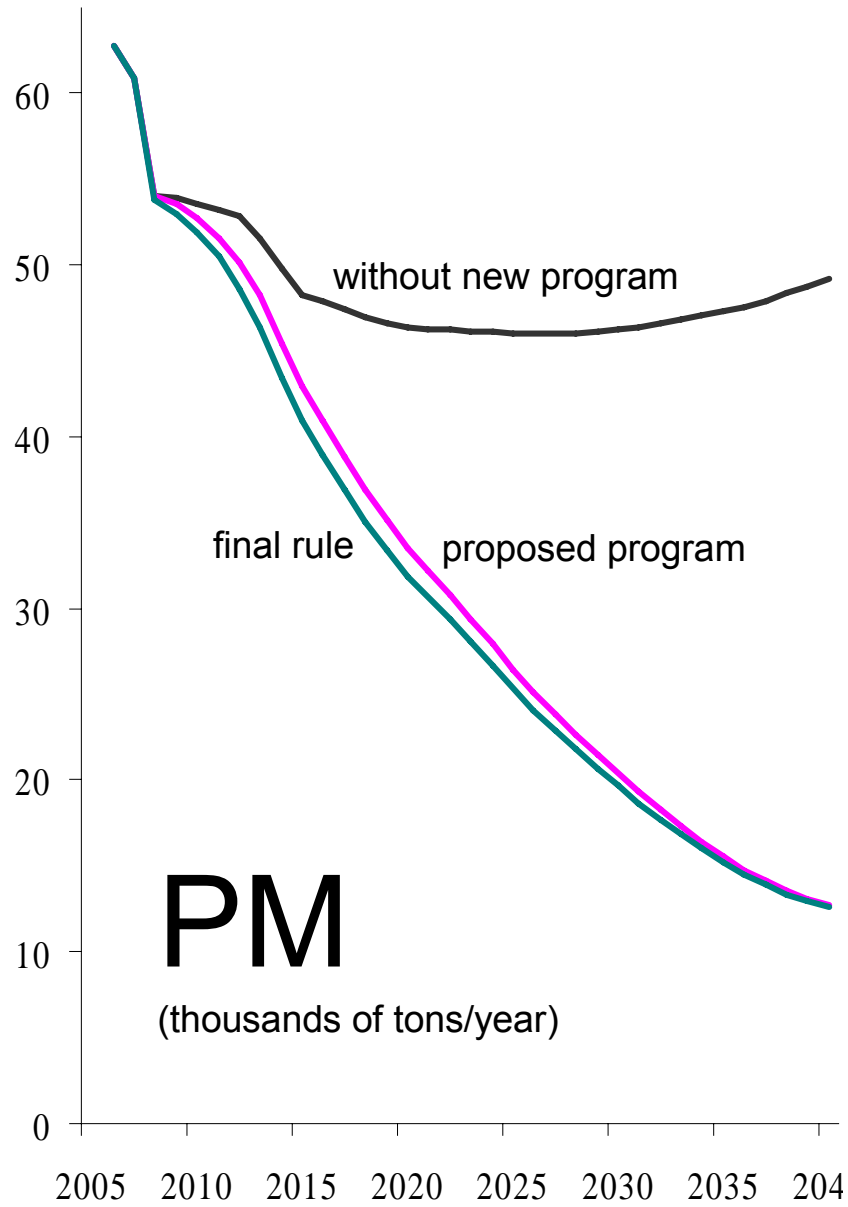
Extensive Collaborative Effort Following March 2007 Proposal

- Major Comments--
 - Program doesn't get reductions early enough for SIP targets
 - NOx catalyst durability unproven for high temperature operation
 - Need to include smaller RRs in Tier 0+ program
 - Certain specialized vessel applications cannot do Tier 4
 - EPA should add an existing marine fleet program
- Many constructive meetings with stakeholders over past year
 - Exploring ways to pull-ahead earlier NOx benefits
 - And address other comments

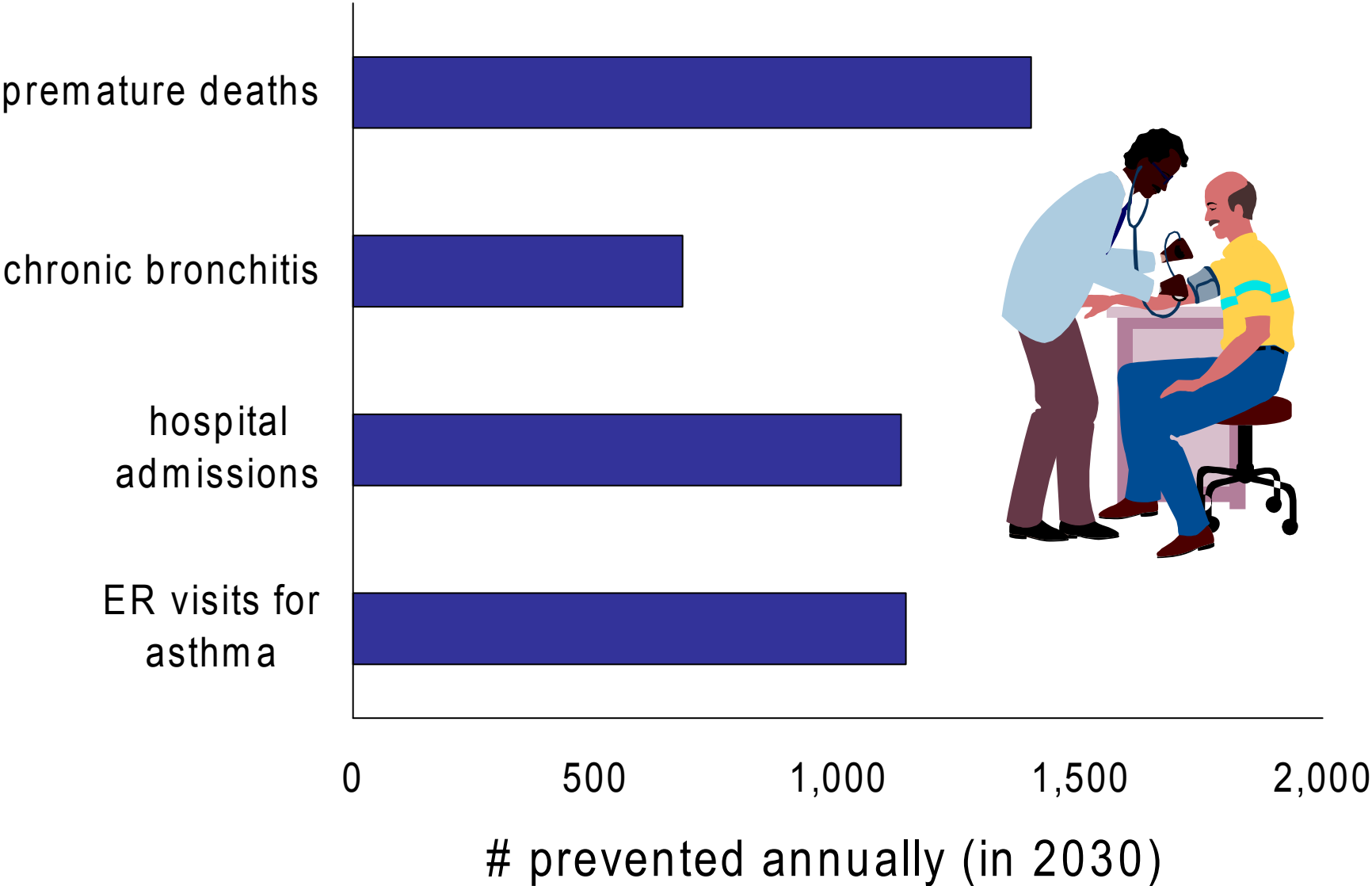
Final Rule Substantially Strengthens the Program

- 2 year pull-ahead of locomotive Tier 4 NOx (to 2015)
 - Also alternative compliance program focused on more in-use testing
- 2 year pull-ahead of Tier 4 NOx for 2000-3700 kW marine engines (to 2014)
 - skips to early Tier 4 NOx directly from Tier 2-- more NOx tons at less overall cost
- Standards adopted for existing marine fleet
- Tier 4 exclusions/exemptions for special marine applications with uncertain feasibility– recreational, migratory, emergency
- Class II (regional) railroads included in remanufactured locomotive program

Final Rule Substantially Strengthens the Program



Large Health Benefits

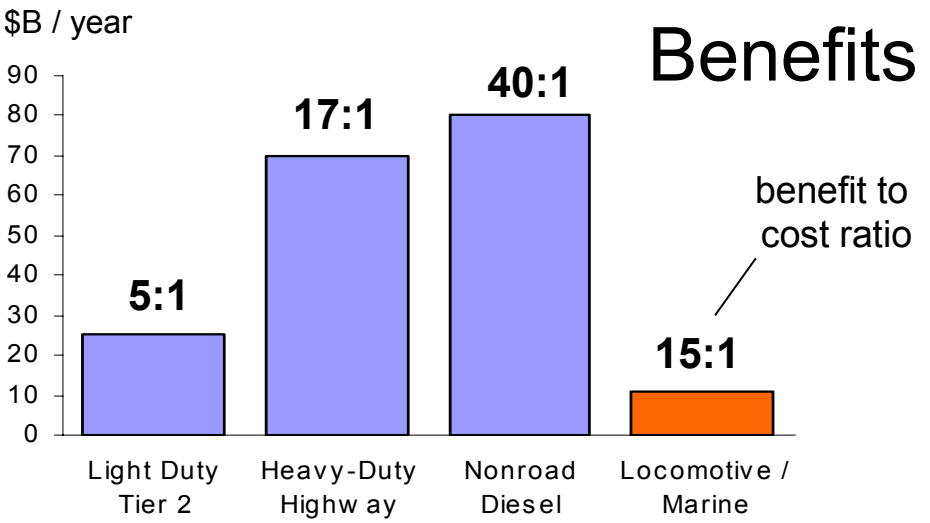
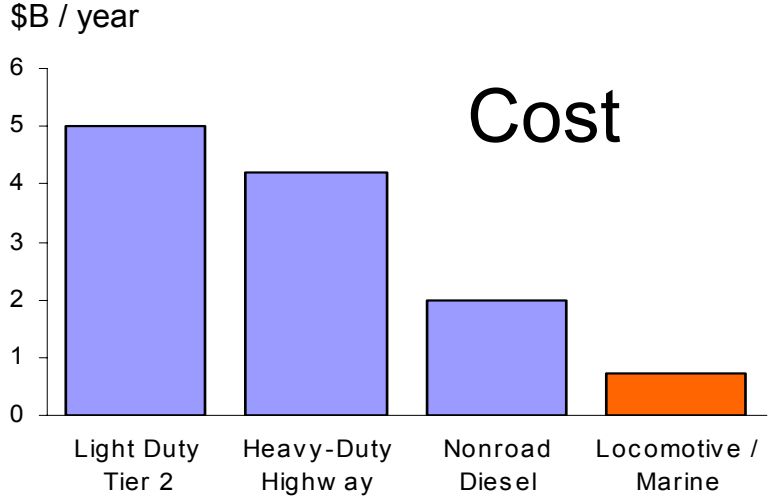
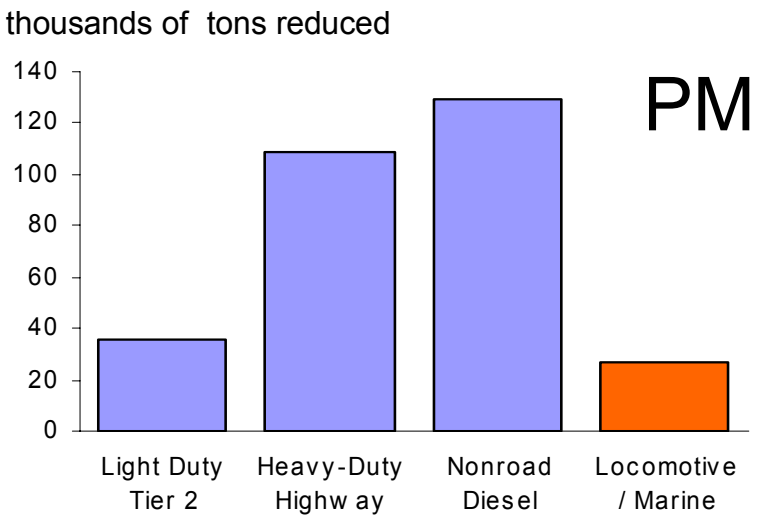
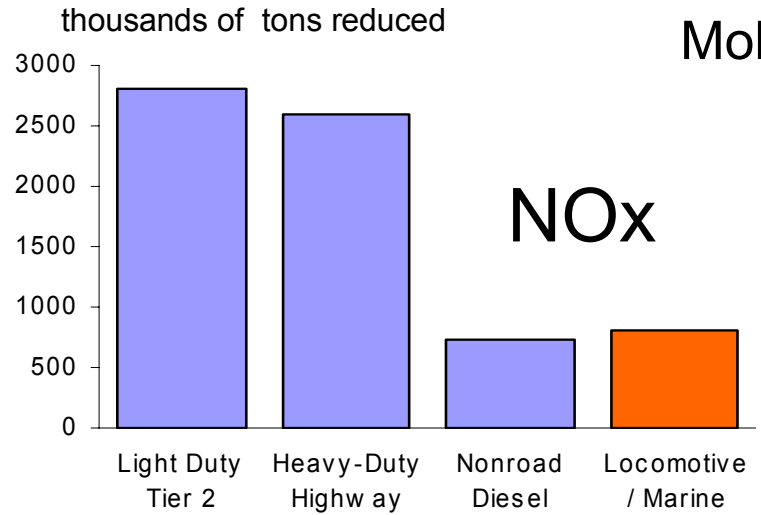


Annual Costs and Benefits in 2030

	PM	NO _x
Cost	\$180 M	\$580 M
Inventory reduction, tons	27,000	800,000
Cost per ton	\$6600	\$700
Unit cost as % of typical new locomotive price (similar for marine vessels, but varies vessel to vessel)	3%	
Monetized benefits	\$8.4B to \$11B	
Benefit to cost ratio	11:1 to 15:1	

How does this rule stack up?

Mobile Source Program Impacts in 2030



Appendix: Emissions Standards Summaries

The New Line-Haul Locomotive Standards (g/bhp-hr)

locomotive group	date	PM		NOx		HC	
		previous standard	new standard	previous standard	new standard	previous standard	new standard
Remanufactured Line-Haul Locomotive Standards							
Remanufactured Tier 0 & 1	2008 as available 2010 required	0.60	0.22	9.5 (Tier 0) 7.4 (Tier 1)	7.4 (8.0 if no SLAC)	1.00 (Tier 0) 0.55 (Tier 1)	0.55 (1.00 if no SLAC)
Remanufactured Tier 2	2008 as available 2013 required	0.20	0.10	5.5	5.5	0.30	0.30
Newly-built Line-Haul Locomotive Standards							
Tier 3	2012	--	0.10	--	5.5	--	0.30
Tier 4	2015	--	0.03	--	1.3	--	0.14

SLAC = separate loop intake air cooling.

Additionally, in all locomotive groups:

Idle emissions control– must equip locomotive with automatic engine stop/start.

HC standards are Total HC, except Tier 4 (NMHC).

Part 92 smoke standards apply if PM FEL >0.05 g/bhp-hr, but are generally waived from testing.

Part 92 CO standards continue to apply (at Tier 2 levels for Tiers 3&4); notch caps also apply.

Must also meet switch-cycle standards of the same tier (of Tier 2 for Tier 3 line-haul locomotive) except for Tier 4.

The New **Switch** Locomotive Standards (g/bhp-hr)

locomotive group	date	PM		NOx		HC	
		previous standard	new standard	previous standard	new standard	previous standard	new standard
Remanufactured Switch Locomotive Standards							
Remanufactured Tier 0	2008 as available 2010 required	0.72	0.26	14.0	11.8	2.10	2.10
Remanufactured Tier 1	2008 as available 2010 required	0.54	0.26	11.0	11.0	1.20	1.20
Remanufactured Tier 2	2008 as available 2013 required	0.24	0.13	8.1	8.1	0.60	0.60
Newly-built Switch Locomotive Standards							
Tier 3	2011	--	0.10	--	5.0	--	0.60
Tier 4	2015	--	0.03	--	1.3	--	0.14

Additionally, in all locomotive groups:

Idle emissions control– must equip locomotive with automatic engine stop/start.

HC standards are Total HC, except Tier 4 (NMHC).

Part 92 smoke standards apply if PM FEL >0.05 g/bhp-hr, but are generally waived from testing.

Part 92 CO standards continue to apply (at Tier 2 levels for Tiers 3&4); notch caps also apply.

Can also use alternative nonroad engine-based program.

EPA's New Marine Diesel Standards (p.1 of 2)

New Marine Diesel Standards: Standard Power Density Commercial

Category	Displacement L/cyl	Tier 2 g/kW-hr g/hp-hr	2009		2010		2011		2012		2013		2014		2015		2016		2017		2018		2019	
			g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr
Category 1 <75kW	<0.9 PM <19 kW NOx+HC	0.80 0.60 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6	0.40 0.30 7.5 5.6
	see note 5: <0.9 PM 19 - <75kW NOx+HC	0.6/0.4 0.30/0.45 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6	0.30 0.22 7.5 5.6
Category 1 75-600kW	<0.9 PM NOx+HC	0.40 0.30 7.5 5.6							0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	0.14 0.10 5.4 4.0	
	0.9 - <1.2 PM NOx+HC	0.30 0.22 7.2 5.4							0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	0.12 0.09 5.4 4.0	
	1.2 - <2.5 PM NOx+HC	0.20 0.15 7.2 5.4									0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.10 0.07 5.6 4.2	0.10 0.07 5.6 4.2	0.10 0.07 5.6 4.2	0.10 0.07 5.6 4.2	
	2.5 - <3.5 PM NOx+HC	0.20 0.15 7.2 5.4									0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.11 0.08 5.6 4.2	0.10 0.07 5.6 4.2	0.10 0.07 5.6 4.2	0.10 0.07 5.6 4.2	0.10 0.07 5.6 4.2	
	3.5 - <7.0 PM NOx+HC	0.20/0.27 0.15/0.20 7.2/7.8 5.4/5.8								0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.11 0.08 5.8 4.3	0.10 0.07 5.8 4.3	0.10 0.07 5.8 4.3	0.10 0.07 5.8 4.3	0.10 0.07 5.8 4.3	0.10 0.07 5.8 4.3
Category 1 600-3700 kW	all PM NOx	Same Tier 2 & 3 standards.																see note 3: 600 - <1400 kW: 0.04 0.03 1.8 1.3		0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3
	all PM NOx	displacement categories,																1400-2000 kW: 0.04 0.03 1.8 1.3		0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3
	all PM NOx	and start dates as for 75-600 kW (see note 6)																2000-3700 kW (see note 6): 0.04 0.03 1.8 1.3		0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3	0.04 0.03 1.8 1.3
Category 2 <3700 kW	7.0 - <15.0 PM NOx+HC	0.27 0.20 7.8 5.8							see note 2: 0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	0.14 0.10 6.2 4.6	
	15.0 - <20.0 PM <3300kW NOx+HC	0.50 0.37 8.7 6.5									0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	0.34 0.25 7.0 5.2	
	15.0 - <20.0 PM ≥3300kW NOx+HC	0.50 0.37 9.8 7.3									0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	0.27 0.20 8.7 6.5	
	20.0 - <25.0 PM NOx+HC	0.50 0.37 9.8 7.3									0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	0.27 0.20 9.8 7.3	
	25.0 - <30.0 PM NOx+HC	0.50 0.37 11.0 8.2									0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	0.27 0.20 11.0 8.2	
>=3700 kW	<15.0 PM NOx+HC	0.27 0.20 7.8 5.8							see note 2: NOx	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	0.12 0.09 1.8 1.3	
	>=15.0 PM NOx+HC	0.50 0.37 same as for <3700 kw							NOx	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	0.25 0.19 1.8 1.3	

Notes:

- option for 19-75 kW starting in 2014: 0.20 and 5.8 g/kW-hr (0.15 and 4.3 g/hp-hr) PM and NOx+HC.
 - option for C2 >1400kw: Tier 3 in 2012: 0.14/7.8 g/kW-hr PM/NOx+HC; Tier 4 in 2015, including 0.06 PM for >3700kW.
 - manufacturer may delay compliance within indicated 2017 compliance model year: to 10/1/2017 for 600-1000 kW
 - manufacturer may delay compliance within the indicated 2016 compliance model year: to 12/31/2016
 - any <75 kW engines with displacement above 0.9 L/cyl are subject to corresponding 75-600 kW standards
 - Tier 3 PM standards/dates apply for 2000-3700 kw, but not Tier 3 NOx+HC (Tier 2 NOx+HC levels apply through 2013)
- 1st MY for new standards are boxed in red

Tier 2
Tier 3
Tier 4

EPA's New Marine Diesel Standards (p.2 of 2)

New Marine Diesel Standards: High Power Density (>=35 kW/L) Commercial & Recreational

Category	Displacement L/cyl	Tier 2		2009	2010	2011	2012		2013		2014		2015		2016		2017		2018		2019	
		g/kW-hr	g/hp-hr				g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr
Category 1 <75kW	<0.9 PM <19 kW see note 1: <0.9 PM 19 - <75kW NOx+HC	same as for <i>standard</i> power density engines																				
Category 1 75-600kW	<0.9 PM NOx+HC	0.40 7.5	0.30 5.6				0.15 5.8	0.11 4.3	0.15 5.8	0.11 4.3	0.15 5.8	0.11 4.3	0.15 5.8	0.11 4.3	0.15 5.8	0.11 4.3	0.15 5.8	0.11 4.3	0.15 5.8	0.11 4.3	0.15 5.8	0.11 4.3
	0.9 - <1.2 PM NOx+HC	0.30 7.2	0.22 5.4				0.14 5.8	0.10 4.3	0.14 5.8	0.10 4.3	0.14 5.8	0.10 4.3	0.14 5.8	0.10 4.3	0.14 5.8	0.10 4.3	0.14 5.8	0.10 4.3	0.14 5.8	0.10 4.3	0.14 5.8	0.10 4.3
	1.2 - <2.5 PM NOx+HC	0.20 7.2	0.15 5.4						0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3
	2.5 - <3.5 PM NOx+HC	0.20 7.2	0.15 5.4				0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3	0.12 5.8	0.09 4.3
	3.5 - <7.0 PM NOx+HC	0.20/0.27 7.2/7.8	0.15/0.20 5.4/5.8				0.12 5.4	0.09 4.0	0.12 5.4	0.09 4.0	0.12 5.4	0.09 4.0	0.12 5.4	0.09 4.0	0.12 5.4	0.09 4.0	0.12 5.4	0.09 4.0	0.12 5.4	0.09 4.0	0.12 5.4	0.09 4.0
Category 1 >=600kW	all	Tier 2 and 3 standards and dates are the same as for high power density 75-600 kW engines (except see note 6 on standard power density summary)										Tier 4 standards and dates are the same as for <i>standard</i> power density engines (except no Tier 4 for recreational)										

Notes:

1) any <75 kW engines with displacement above 0.9 L/cyl are subject to the corresponding 75-600 kW standards

Tier 2

Tier 3

Tier 4

1st MY for new standards are boxed in red