

**M.J. Bradley & Associates**

# **Mitigating SLCFs – Reducing Black Carbon**

NESCAUM Training Session

Short-lived Climate Forcers

September 22, 2010

# Outline

- Black Carbon Inventory
  - ✓ What are the main mitigation opportunities?
  - ✓ How do mitigation opportunities vary by location?
- Mitigation Technologies/approaches
  - ✓ Diesel emission reduction
  - ✓ Wood smoke reduction
- Barrier and Trade-offs

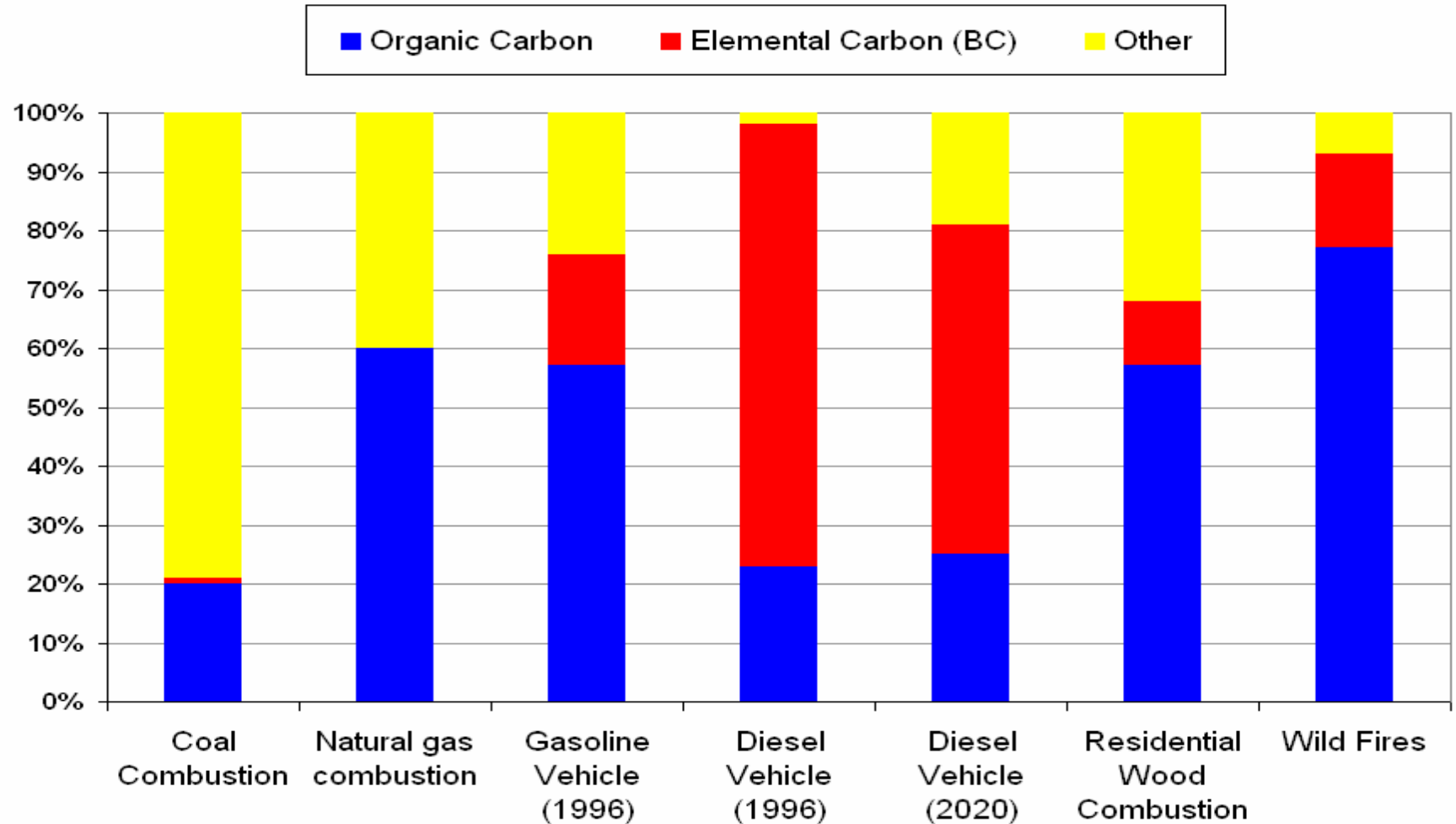


# Black Carbon Sources

- Black carbon is primarily produced during combustion of carbon-rich fuels
  - ✓ Coal, petroleum, natural gas, bio-mass
  - ✓ Unburned carbon particles
- BC is a component of Primary PM emissions from both mobile and stationary sources
  - ✓ Proportion of PM that is BC varies by combustion source
  - ✓ Other components of PM: Organic carbon, Sulfates, nitrates
- Most important BC sources can vary significantly across a region
  - ✓ Very significant urban/rural difference

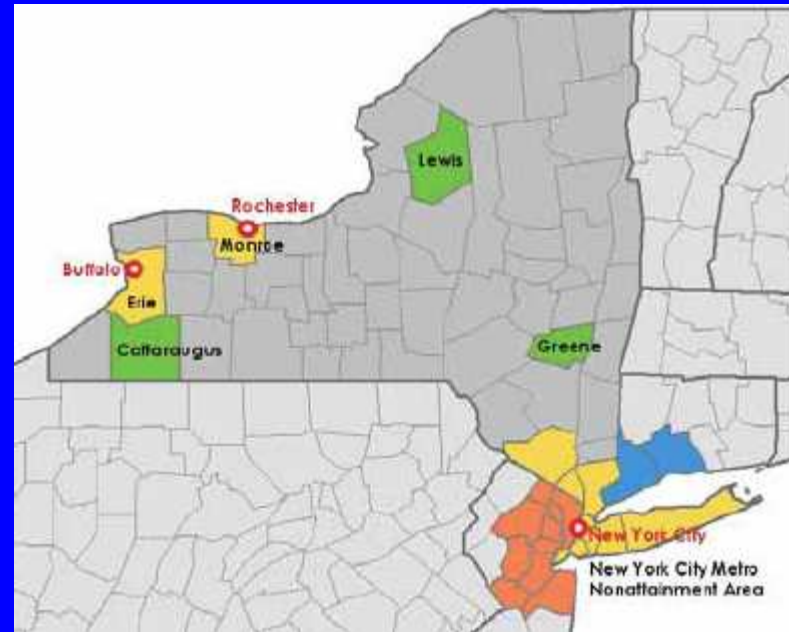


# BC Portion of Primary PM

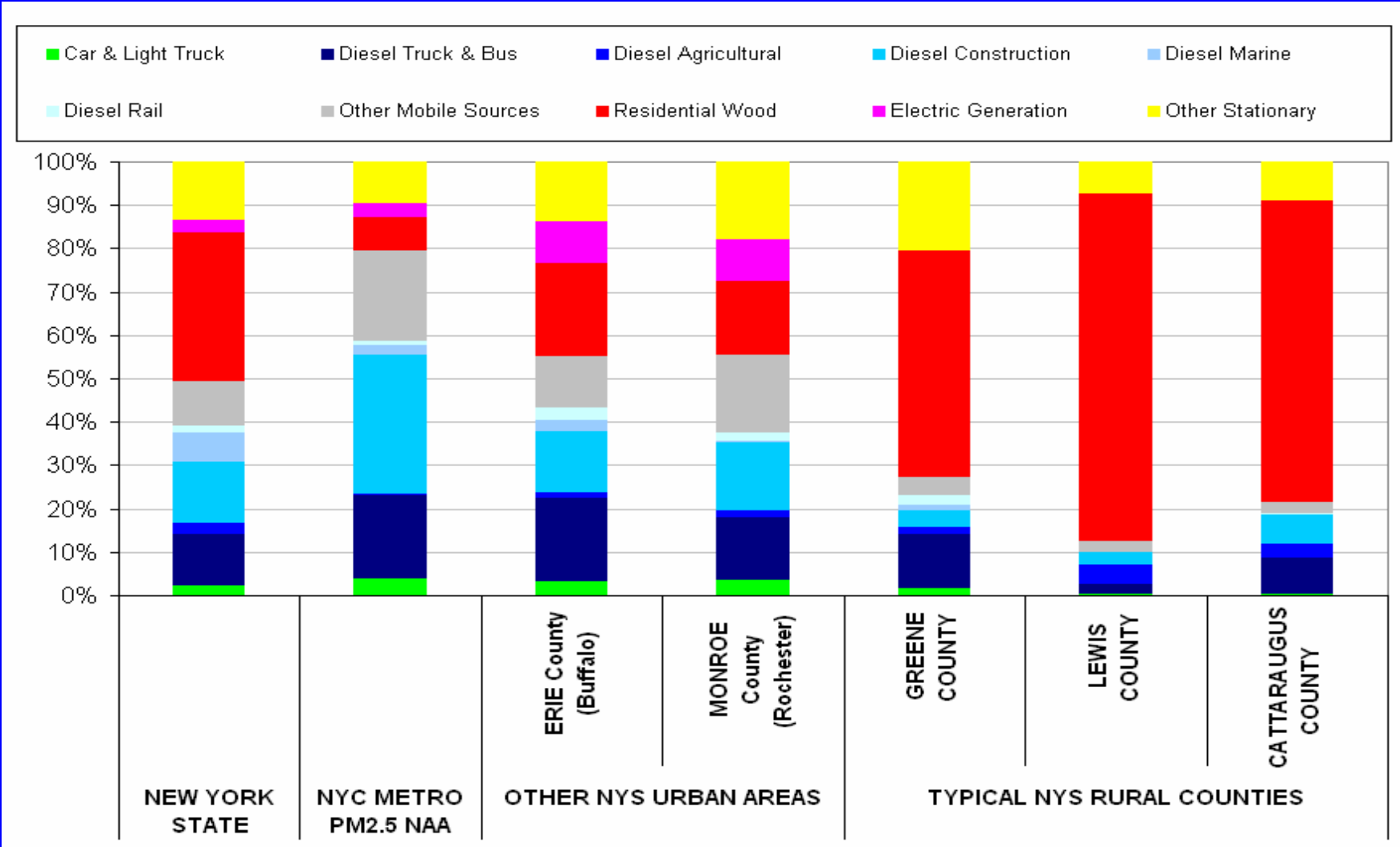


# BC Sources in NYS

- Will use  $PM_{2.5}$  emissions in New York State to illustrate major BC sources & regional variation
  - ✓ Based on EPA 2002 NEI
  - ✓ Applied EPA factors by combustion source to calculate BC portion
  - ✓ Compare:
    - NYC NAA
    - Rochester Area
    - Buffalo Area
    - Three rural counties



# NYS Black Carbon Sources



# Open Burning & Wild Fires

- PM from “open bio-mass burning” a significant source of global BC emissions
  - ✓ ~10-12% of total annual BC in New York State
  - ✓ ~30% of global BC emissions \*
- PM from open bio-mass burning has higher OC:EC ratio than PM from fossil fuel or solid bio-fuel burning \*
  - ✓ PM appears brown rather than black
  - ✓ Can turn white when hydrated in the atmosphere
- Scientific uncertainty as to net short and long-term effect on warming
  - ✓ Potential short-term cooling from released particles, and longer-term warming from released CO<sub>2</sub> and deforestation \*



# BC Reduction Opportunities

- Diesel
  - ✓ Onroad
  - ✓ Nonroad
- Residential Wood-fired heating
  - ✓ Fire places
  - ✓ Wood stoves
  - ✓ Outdoor wood boilers
- Will not discuss open biomass burning due to scientific uncertainty as to net short term effect, and lack of policy options





# Onroad Diesel

- ❑ Diverse fleet
- ❑ Nationally, total fuel use and emissions dominated by CL8 combination trucks
- ❑ In urban areas vocational trucks, buses more important
- ❑ All have similar engines, 200 – 500 hp
- ❑ EPA Emission standards will result in full “clean up” by 2020 - 2025



# Nonroad Diesel

## □ Construction & portable engines

- ✓ Similar to onroad diesel (25 – 2500 hp)
- ✓ Less advanced technology



## □ Locomotive

- ✓ Engines are unique
- ✓ Switcher (~2000 hp), Linehaul (3500+ hp)

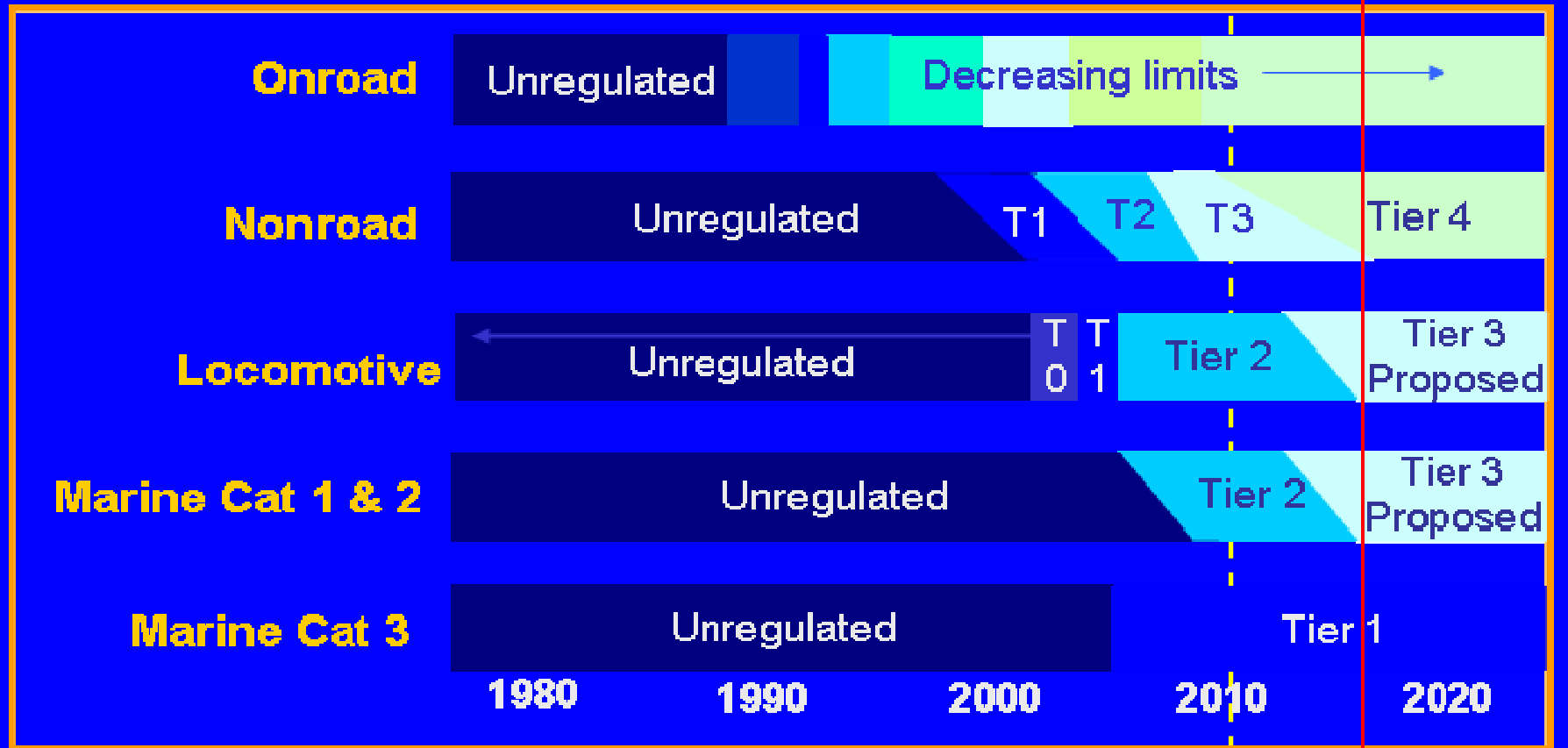


## □ Marine

- ✓ Harbor craft - construction or locomotive engines
- ✓ Ocean-going – unique engines up to 100,000 hp
- ✓ Burn heavy, residual “bunker” fuel



# Diesel Emission Standards



*Tier 0 locomotive standards apply retroactively to engines built since 1973, upon remanufacture.*

**"Zero"  
BC  
Emissions**



# Diesel Emission Reduction

- **Repair**

- ✓ Inspection & maintenance

- **Repower or Replace**

- ✓ Take advantage of new, EPA-compliant engines

- **Retrofit**

- ✓ DOC, FTF, DPF

- **Reduce Long Duration Idling**

- ✓ Most effective for sleeper cab –equipped truck, switcher locomotives

- **Reduce fuel use**

- ✓ VMT reduction, hybrid and advanced technologies



# Diesel Policy Options

- Retrofit/Repower/Replacement programs
  - ✓ Mandatory (state/local regulation)
  - ✓ Mandatory for government contracting (state/local regulation)
  - ✓ Voluntary (with Funding Assistance)
- Diesel Inspection & Maintenance
- Highway Truck Idle Reduction
- Locomotive Idle reduction



# Retrofit Programs

## □ Precedents

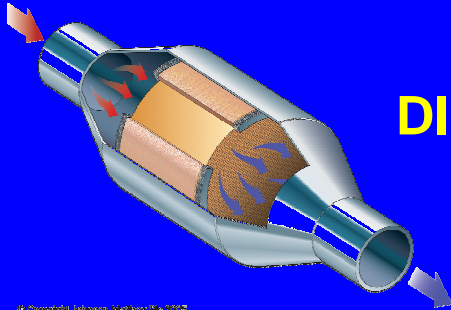
- ✓ Mandatory: CARB, NJ
- ✓ Gov't Contracting: NYC Local Law 77
- ✓ Voluntary: EPA DERA, NYS Bond Act, Carl Moyer

## □ Constraints

- ✓ High cost
- ✓ No economic incentive for vehicle owner
- ✓ Lack of verified technology
- ✓ High sulfur fuel limits DPF use (locomotive, marine)
- ✓ Fleet turn-over limits candidate vehicles (onroad)

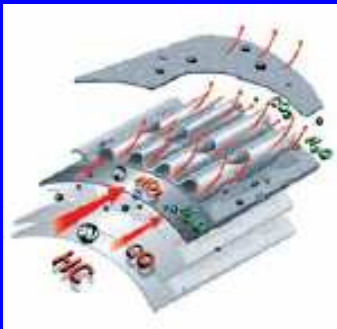


# Diesel Retrofits



## DIESEL OXIDATION CATALYST

- 20 – 30% PM reduction
- 0 – 10% BC reduction
- \$1,000 - \$3,000/engine

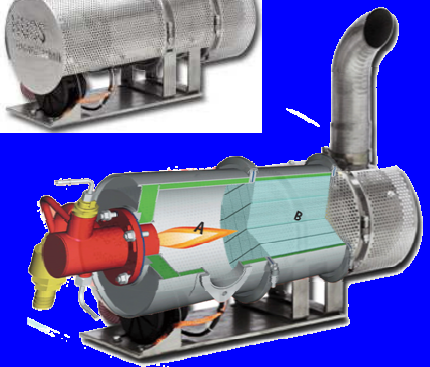
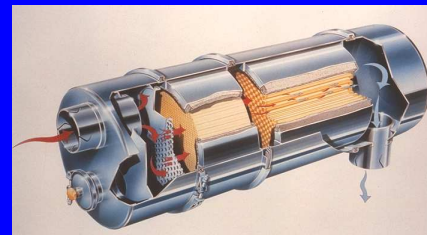


## FLOW-THRU FILTER

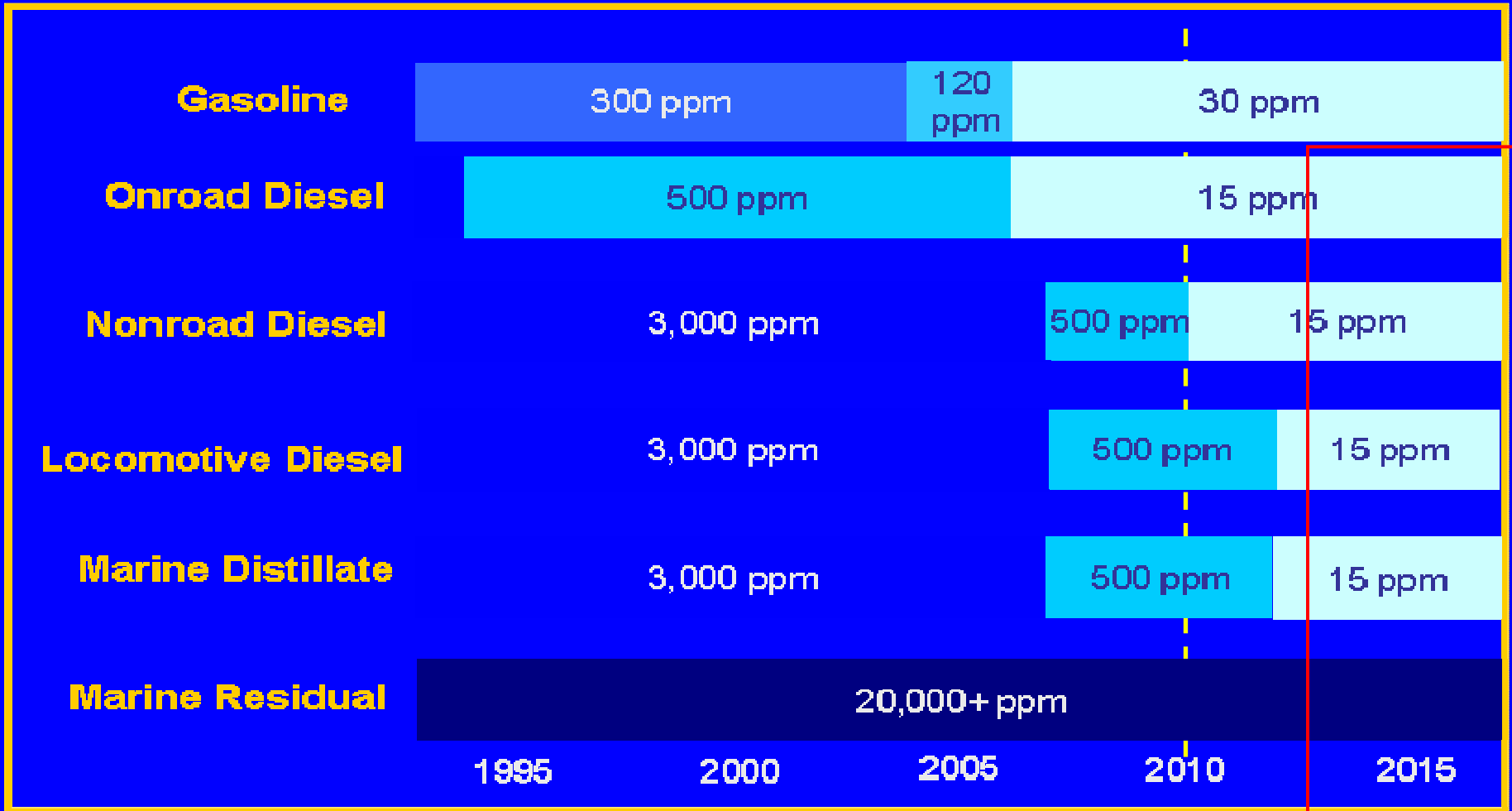
- 50 – 70% PM reduction
- 20 – 50% BC reduction
- \$4,000 - \$10,000/engine

## DIESEL PARTICULATE FILTER

- 85 - 99% PM reduction
- 85 - 99% BC reduction
- \$6,000 - \$30,000/engine



# Diesel Fuel Sulfur



Req'd for DPF





# Diesel Inspection & Maintenance

- Precedents

- ✓ Opacity testing in MA, NY

- Constraints

- ✓ Not practical for unregistered nonroad equipment
- ✓ Opacity not well correlated to PM / BC mass or particle number – need better test methods
- ✓ Failure threshold in most current programs too high for modern, clean engines

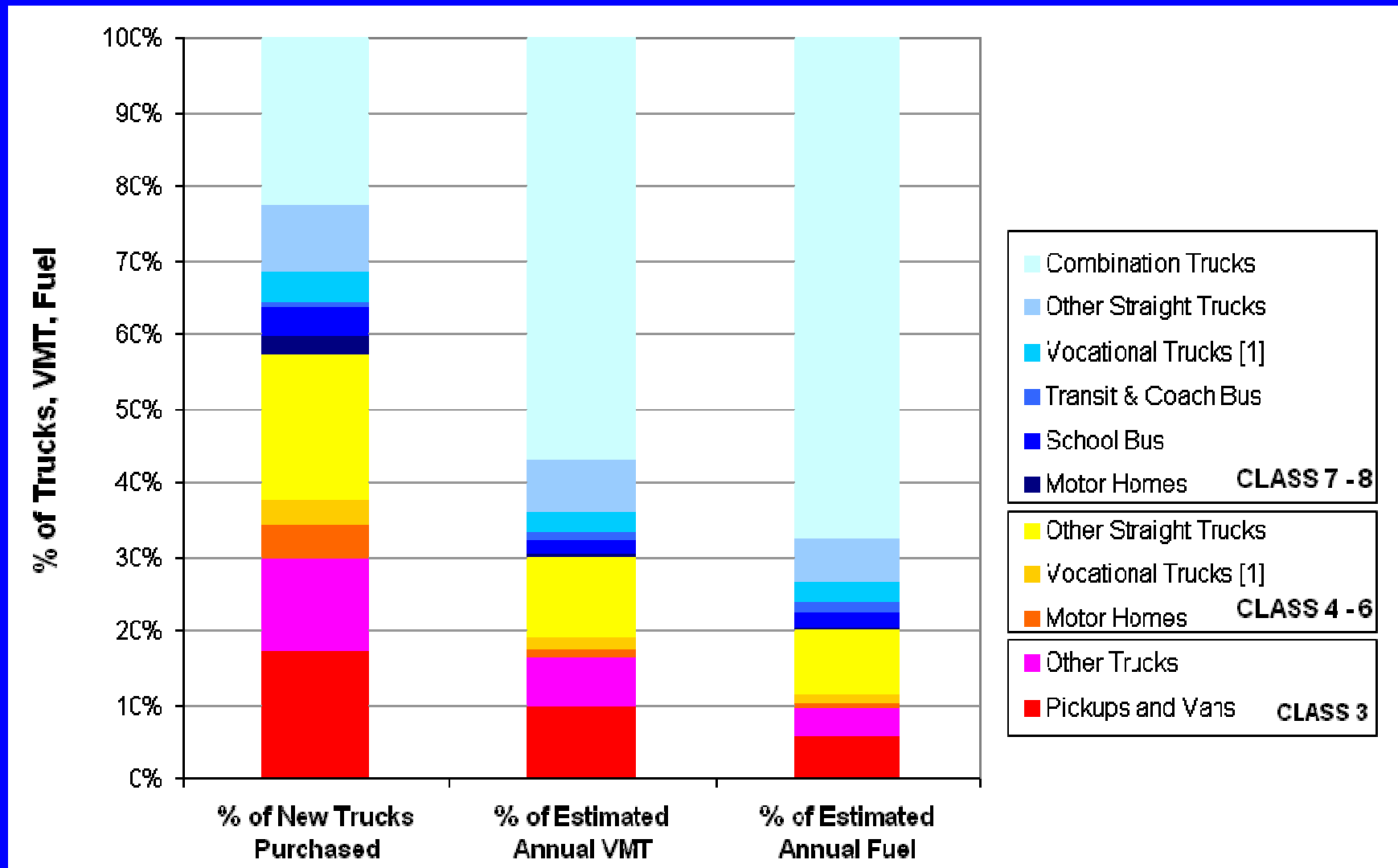


# Diesel Inspection & Maintenance

- Emphasis of future diesel I&M will shift from catching “smokers” to identifying failed DPFs
- California OBD requirement (MY2010) will allow better test methods in the future
  - ✓ Opacity testing not required
  - ✓ Regulations still need to be written
- Road side inspection emphasis should shift from single unit to long haul combination trucks
  - ✓ Majority of miles and PM emissions



# Estimated VMT by Truck Type



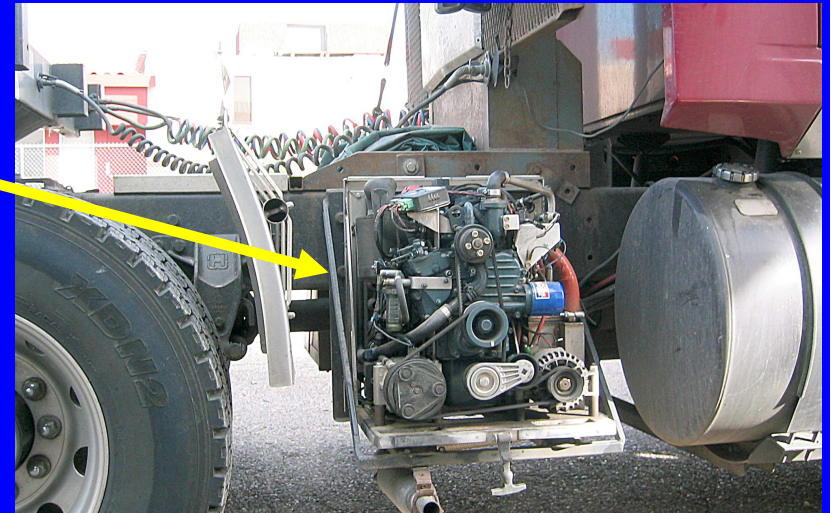
# Truck Idle Reduction

- For truckers that idle 8 hrs/day virtually all idle reduction technologies have a pay-off period of less than 2 years
  - ✓ At \$3.00/gal idling costs \$1.50 - \$2.50/hr
  - ✓ Idling could cost a trucker \$4,000/yr
- Most fleets still do not invest
  - ✓ Lack of capital; other uses for capital
  - ✓ Cost of fuel on driver, but fleet buys equipment
- Public Policy Options
  - ✓ Mandatory (CARB)
  - ✓ Low/no-interest revolving loan fund
  - ✓ Direct investment in truck stop electrification



# Trailer Truck Idle Reduction

Auxiliary Engine to power hotel loads while parked overnight  
\$6,000 - \$9,000



IdleAire™

Connection to stationary source of hot/cold air and power at truck stops  
\$0.50 - \$1.50/hr charge



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# Locomotive Idle Reduction

- Switcher locomotives idle up to 60% of time equipment in service
  - ✓ Keep engine oil warm, keep air in train line, cab heating/AC
- State & local action limited by Commerce Clause & Clean Air Act
  - ✓ Even CARB has only “voluntary” MOU with rail roads
- As with sleeper cab equipped trucks, cost-effective technologies exist, but there is under investment
- Public Policy Options
  - ✓ Voluntary agreements, including as SEP (enforcement action)
  - ✓ Low/no-interest revolving loan fund



# Residential Wood-Fired Heating

- ❑ 40 – 45 million wood-burning appliances in US (EPA)
- ❑ In some locations more than half of winter PM<sub>2.5</sub> ambient concentration can be attributed to wood smoke
- ❑ Northeast households burn more than twice as much wood per year as households in Midwest, South, or West
- ❑ Newer wood stoves are much cleaner than older stoves, due to adoption of federal NSPS limits in 1988
  - ✓ NSPS emission limits DO NOT APPLY to outdoor wood boilers
  - ✓ Over 150,000 OWBs sold nation-wide since 1990
- ❑ Newer wood stoves are also 10 – 20% more efficient than older “conventional” stoves



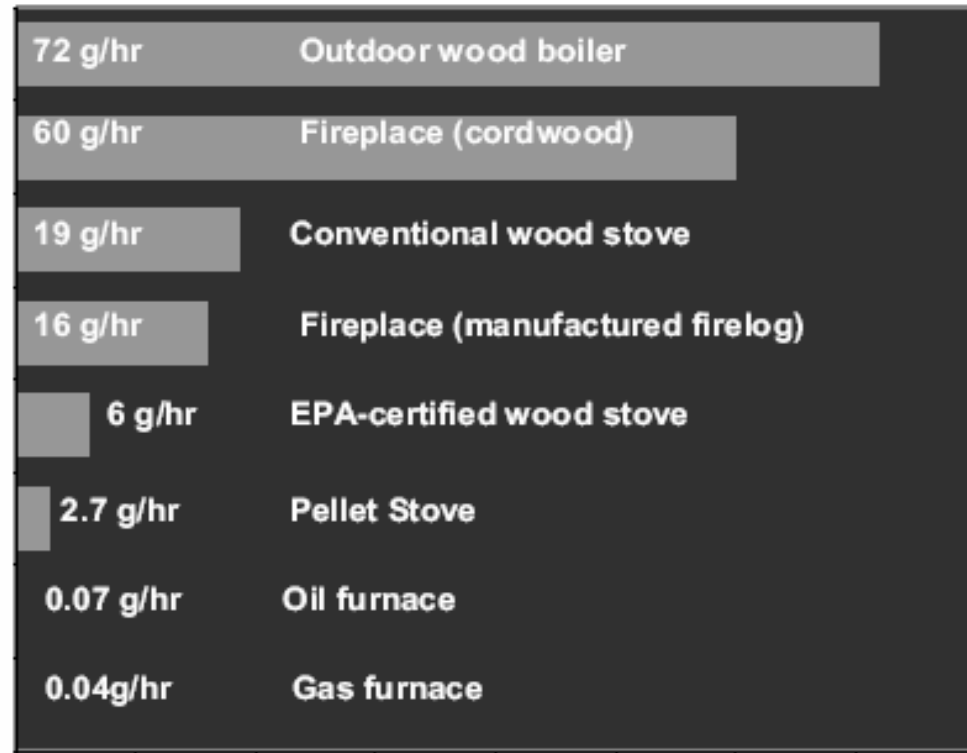
# Wood Stove Emissions



Wood Boiler



Wood Stove



Source: U.S. EPA 1996; Houck et al. 2005

Stove Type	AP-42 PM <sub>2.5</sub> Emissions Factors (lb/ton)	Houck PM <sub>2.5</sub> Emissions Factors (lb/ton)
Conventional wood stove	30.6	66.8
Catalytic EPA-certified wood stove	16.2	15.1
Noncatalytic EPA-certified wood stove	14.6	11.7
Pellet stove	8.8	2.5





# Residential Wood Policy Options

- Wood Stove Replacement Program
  - ✓ Voluntary
  - ✓ Mandatory
- Restrictions on Use of Outdoor Wood Boilers



# Voluntary Wood Stove Replacement

## □ Precedents

- ✓ 2001 *Great Fire Place & Woodstove Change out* (Great Lakes)
- ✓ 2005 EPA Model Programs (MN, PA)

## □ OPTIONS

- ✓ Tax incentive
- ✓ Rebate
- ✓ Low / No-interest loan
- ✓ Greater incentive for low-income households
- ✓ Greater incentive for lower emitting devices (pellet stove, NG)

## □ CONSTRAINT – Need funding source



# Mandatory Wood Stove Replacement

- Precedents
  - ✓ Several communities in Northern California & Nevada
- OPTIONS
  - ✓ Require replacement of old fireplace or wood stove with EPA certified wood stove or NG fire place prior to sale or transfer of a property
- CONSTRAINT – Local regulation & enforcement required



# Outdoor Wood Boilers

- Large fire box surrounded by water jacket to create hot water for space heating
  - ✓ Electronically controlled combustion air damper to control heat output – large release of smoke when damper opens
  - ✓ Up to 6x PM emissions of new, certified wood stoves
- Policy Options
  - ✓ Petition EPA to revise NSPS standards for wood stoves to include Wood Boilers, or create new NSPS standards
  - ✓ State, local restriction on installation/use (enforcement?)
  - ✓ Voluntary “verification” program to incentivize development and use of cleaner technologies

