Reducing Pollution from Trucks and Nonroad Equipment

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OTAQ Mission and Focus

All Air Emissions -- All Transportation Sources

- **Vehicles, Engines, Fuels**
- **Criteria pollutants (NOx, PM, …) and greenhouse gases (GHGs)**

Operate the National Vehicle & Fuel Emissions Lab

- **in Ann Arbor, Michigan**
- **Conduct official government certification & fuel consumption testing**
- **Test procedure development and technology evaluation**

Utilize a combination of approaches to fulfill mission

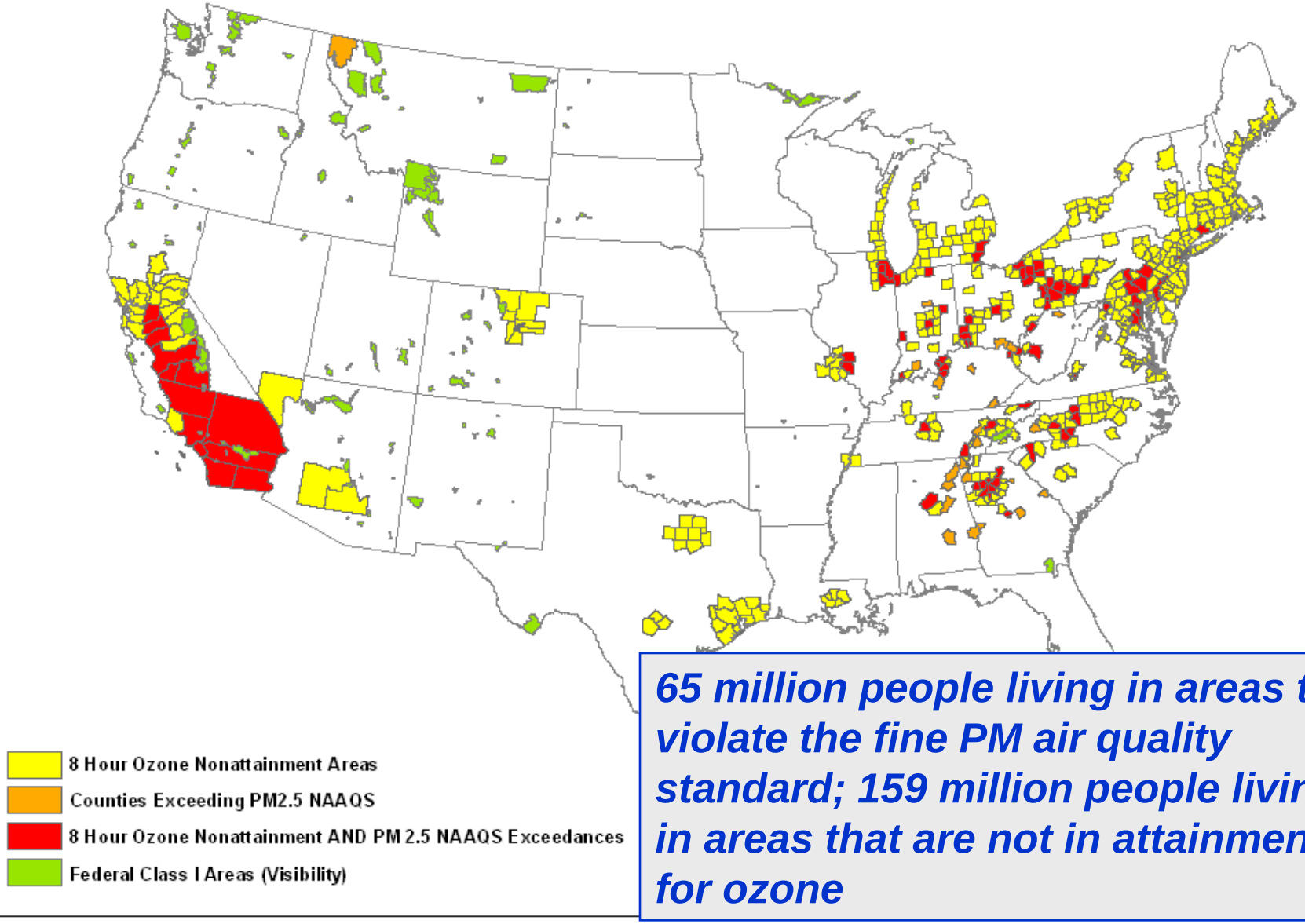
- **Mandatory performance-based standards**
- **Partnership incentive-based programs (Smartway, DERA grants)**

America's Work Horse Makes America Work …

… though not always appreciated …

Diesels in the 90's -- Under Pressure To Come Clean

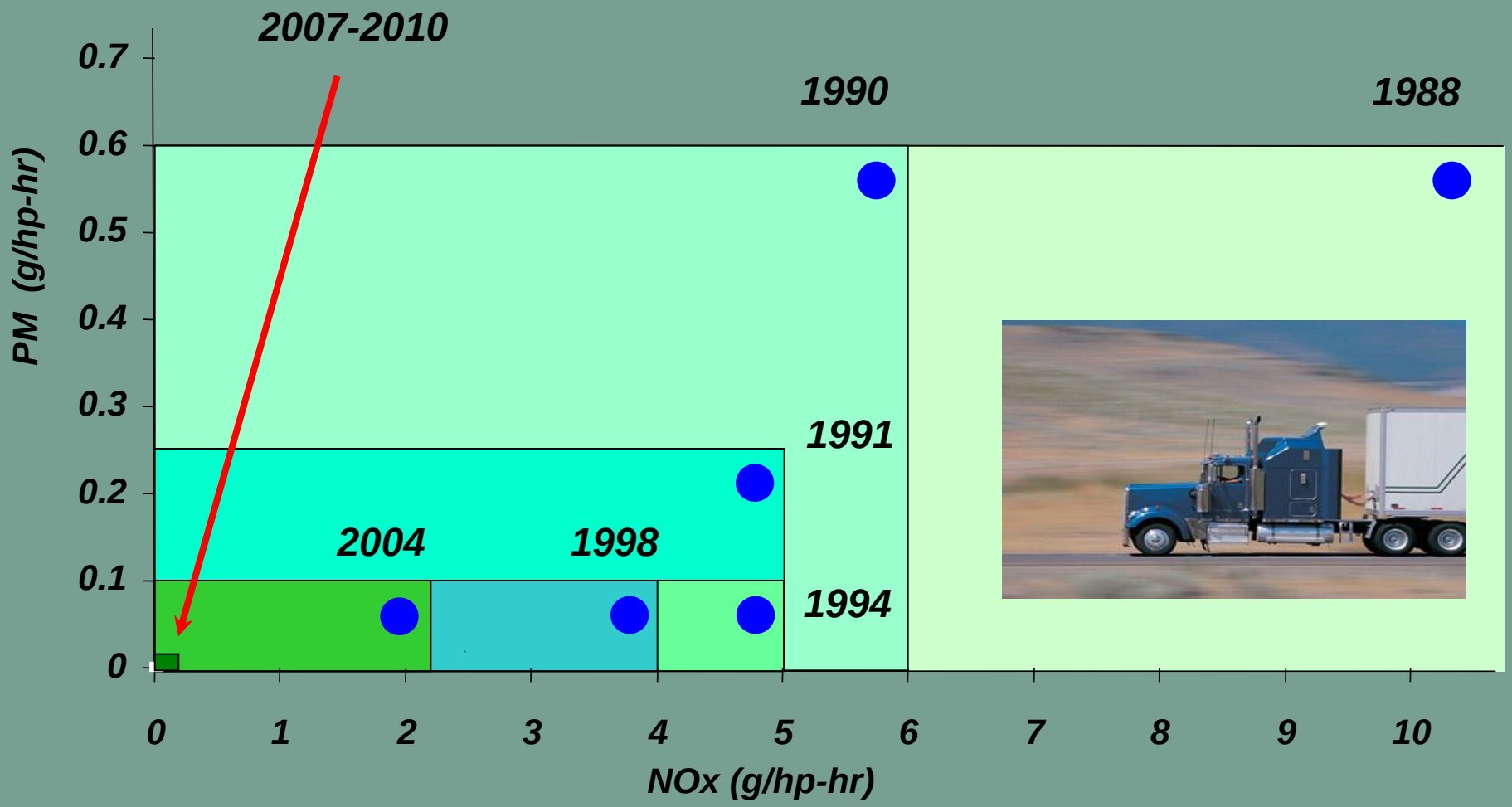
Widespread Need for Air Pollution Reductions



65 million people living in areas that violate the fine PM air quality standard; 159 million people living in areas that are not in attainment for ozone

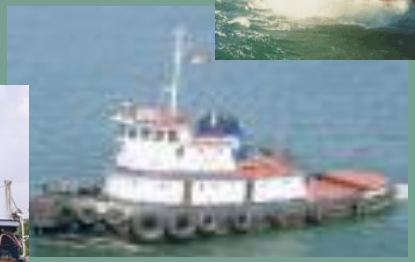
U.S. EPA Response--

Increasingly Stringent Technology-Forcing Standards

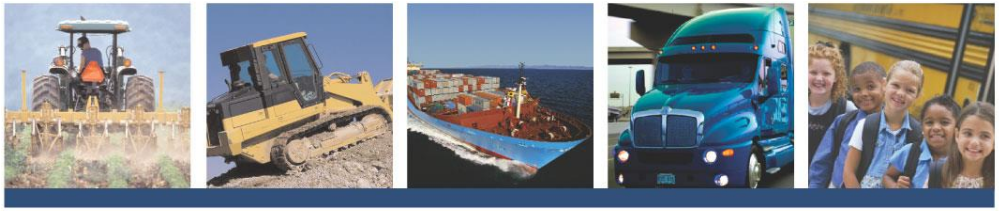


Reconciling Diesels with the Environment: **EPA's National Clean Diesel Campaign**

- **Systems approach– fuel change (ULSD) enables clean engine technology (exhaust aftertreatment)**
- **Large environmental benefits**
- **Responsive to needs of States to meet air quality goals**
- **Collaborative process**
- **EPA standard-setting rulemakings are enablers for collaborative partnerships with industry and state/local governments**



Tier 2 Light-Duty
fully phased in 2009



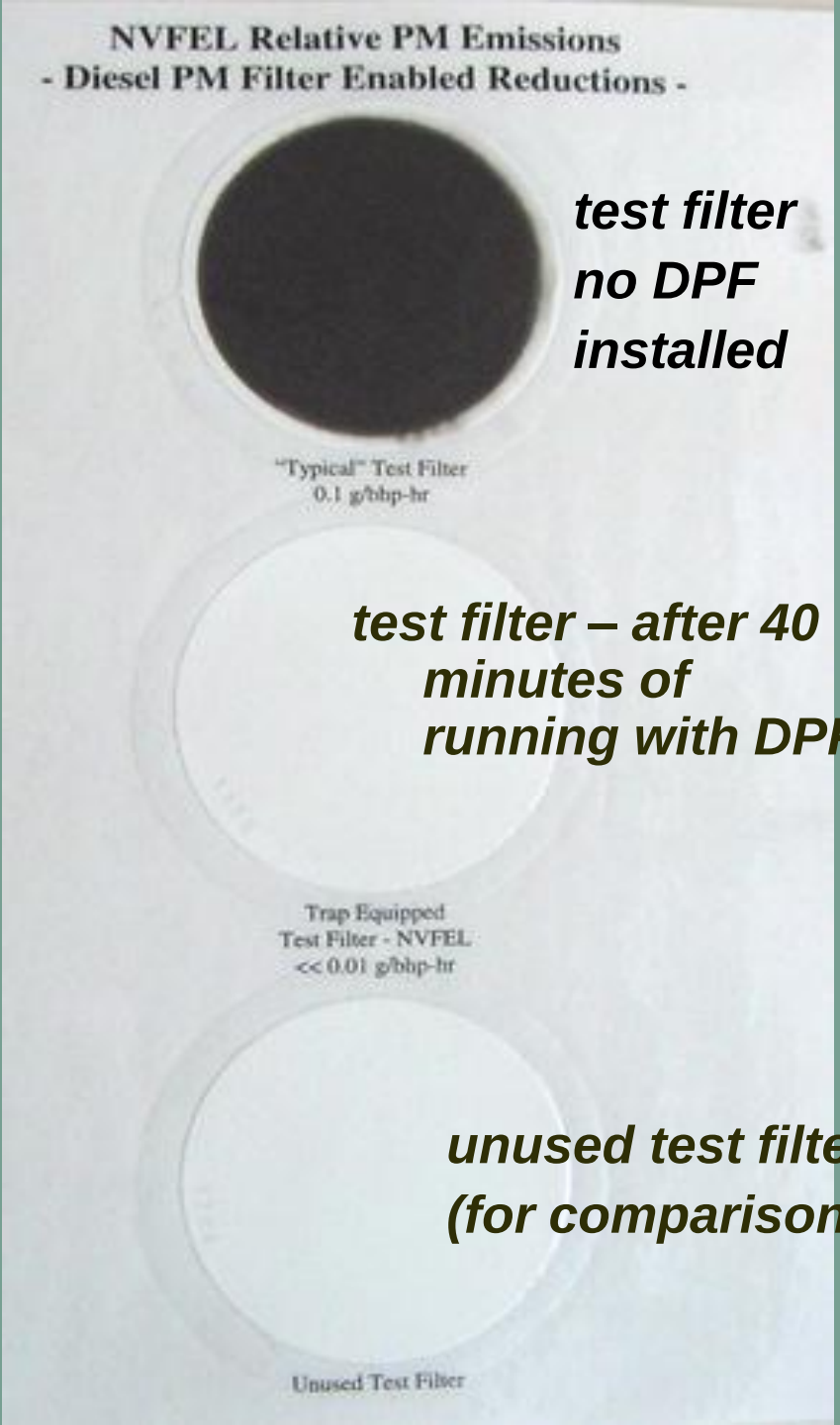
Heavy-Duty Highway
fully phased in 2010

Ocean-going Vessels
2015-2016

Locomotive/Marine
fully phased in 2017

Nonroad Diesel
fully phased in 2015

NVFEL Relative PM Emissions
- Diesel PM Filter Enabled Reductions -

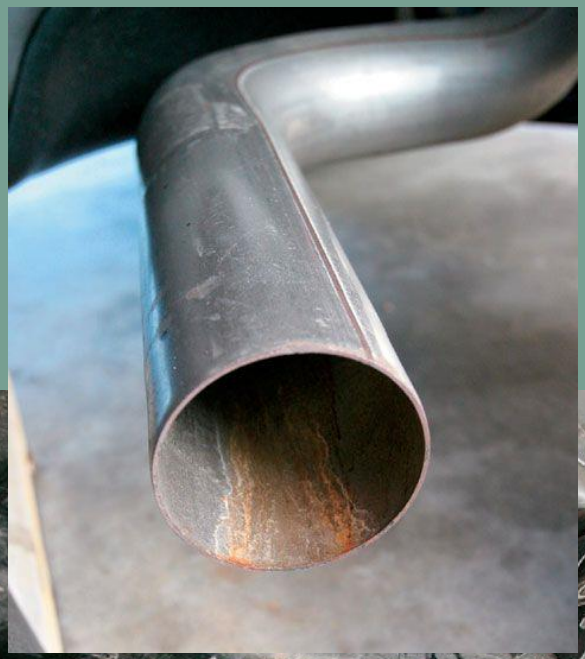


test filter no DPF installed

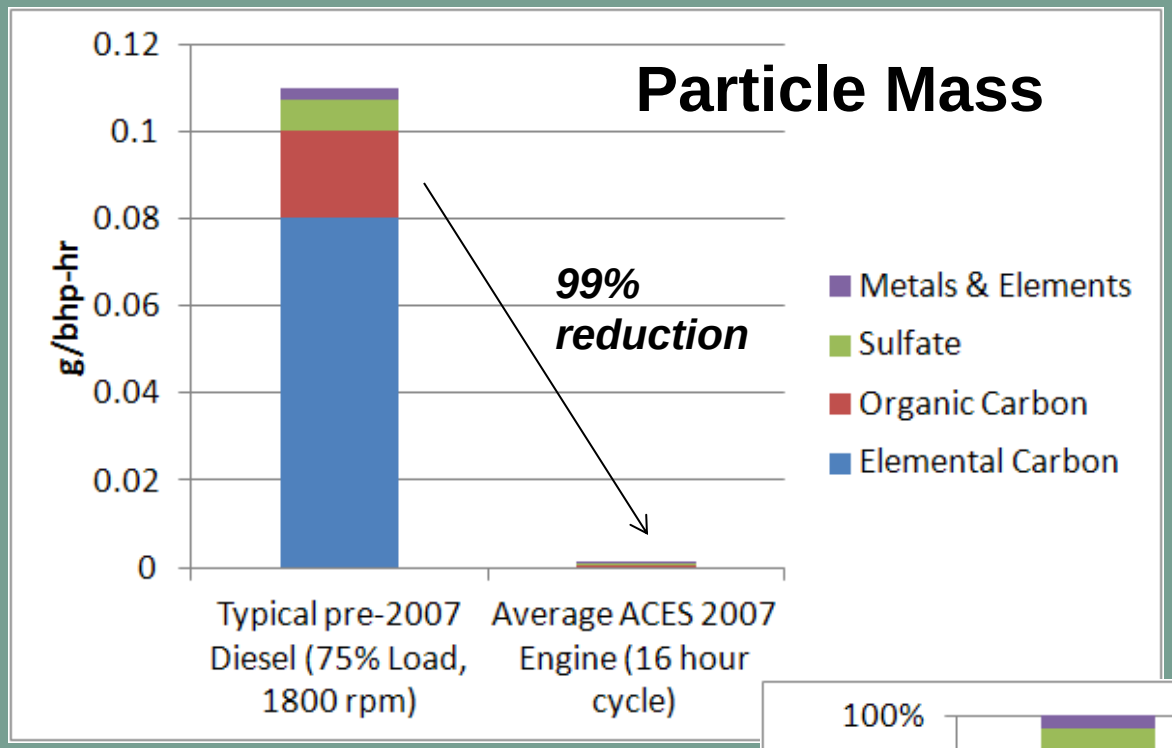
test filter – after 40 minutes of running with DPF

unused test filter (for comparison)

Millions of Diesel Particulate Filters (DPFs) are now in use

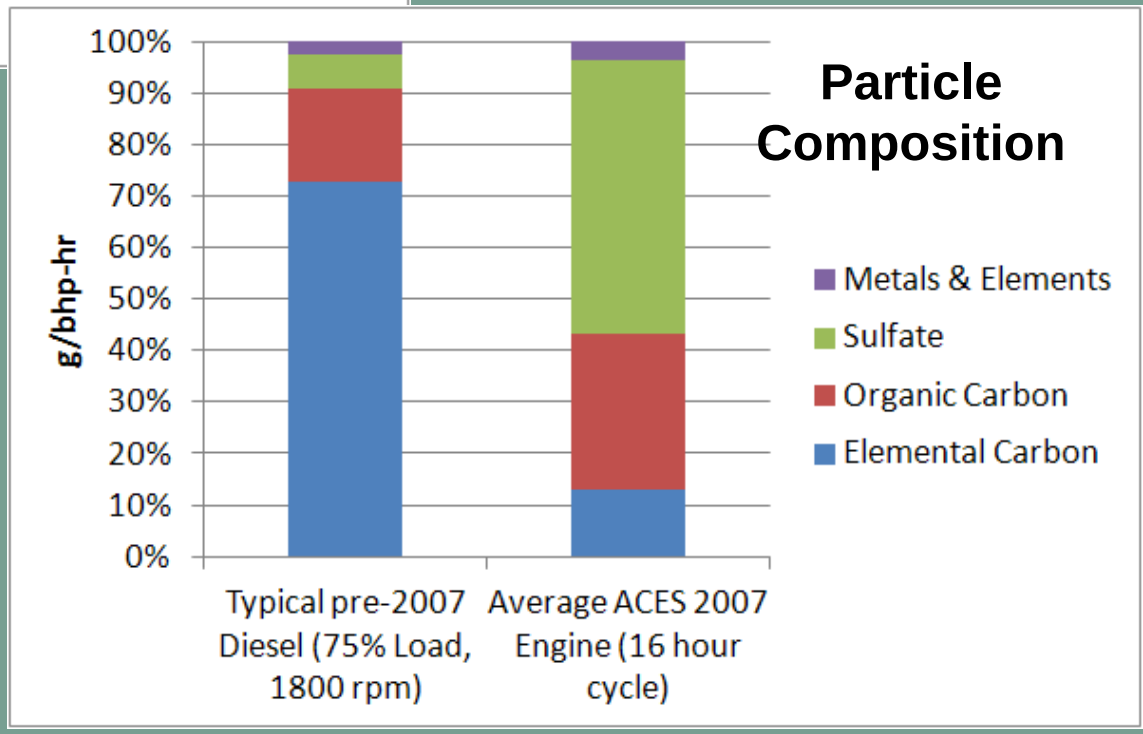


Source: DieselPower Magazine



DPFs Impact PM Emissions in Both Quantity and Make-up

Data from Advanced Collaborative Emissions Study (ACES)



Wide Range of Diesel Machines

skid steer loader 80 hp

backhoe loader 80 hp

genset 20 hp

2WD tractor 130 hp

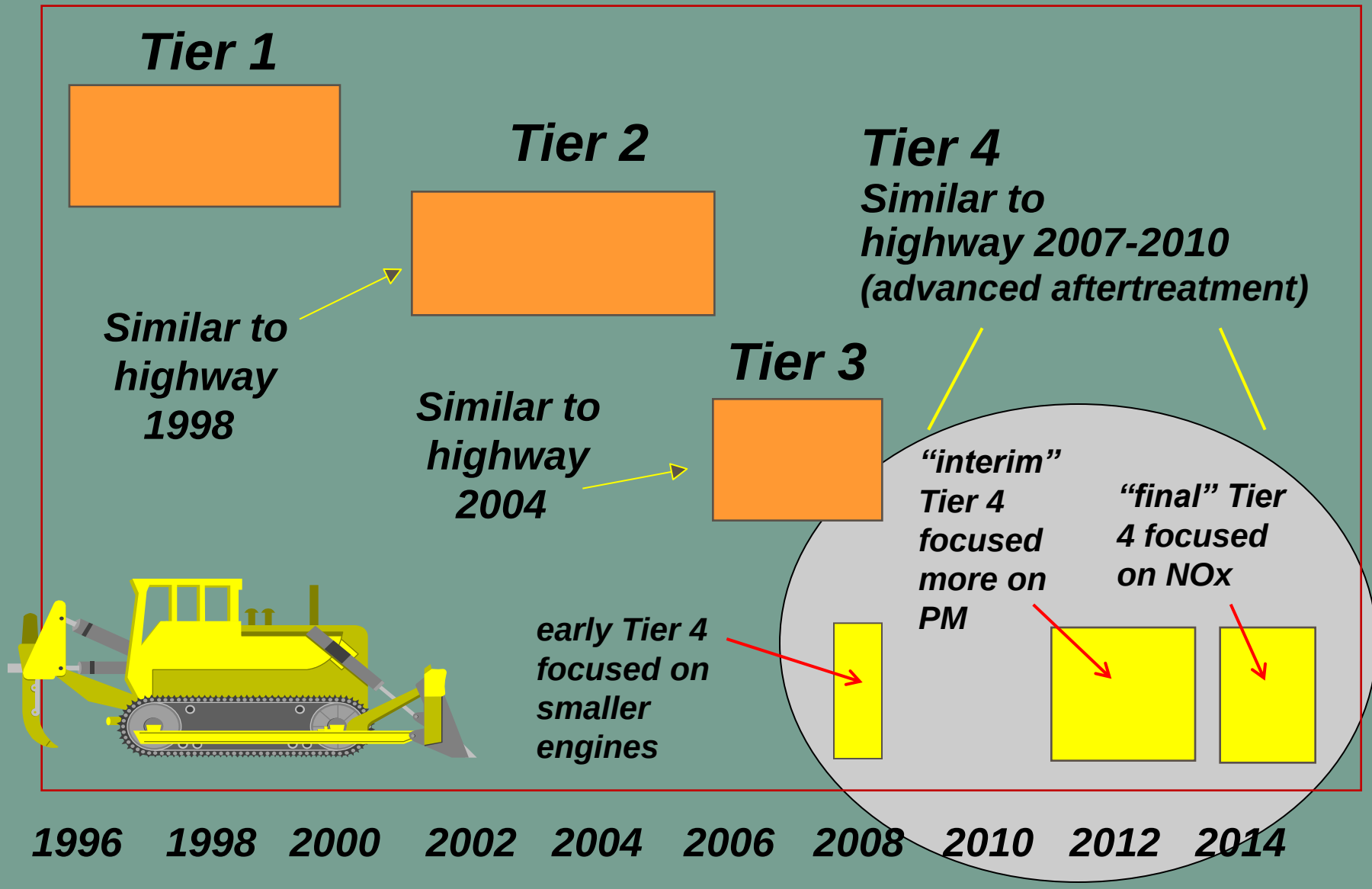
utility vehicle 18 hp

light tower 10 hp

combine 285 hp

off-hw truck 1000 hp

Phase-In of Nonroad Diesel Engine Programs



Nonroad Diesel Emission Standards

Tier 1
1996

Tier 4
2011-2014

Tier 3
2006

Tier 2
2001-2003

Standards and dates vary by engine size. Shown here are standards for 175-750 hp engines

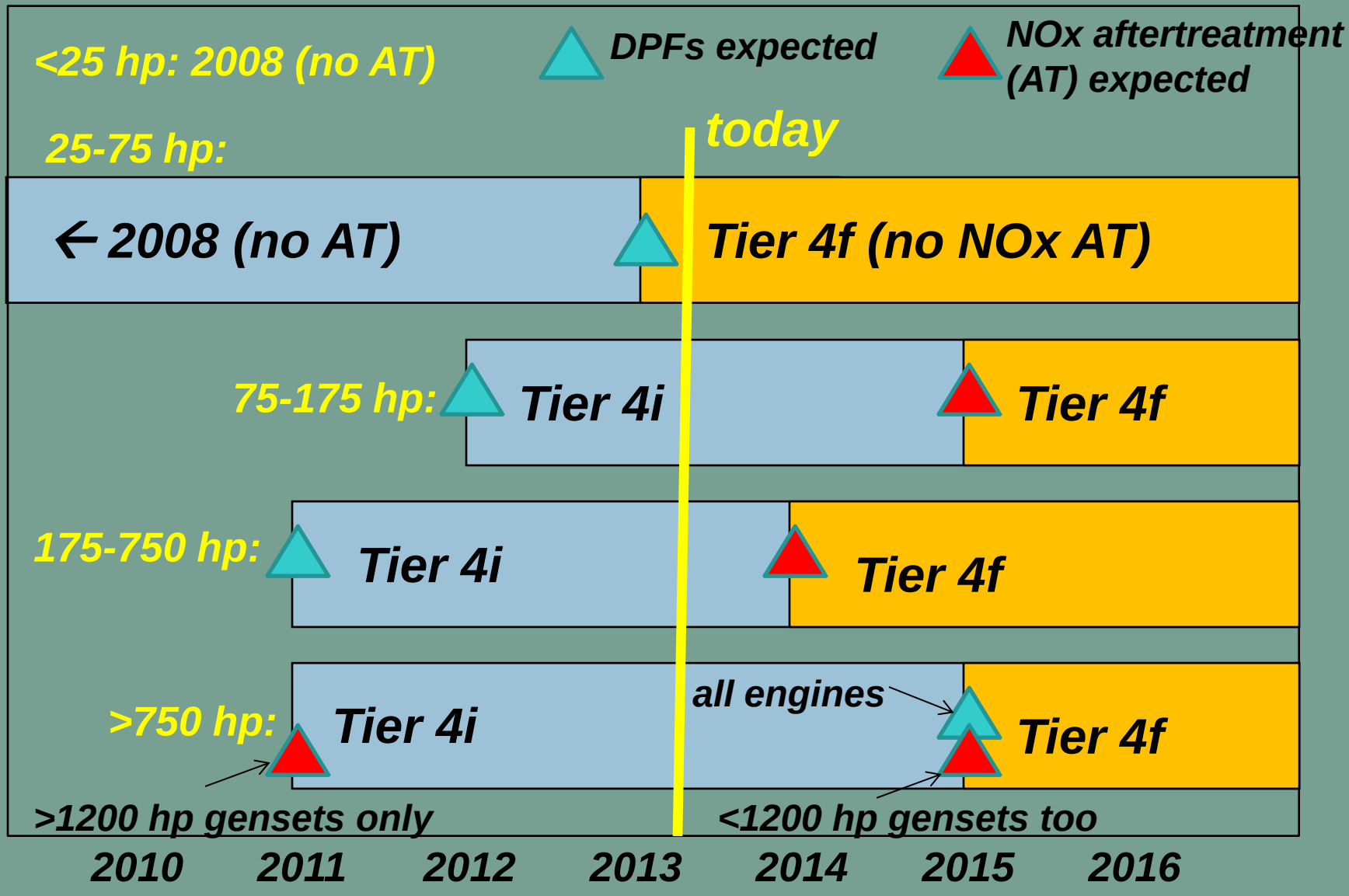
PM (g/hp-hr)

0.4
0.3
0.2
0.1
0

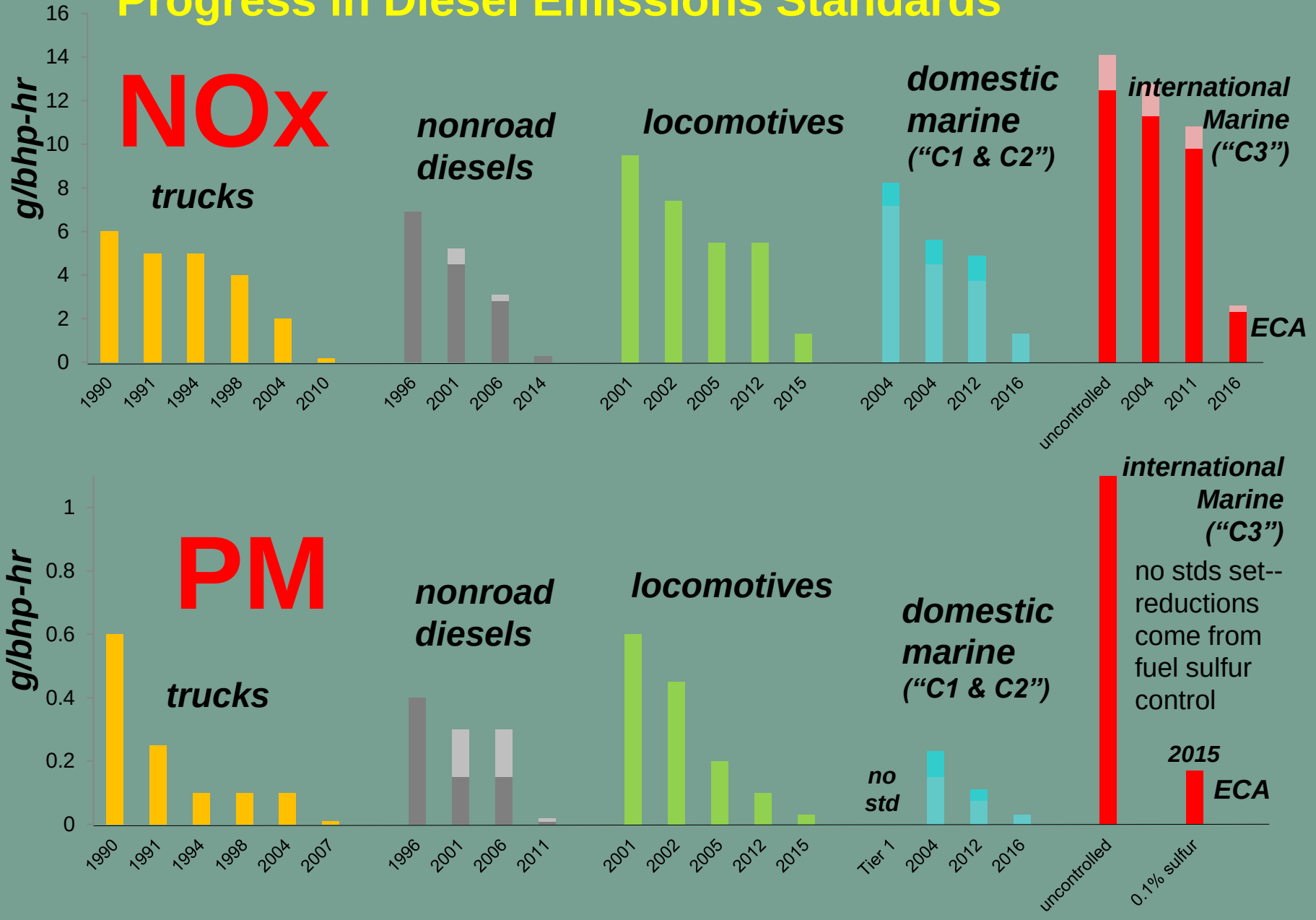
0 1 2 3 4 5 6 7 8

NOx (g/hp-hr)

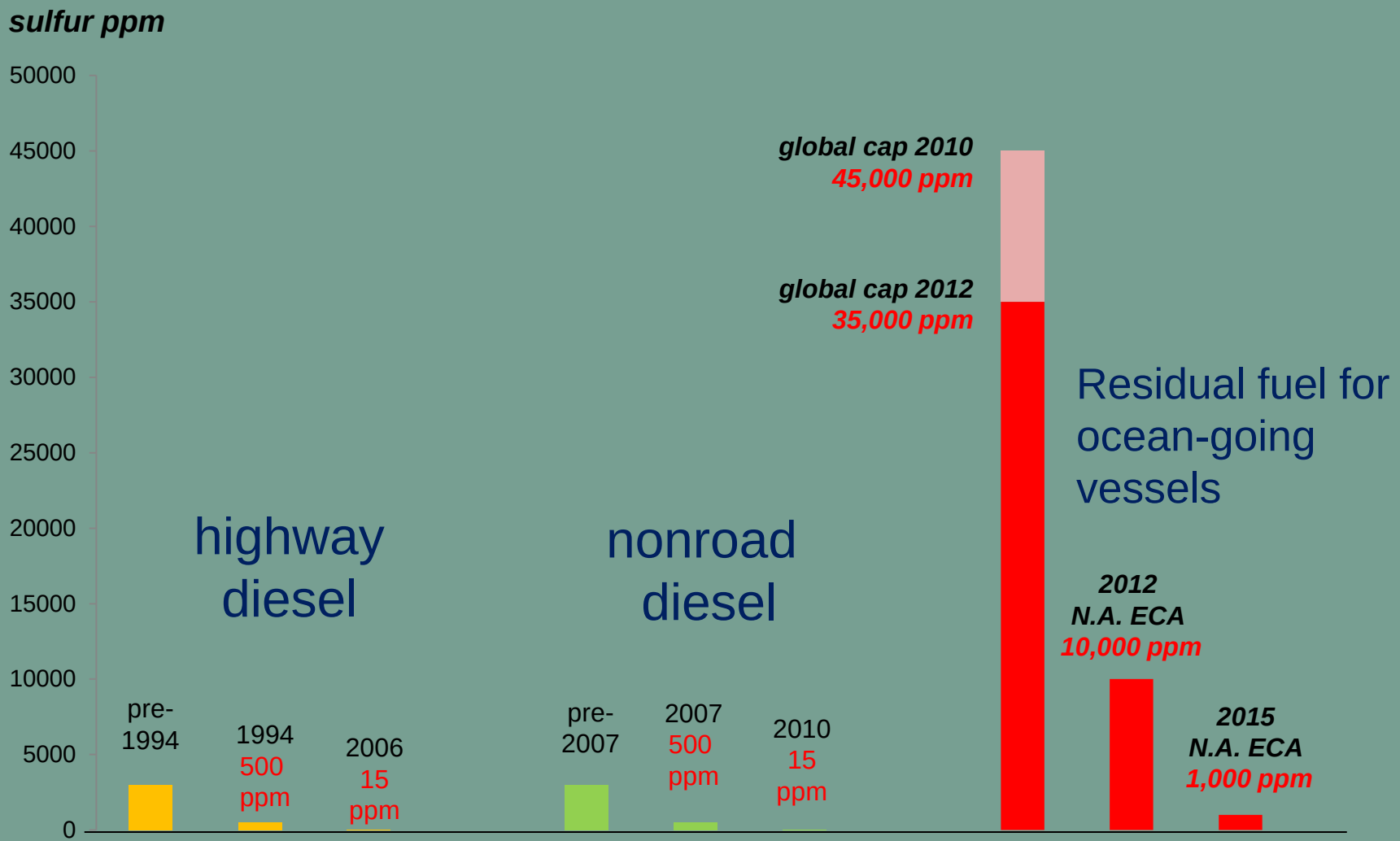
Phase-In to Nonroad Diesel Tier 4

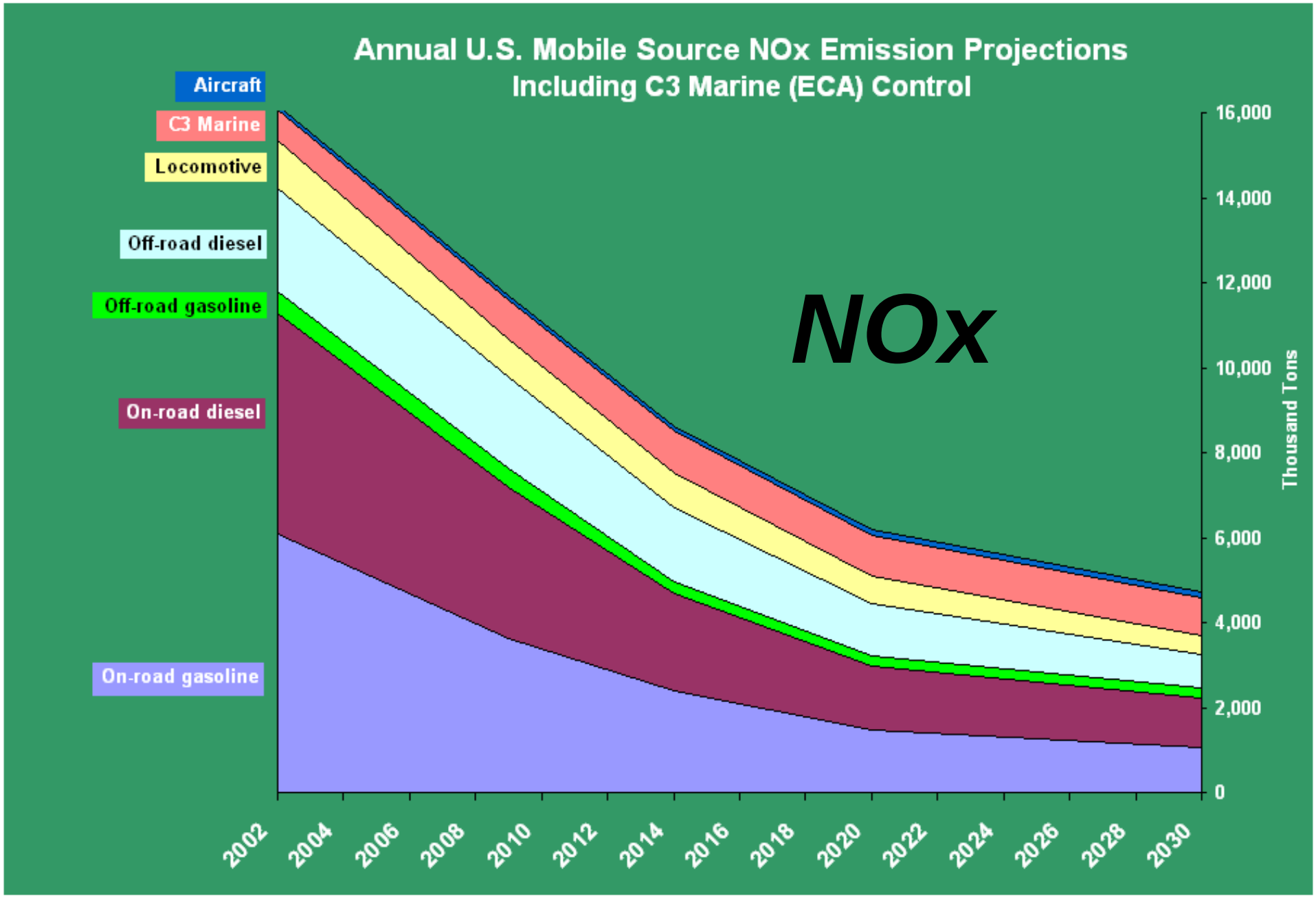


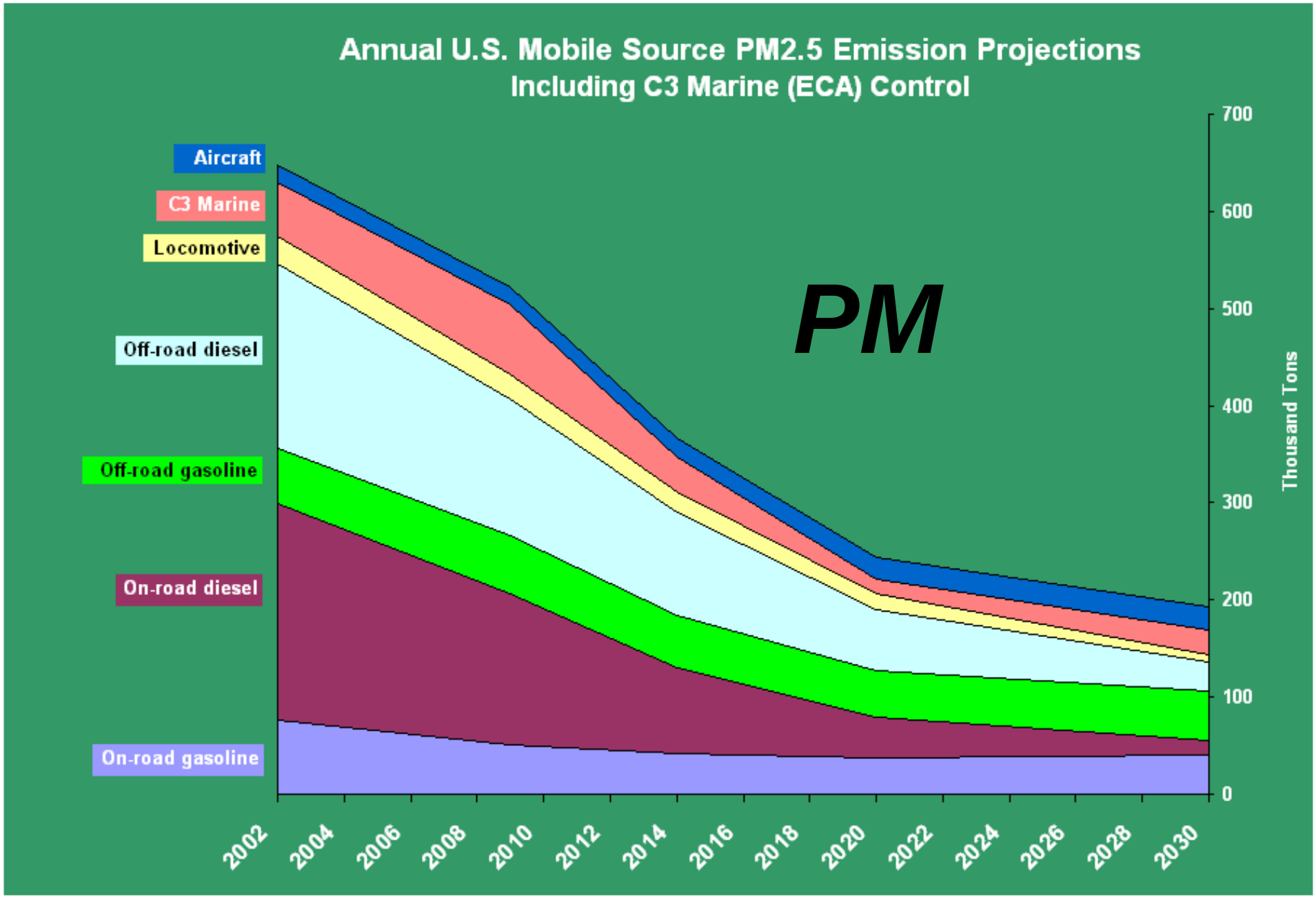
25 years of perseverance at a glance--
Progress in Diesel Emissions Standards



Clean Diesel Fuel Enables Clean Diesel Engines




Annual U.S. Mobile Source NOx Emission Projections
Including C3 Marine (ECA) Control
Aircraft
C3 Marine
Locomotive
Off-road diesel
Off-road gasoline
On-road diesel
On-road gasoline
NOx
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Thousand Tons
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030


Annual U.S. Mobile Source PM2.5 Emission Projections
Including C3 Marine (ECA) Control
Aircraft
C3 Marine
Locomotive
Off-road diesel
Off-road gasoline
On-road diesel
On-road gasoline
PM
700
600
500
400
300
200
100
0
Thousand Tons
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030

2007-2010 Standards Were A Major Step Change

- Previous standards focused only on engine improvements
- A new approach: Regulate vehicle and fuel as a system to gain order-of-magnitude reductions
- Low sulfur fuel enables advanced aftertreatment technology –
  - Diesel Particulate Filters (DPFs)
  - NOx catalysts
- 95%+ emission reductions in NOx & PM
- Also Very Large Secondary Benefits:
  - Truck program provided springboard for parallel programs:
    - Nonroad diesels (farm, construction), locomotives, marine vessels, voluntary retrofits of older trucks
  - Low sulfur highway diesel fuel also enabled light-duty diesels to meet stringent passenger car standards

Health Benefits of New Programs

premature deaths

chronic bronchitis

hospital admissions

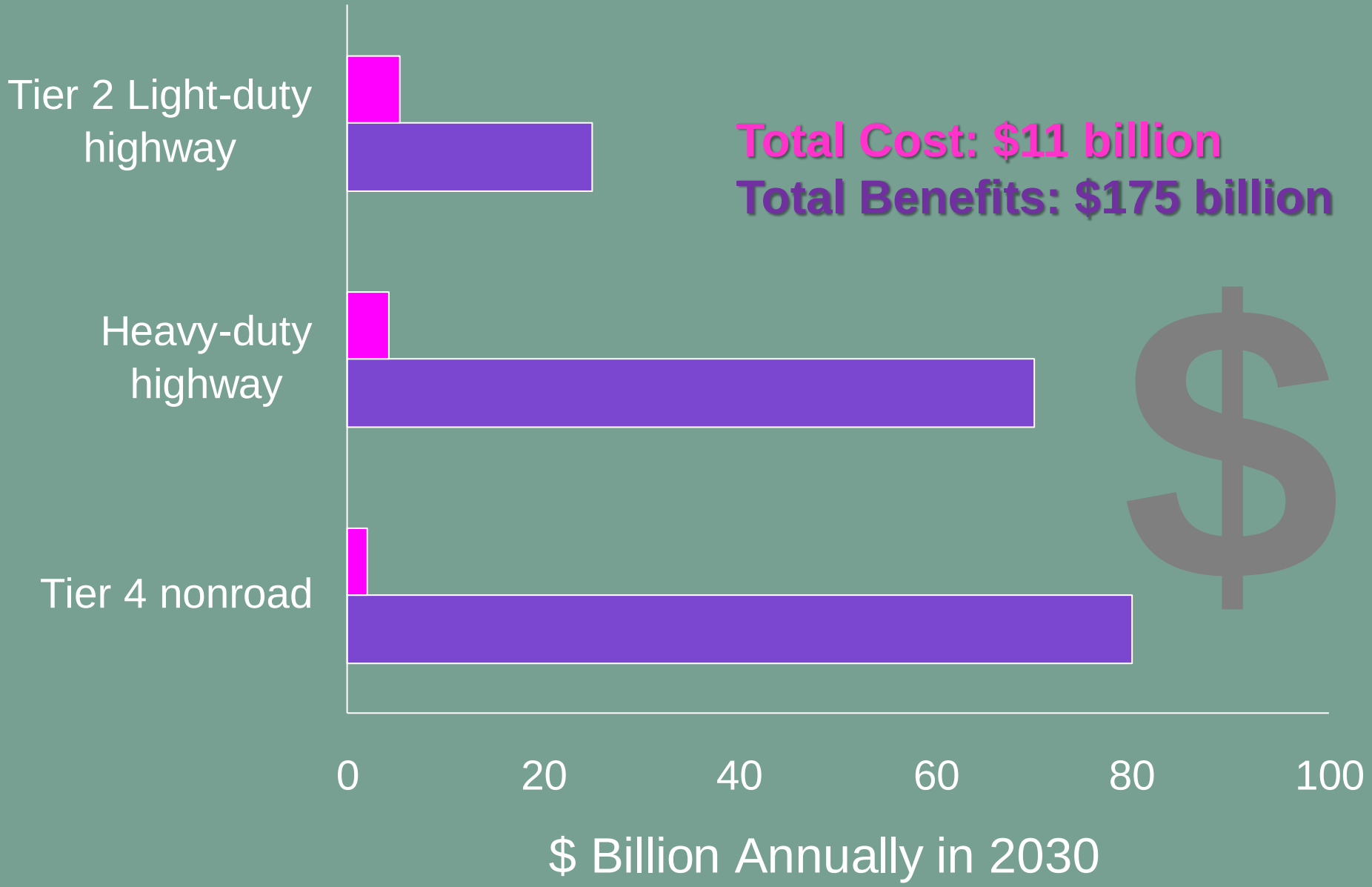
lost work days

over 3 million

0 10,000 20,000 30,000 40,000

prevented annually (in 2030)

Costs & Benefits of Clean Fuels and Vehicles

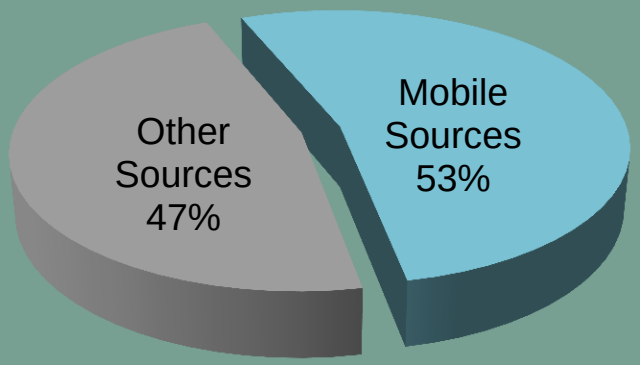


Nonroad DPF Tier 4f Product Plans

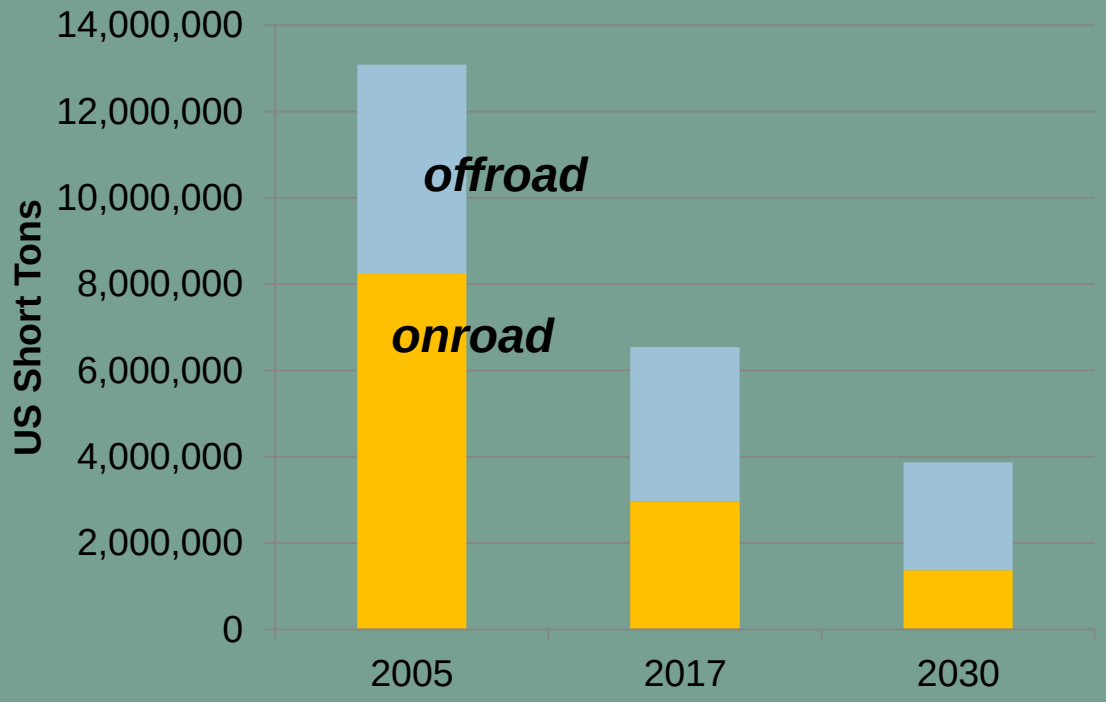
company	hp range	DPF?	notes
A	11-6600	yes (not >750hp, others?)	some have “no ash service DPF”; SCR in most T4f
B	49-4000	only >175 hp	DOC on 75-175 hp, no AT or EGR on <75 hp
C	48-600	yes	Adding SCR in T4f; maybe dropping some DPFs?
D	20-1032	no	SCR
E		only <100 hp	SCR w/o DPF for >100 hp
F	54-497	no	SCR, some cEGR
G	6-114	yes for some tractors	
H	25-100	no in T4i	
I	35-700	yes/optional	optional on 25-75 hp
J		yes in T4i	
K	4-110	yes in T4i	
L	141-700	yes in T4i	SCR
M	10-550	yes in T4i	
N	6-2680	yes in T4i	
O	30-12,200	no	
P		only <175 hp in T4i	But not in T4f?
Q	<173	no	no AT at all in T4f <75hp
R	2-74	yes	
S	275-770	no	SCR

Trends Looking Forward--
NOx

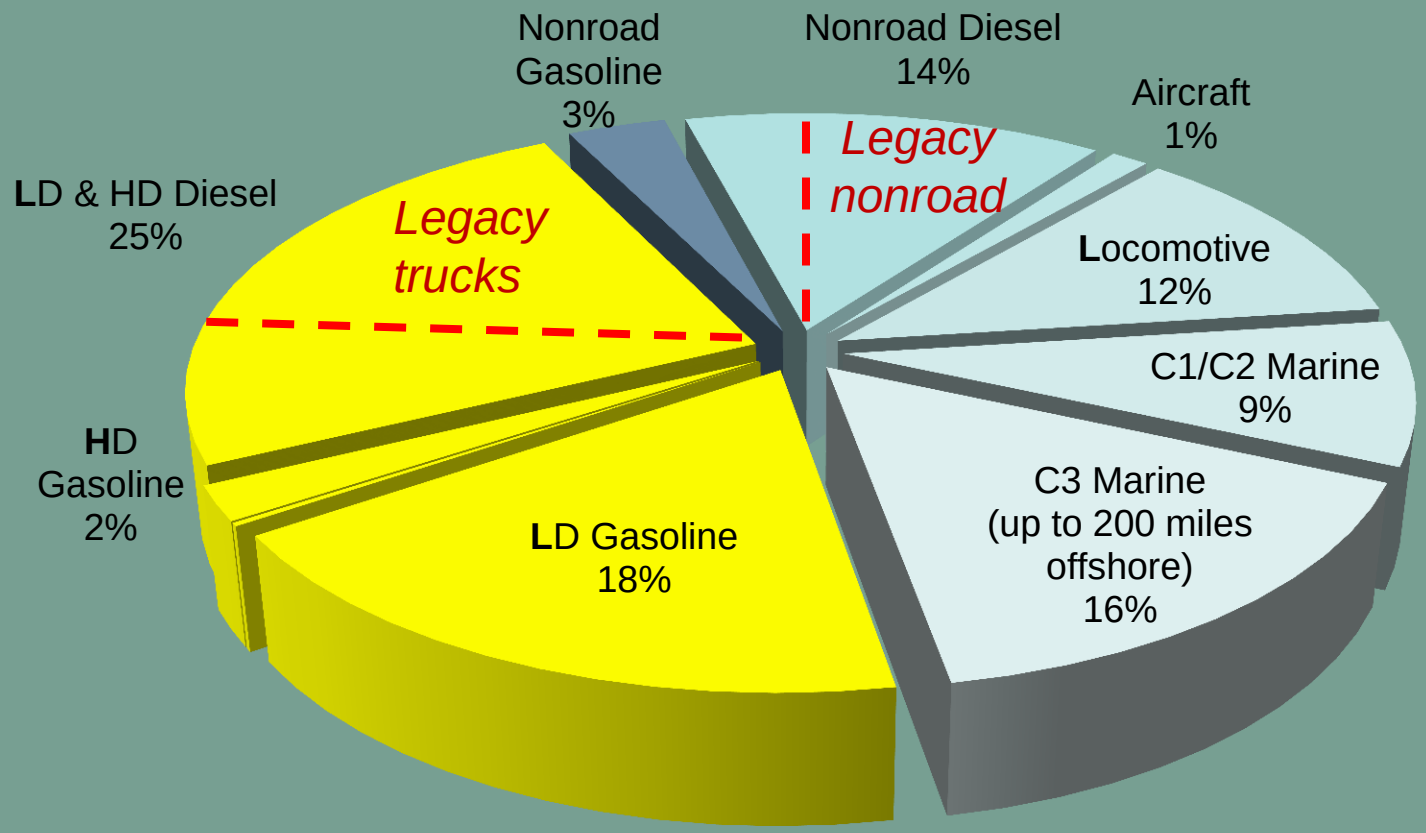
Contribution to Total Emissions in 2017



Mobile Source Trends

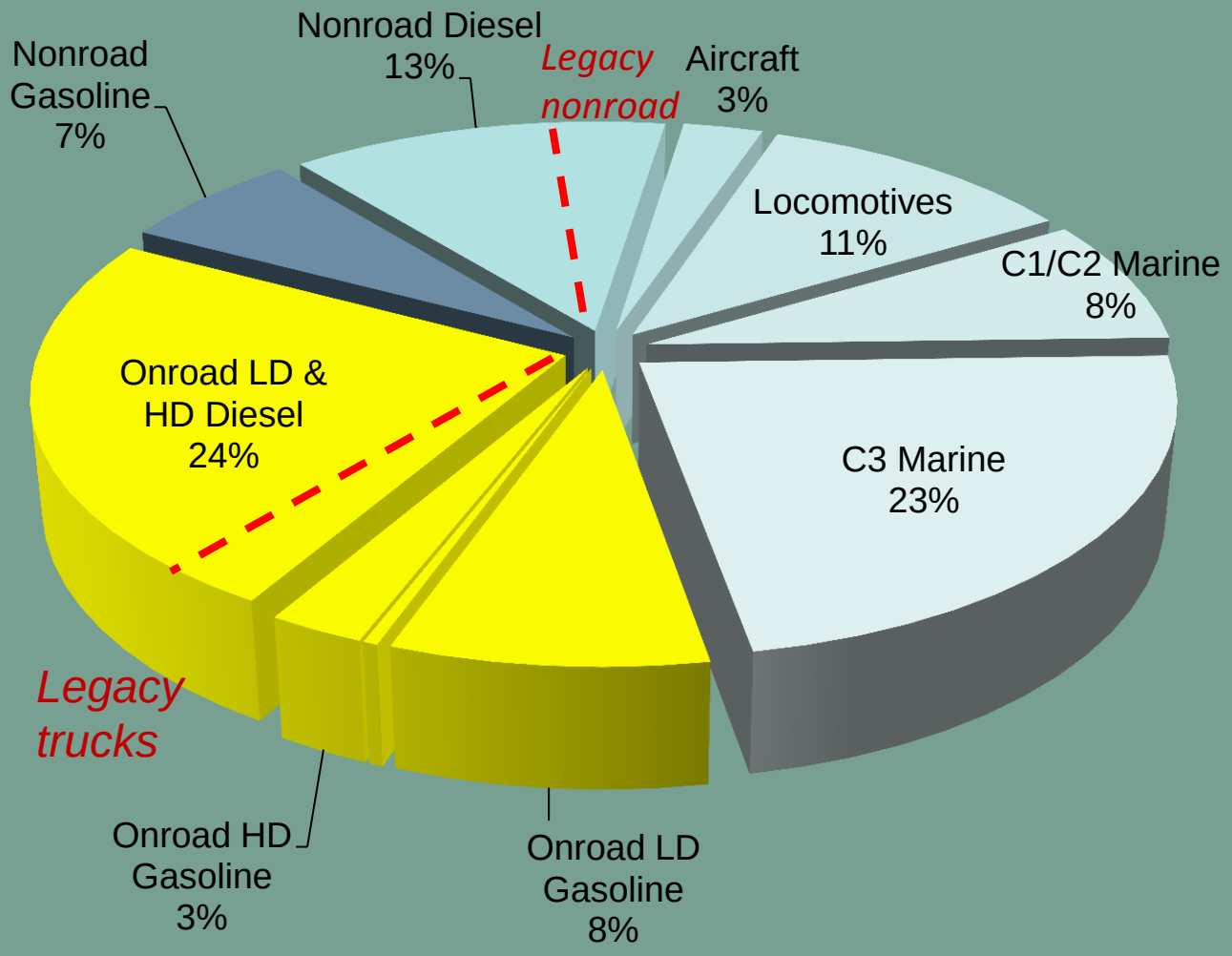


2017 NOx Breakdown



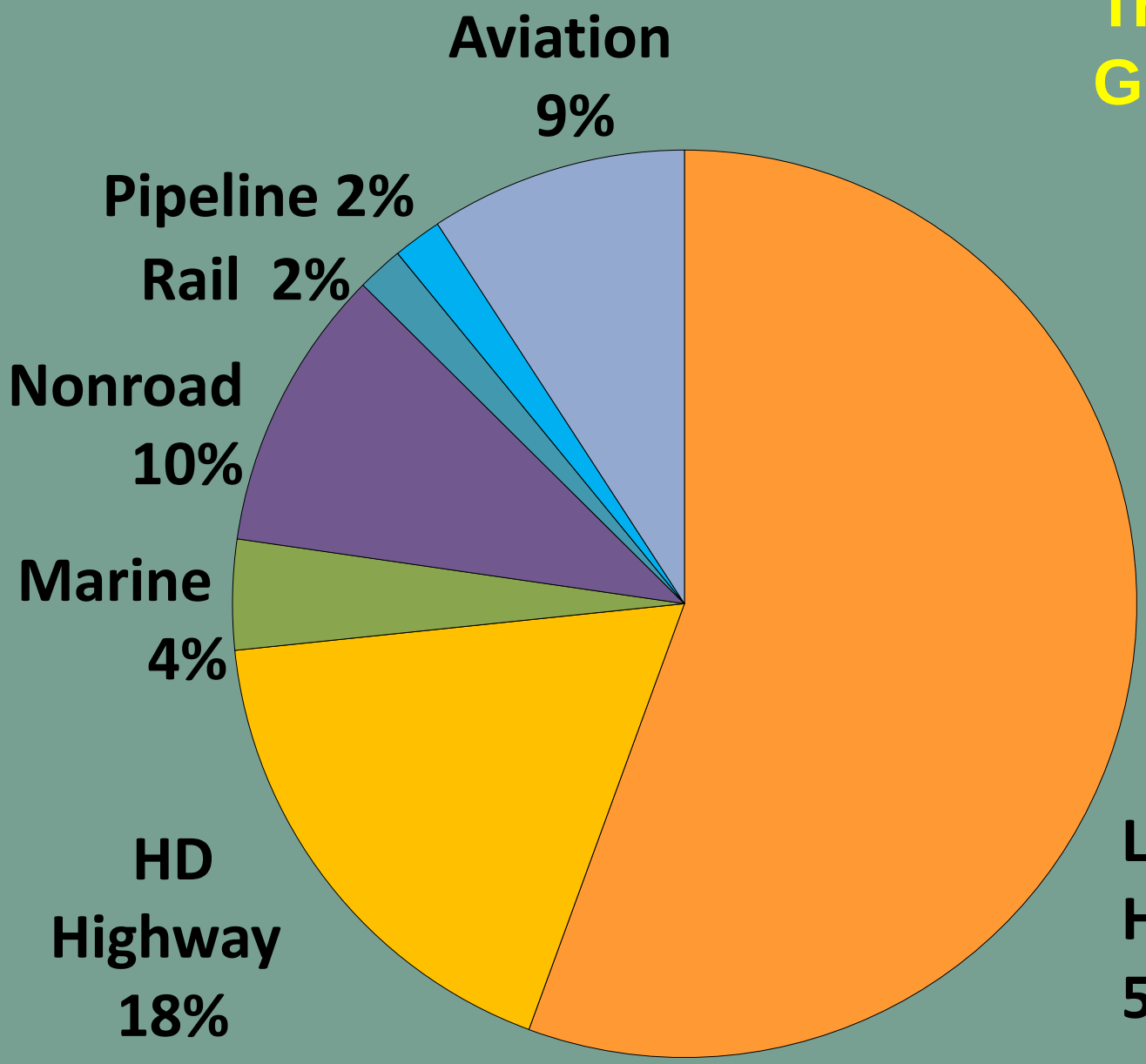
"Legacy":
- Pre-2007/10 HDD trucks
- Pre-Tier 4 Nonroad CI

2030 NOx Breakdown



Transportation GHG Inventory in 2010

(pre-GHG rules)



Total:
2138 mmt

New Initiatives Phasing In or Taking Shape

- **Light-Duty GHGs (EPA) and fuel economy (NHTSA)**
  - Phase 1 (“35.5 mpg”) set in 2010, phasing in 2012-2016
  - Phase 2 (“54.5 mpg”) set last year, phasing in 2017-2025
    - Mid-term re-evaluation of model year 2022+ standards
- **Heavy-Duty GHGs (EPA) and fuel consumption (NHTSA)**
  - Phase 1 set in 2011, phasing in 2014-2018
  - Phase 2 under development
- **Highway Tier 3 for non-GHGs pollutants**
  - New exhaust standards for <14,000 lb GVWR
  - Also evaporative emissions standards for larger HDGVs
  - Proposed last month, comment period thru July 1
  - Class 2b/3 standards would phase in 2018-2022
  - Mostly involves improvements on current technologies

HD GHG Phase 1 Structure

HD pickups and vans

- Tested using chassis dynamometers; like LD
- g/mi standard versus work factor (considers payload, towing)

Vocational vehicles

- Engine tested over same cycles as NOx & PM, g/hp-hr standard
- Vehicle certified using GEM simulation; only tires recognized, g/ton-mi standard

Combination tractors

- Engine tested over same cycles as NOx & PM, g/hp-hr standard
- 9 subdivisions for different cab designs
- Vehicle certified using GEM simulation, g/ton-mi standard, recognizing:

  Tires, aero, mass reduction, idle reduction, vehicle speed limiter

Averaging, banking, and trading credit flexibilities

Innovative and advanced technology credit generating options

- Some tests require “A to B” testing; includes hybrids

Phase 1 stringencies focused on off-the-shelf technologies

- set with Phase 2 in mind

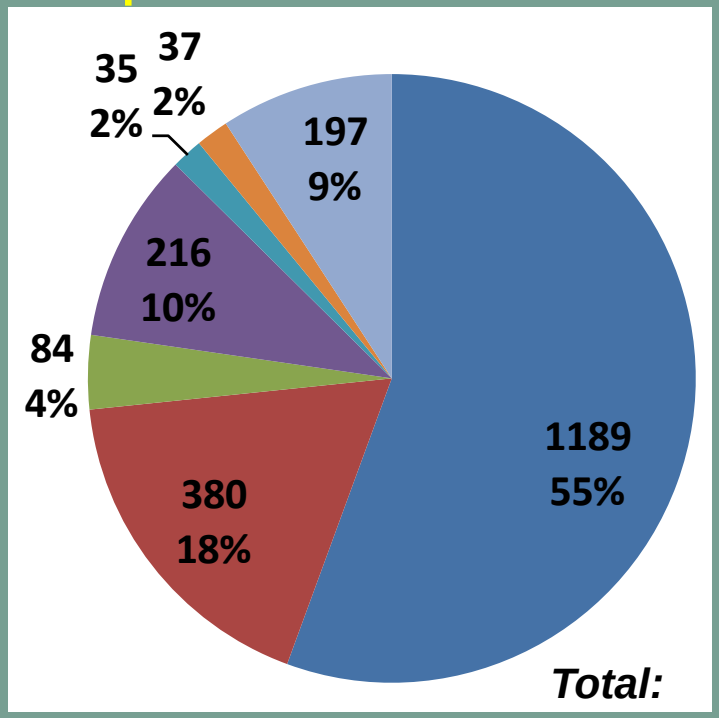
HD GHG Phase 2 Considerations

- Maintain a single national program
- Maintain Phase 1 regulatory structure
- Consider advanced technologies

  Waste-heat recovery, hybrids, etc.; as identified in National Academy of Sciences report
- Revamp GEM to better reflect real-world improvements, new technologies
- Consider trailers
- Standards taking effect sometime after 2018

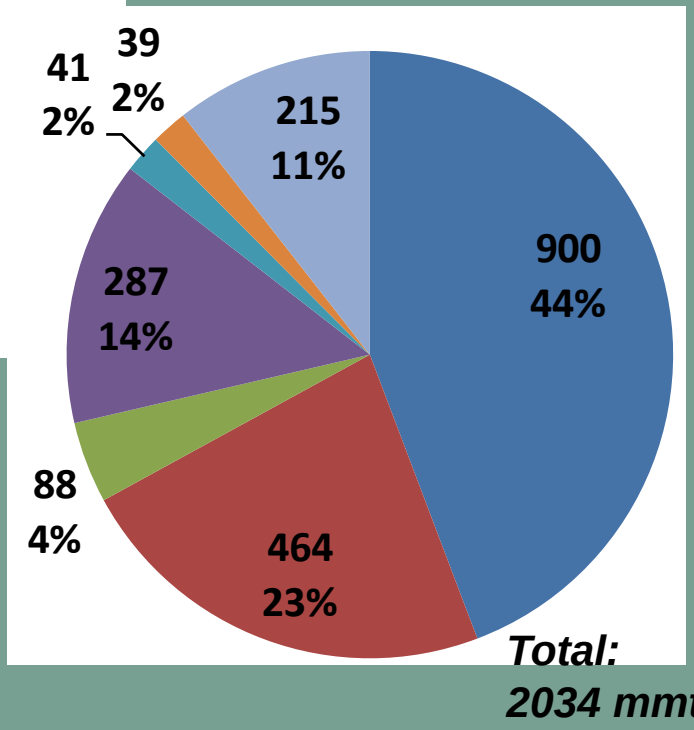
Transportation GHG emissions 2010 and projected 2030

2010
pre-GHG rules



Light Duty
MD/HD highway
Marine
Non-road
Rail
Pipeline
Aviation

2030
with recent LD & HD GHG rules



A Cost-Effective GHG Program Looks at All the Tools in the Toolkit

Operations-based measures—

- *used in voluntary EPA programs (such as Smartway)*
- *may provide good opportunity to gain credits*
- *greater human element-- reductions must be verifiable*
- *provides many more options—*
  - *speed reduction, idling reduction, system efficiency improvements, …*

Vehicle-based measures—

- *(or "equipment"-based, or "vessel"-based)*
- *has been EPA approach for LD highway – "g/mile"*
- *greatly expands the technology options --*
  - *transmissions, hybrids, …*

Engine-based measures--

- *traditional EPA standards-setting for HD sectors – "g/hp-hr"*
- *rewards only <u>engine</u> design improvements --*
  - *electronic fuel controls, 2-stage turbos …*

Developments to Watch

- Continuing air quality problems in California and elsewhere → Calling for more NOx and PM reductions
- Rapid development of fuel-efficient light-duty vehicles
- New offerings of light-duty diesel car and truck models
- Prospects for continued natural gas vehicle expansion
- Roll-out of nonroad Tier 4 technologies
- Focus in Europe on particle number control
- EPA/NHTSA mid-term evaluation


Game 6
June 4, 2008