

US EPA ARCHIVE DOCUMENT

# **Clean Diesel Emission Control Technologies**

*EPA Marine Emissions Seminar  
Mexico City  
September 26, 2012*

Joe Kubsh  
Manufacturers of Emission Controls Association



# Who is MECA?

- Industry association founded in 1976 to be the technical spokesperson for the mobile source emission control industry
- Primary mission is to inform regulatory groups and other stakeholders about the available emission control options for reducing pollution from mobile sources (cars, trucks, off-road equipment, small engines, marine engines, locomotives)
- Currently, 47 member companies:
  - Catalytic Converters (All Fuels)
  - Diesel Particulate Filters
  - Sensor Technologies
  - Thermal Management Strategies
  - Engine/Fuel System Management Technologies
  - Enhanced Combustion Technologies



# Clean Diesel Technology Driven By a Decade of U.S. EPA Mobile Source Emission Regulations

**Average Benefit:Cost = 20:1**

## **Tier 2 Light-Duty**

final rule 1999

**fully phased in 2009**

Diesels held to same standards as gasoline vehicles

**Diesel Sulfur now 15 ppm**



## **Ocean-going Vessels**

final rule 2009; IMO ECA in 2010

**ECA: 1000 ppm Sulfur by 2015;  
80% lower NOx by 2016**



## **Heavy-Duty Highway**

final rule 2000

**Sulfur now 15 ppm**

**fully phased in 2007-2010**



## **Locomotive / Marine Tier 4**

final rule 2008

**15 ppm Sulfur starting mid-2012  
fully phased in 2017**



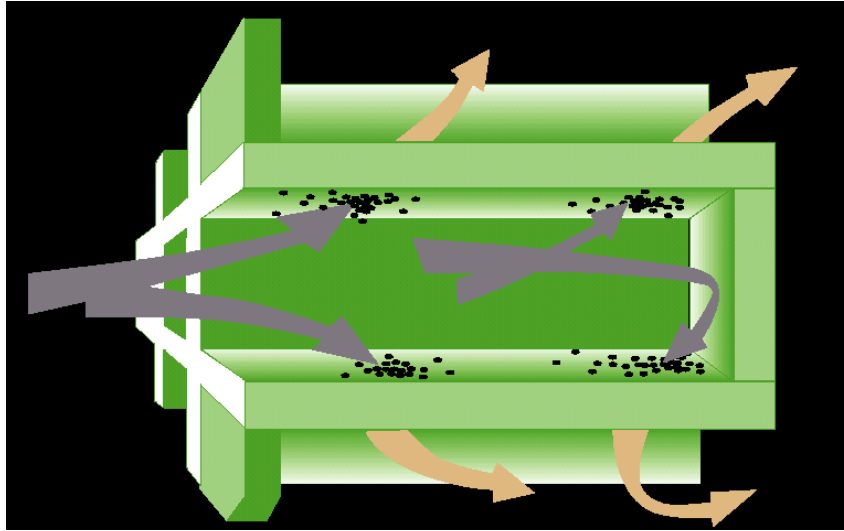
## **Nonroad Diesel Tier 4**

final rule 2004

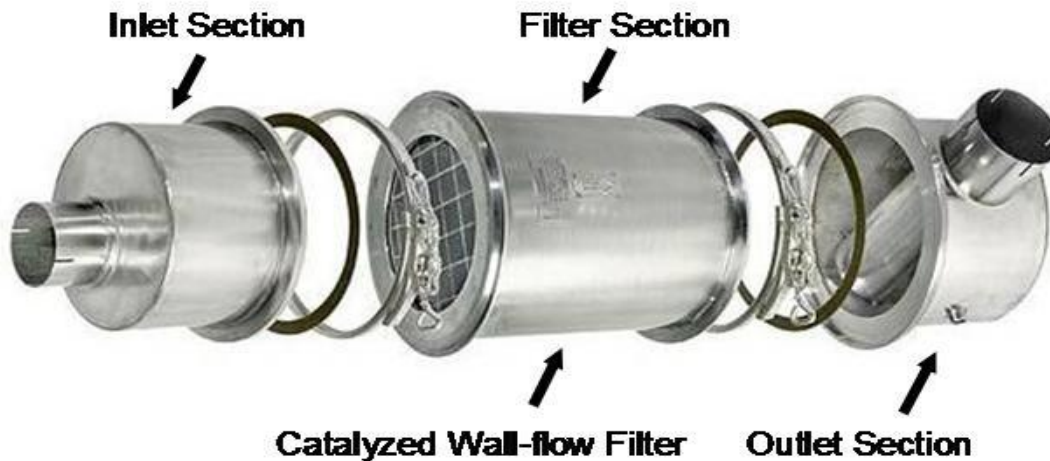
**Sulfur now 15 ppm**

**fully phased in 2015**

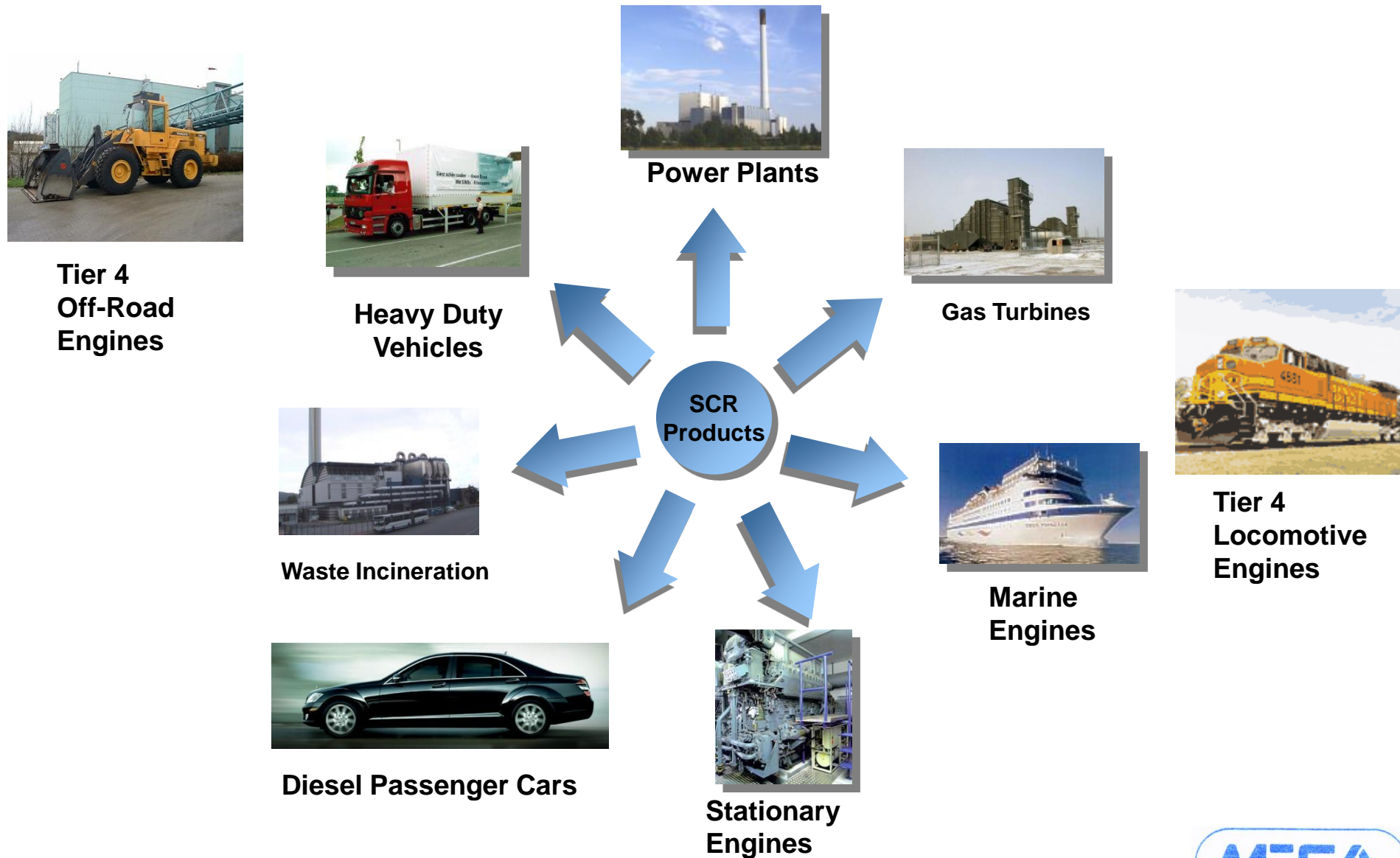
# Wall-Flow Diesel Particulate Filters Offer the Highest PM Filtration Efficiency



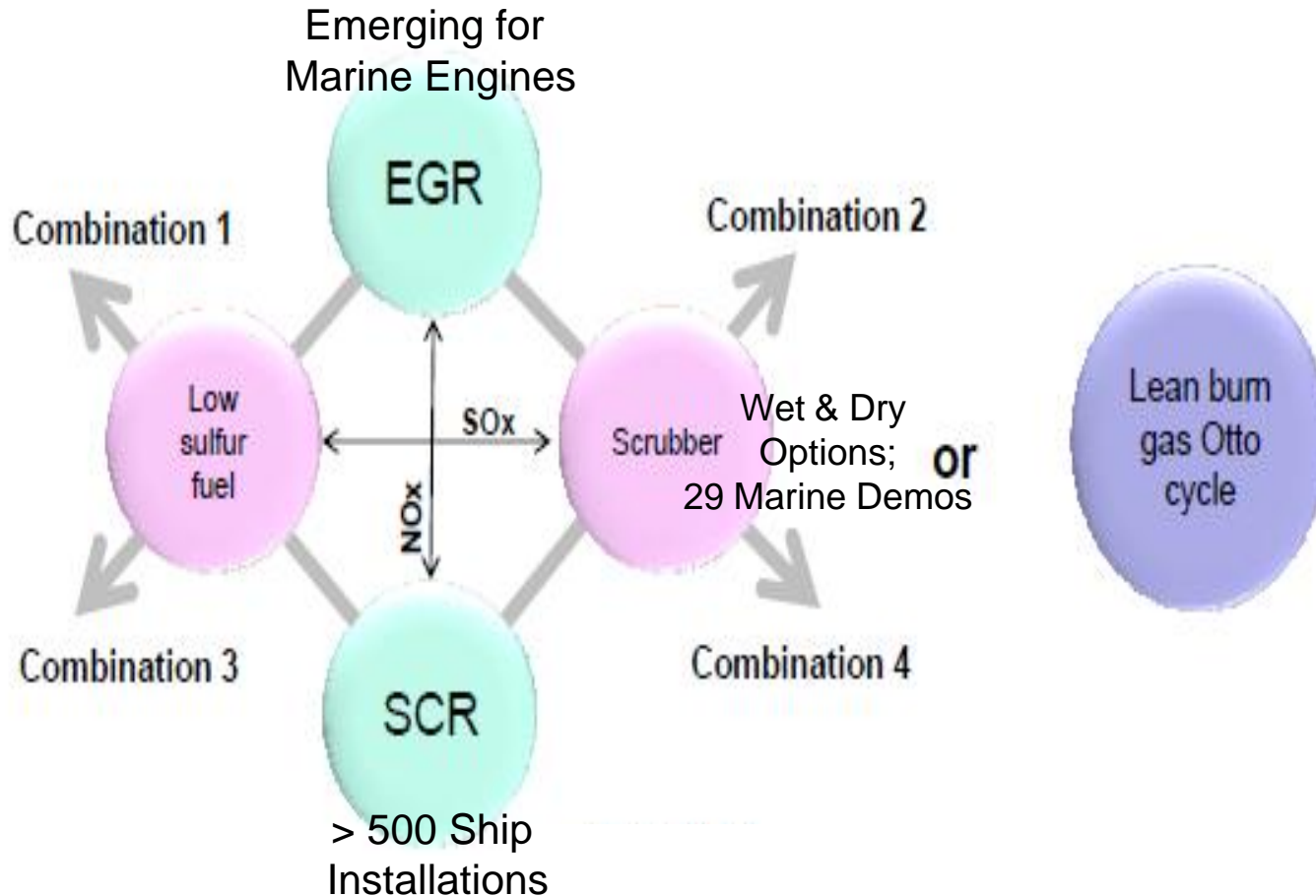
- Large reduction in toxics from catalyzed DPFs
- Large reduction in black carbon (GHG)
- DPFs on U.S. MY 2007+ OE trucks; Euro VI trucks
- >250,000 retrofits worldwide; growing off-road experience



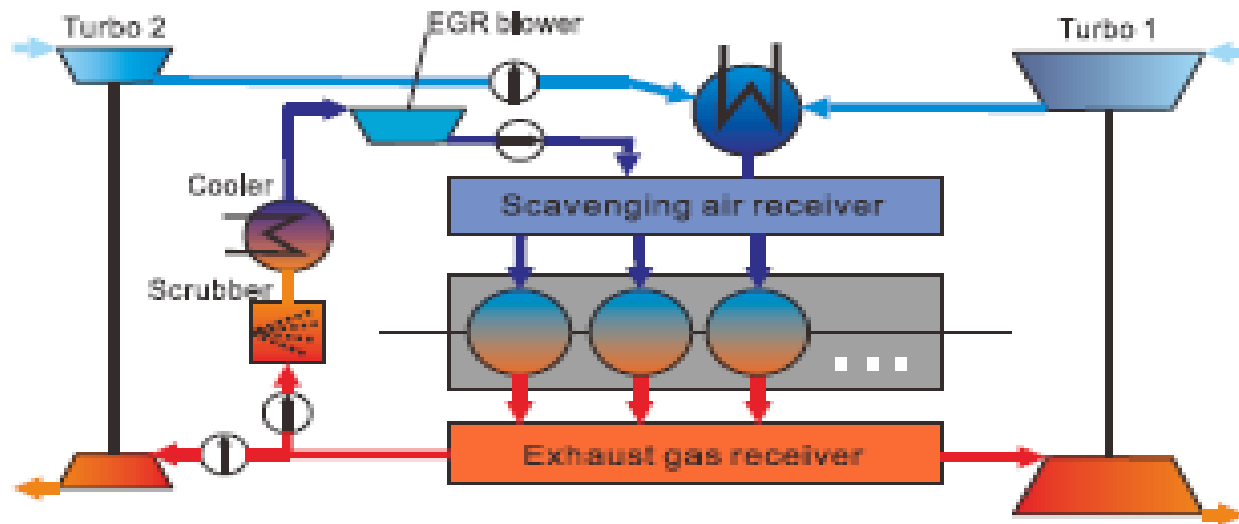
# SCR Becoming a Dominant NOx Control Technology for Mobile and Stationary Sources



# Large Marine Emission Control Options



# EGR for Large Marine Diesel Engines





# U.S. Clean Diesel Marine Demonstrations



SCR Retrofits on 2 Staten Island Ferries



DPF+SCR Retrofit on LA Port Tug

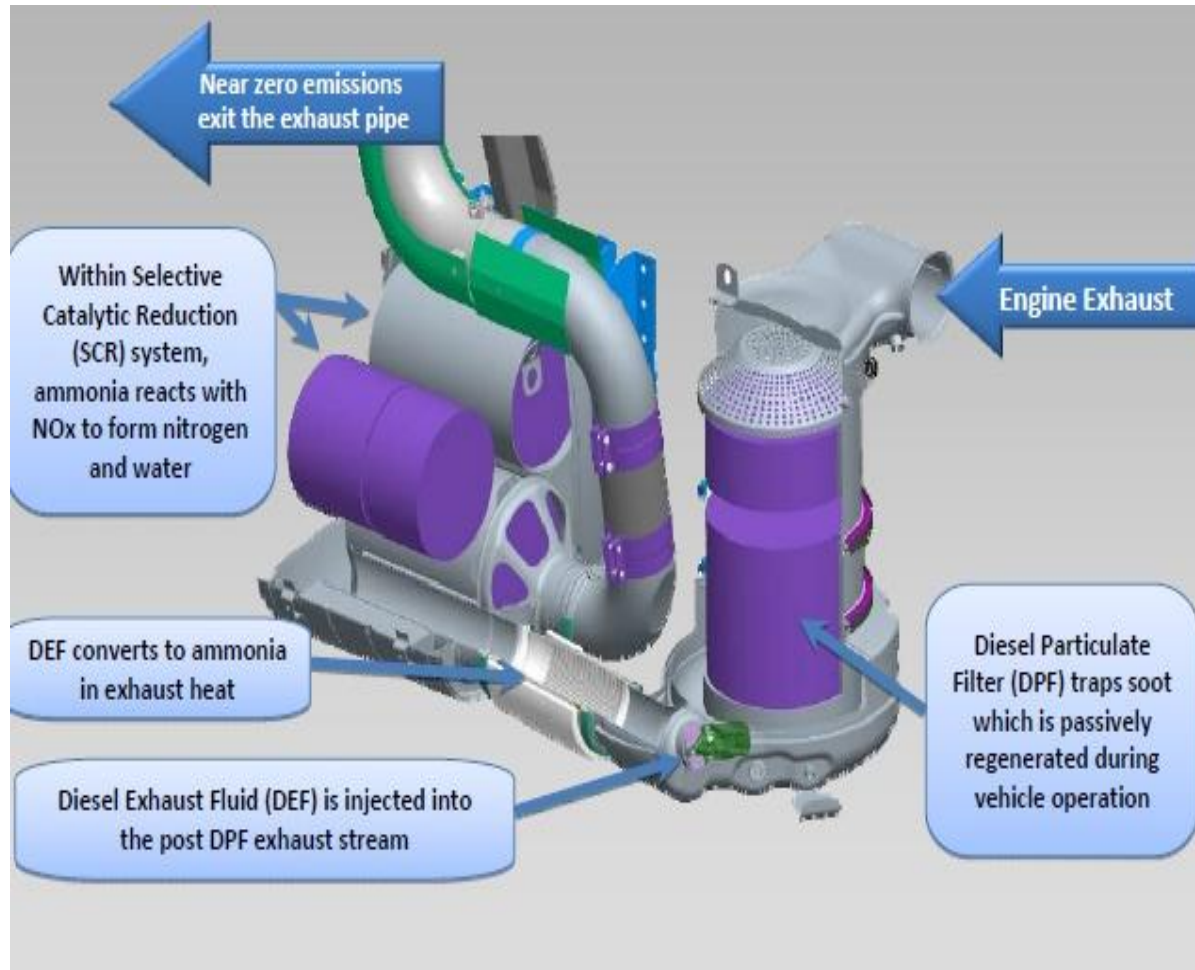


DOC + Crankcase Filter Retrofits  
On Mississippi Barge Tugs



Long Beach Hybrid Tug Retrofit

# US 2010+ HD Engines Available with DPF+SCR Systems



## 2010 DPF+SCR HD System

- Zeolite-based SCR with low  $\text{NH}_3$  slip
- Achieves 0.2 g NOx 2010 EPA standard
- DEF usage of 1.5-2% of diesel fuel usage (10 gal. of DEF for about 5,000 miles)
- Up to 5% lower diesel fuel consumption
- Lower PM load on DPF

# List of Available EPA/CARB-Verified Level 3 Retrofit Technologies Continues to Expand (as of August 2012)

- U.S. EPA ([epa.gov/cleandiesel/verification/verif-list.htm](http://epa.gov/cleandiesel/verification/verif-list.htm))
  - 5 on-road passive DPFs (includes 2 DPF+SCR)
  - 2 on-road active DPFs
  - 1 off-road passive DPF
  - 1 off-road SCR (NO<sub>x</sub> control only)
- California ARB ([www.arb.ca.gov/diesel/verdev/vt/cvt.htm](http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm))
  - 12 on-road passive DPFs (includes 1 DPF+LNC and 1 DPF+EGR)
  - 8 on-road active DPFs
  - 6 off-road passive DPFs (includes 1 DPF+LNC)
  - 3 off-road active DPFs
  - 6 Level 3 devices for TRUs or APUs
  - 11 Level 3 devices for stationary engines

# U.S. EPA/Semarnat Mexico City Bus Retrofit Demonstration Program

## Emissions, % reduction from baseline

Test Route	PM		NOx		CO	
	4,000 km*	55,000 km*	4,000 km*	55,000 km*	4,000 km*	55,000 km*
	DOCs					
Modulo 23	12.8	44.5	14.0	5.0	42.7	43.0
Insurgentes Norte	22.4	--	9.8	--	72.4	--
Montevideo	--	29.2	--	11.8	--	77.0
DPFs						
Modulo 23	79.2	91.7	+9.5	+1.1	100	100
Insurgentes Norte	92.6	--	5.1	--	97.9	--
Montevideo	--	90.5	--	+3.0	--	100
1. The baseline emissions measurements were taken with no retrofit devices, using 350 ppm sulfur fuel; * using 15 ppm sulfur fuel						

Twelve 2001 Buses Fitted with Passive DPFs;

Eight Older Buses Fitted with DOCs; all fueled with 15 ppm S diesel



# Level 3 DPF Retrofit Demonstration at Port of LA



- Tier 2 and 3 Cummins QSM, 375hp
- Electrical regeneration with catalyzed filter element
- Tier 2: Plug-in at every preventative maintenance
- Tier 3: Bi-weekly plug-in





# Clean Diesel Vehicles Include Sophisticated Sensors and Diagnostics



Combined O<sub>2</sub>/NO<sub>x</sub> Sensor



Ammonia Sensor



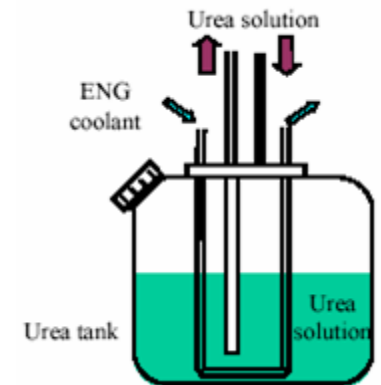
Soot Sensors targeted for 2013 LD/ 2016 HD OBD



Urea Quality Sensor



Diagnostic Systems



Heated Urea Tanks

# www.meca.org & www.dieselfetrofit.org – Your emission control technology resources on the web

The screenshot shows the homepage of the MECA Diesel Retrofit Website. The navigation bar includes links for What's New, Organization Info, Emission Control Technology, Resources, News, Contact Us, and Intranet. The main header features the MECA logo and the text "Technology for Clean Air". A green button labeled "MECA Diesel Retrofit Website" is visible. Below the header, a paragraph states: "Today, MECA's member companies include leading manufacturers of emission control technology for a variety of sources, including:". This is followed by five small images representing different vehicle types: Autos, SUVs & Light Trucks; Trucks & Buses; Off-Road Diesel Equipment; Off-Road SI Equipment; and Alt. Fuel/Adv. Tech. Vehicles. To the right, a paragraph describes the MECA mission: "The Manufacturers of Emission Controls Association (MECA) is a non-profit association incorporated in Washington, DC. MECA's mission is to provide technical information on emission control technology, thereby facilitating the establishment of strong and effective state, federal, and international air quality programs that promote public health, environmental quality, and industrial progress." Below this, a link to "Site map" is provided. At the bottom left, contact information for MECA is listed: 1730 M Street, NW, Suite 206, Washington, DC 20036, with phone, fax, and email details. A "GO" button is also present.

What's New Organization Info Emission Control Technology Resources News Contact Us Intranet

MECA Diesel Retrofit Website

MECA Technology for Clean Air

Today, MECA's member companies include leading manufacturers of emission control technology for a variety of sources, including:

Autos, SUVs & Light Trucks Trucks & Buses Off-Road Diesel Equipment Off-Road SI Equipment Alt. Fuel/Adv. Tech. Vehicles

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For an overview of this website, please refer to our [Site map](#).

Search our Site

GO >

For more information, contact MECA:

1730 M Street, NW  
Suite 206  
Washington, DC 20036

tel: (202) 296-4797  
fax: (202) 331-1388  
e-mail: [info@meca.org](mailto:info@meca.org)

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The screenshot shows the homepage of the MECA Diesel Retrofit Technology for Clean Air website. The navigation bar includes links for What's New, What is Retrofit?, Manufacturers, Projects, Funding, News, Useful Documents, Links, and Contact Us. The main header features the MECA logo and the text "Diesel Retrofit Technology for Clean Air". Below the header, a large image of a blue truck is shown. To the right of the image, a paragraph describes the MECA mission: "The Manufacturers of Emission Controls Association (MECA) is a non-profit association incorporated in Washington, DC. MECA's mission is to provide technical information on emission control technology, thereby facilitating the establishment of strong and effective state, federal, and international air quality programs that promote public health, environmental quality, and industrial progress." Below this, a link to "Site map" is provided. At the bottom left, a paragraph states: "The purpose of this web site is to provide useful information related to diesel retrofit emission control technology. By making this information available, MECA hopes to assist interested stakeholders in establishing and operating more effective diesel retrofit programs." At the bottom right, contact information for MECA is listed: 1730 M Street, NW, Suite 206, Washington, DC 20036, with phone, fax, and email details. A "GO" button is also present.

What's New What is Retrofit? Manufacturers Projects Funding News Useful Documents Links Contact Us

MECA Diesel Retrofit Technology for Clean Air

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For an overview of this website, please refer to our [Site map](#).

For more information, contact MECA:

1730 M Street, NW  
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tel: (202) 296-4797  
fax: (202) 331-1388  
e-mail: [info@meca.org](mailto:info@meca.org)

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Home | [Site map](#) | [What's New](#)  
[What's New](#) | [What is Retrofit?](#) | [Manufacturers](#) | [Projects](#) | [Funding](#) | [News](#) | [Useful Documents](#) | [Links](#) | [Contact Us](#)

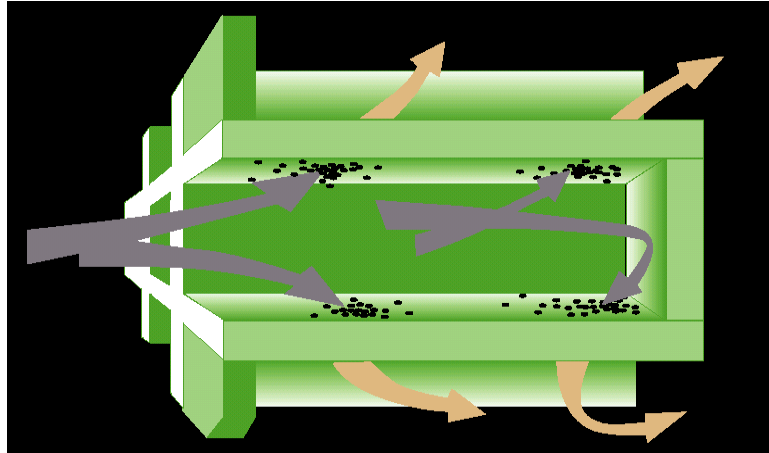
- Retrofit technology descriptions
- Contacts for retrofit suppliers
- Case study reports



- Emission control technology white papers and fact sheets
- Public testimony
- Regulatory information

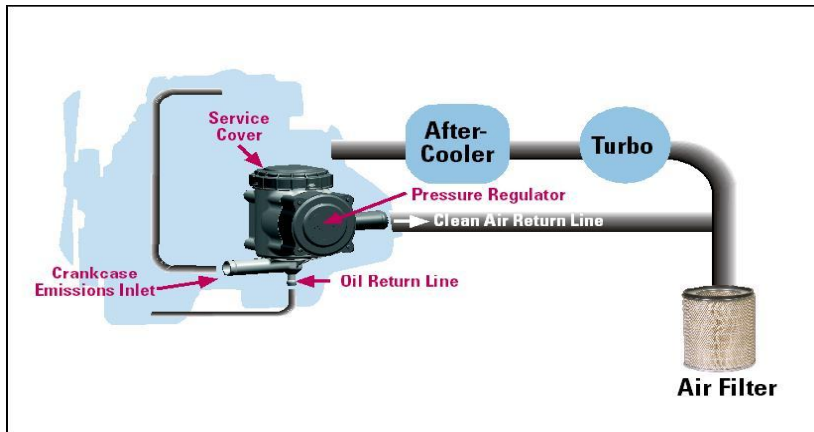
# DOCs and DPFs Form the Technology Base for Reducing PM Emissions from US 2007 Diesel Engines

Diesel Particulate Filters

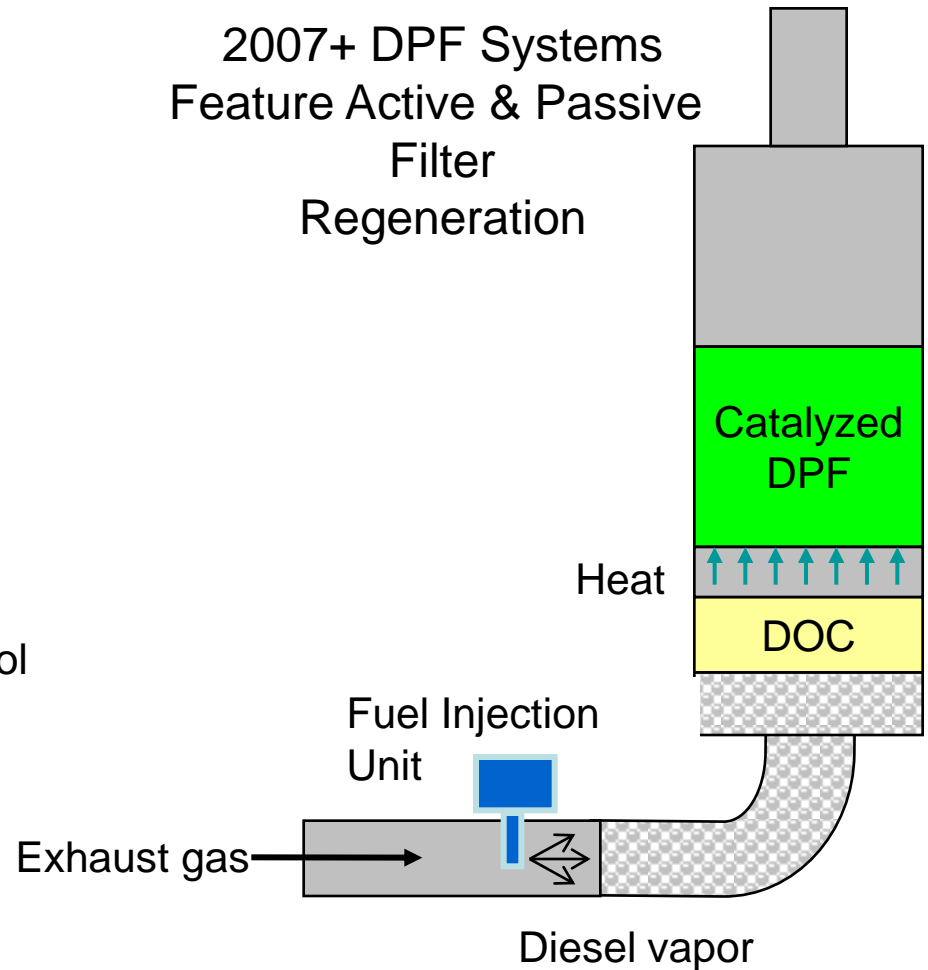


- Significant experience base with LDD in Europe (> 6 M) & HDD retrofits (> 250 K)

Crankcase Filters Provide Additional PM Control



2007+ DPF Systems  
Feature Active & Passive  
Filter  
Regeneration



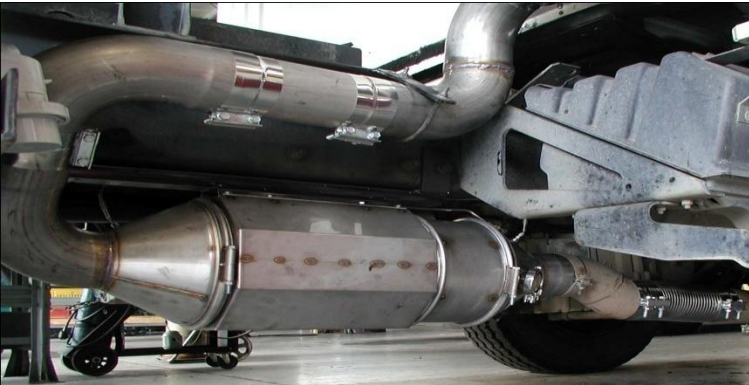


# Types of Diesel Retrofit Technologies

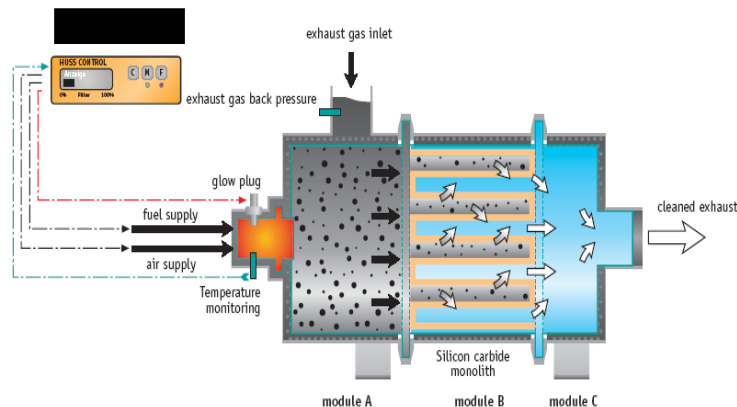
## PM Reduction

- **Diesel Particulate Filter**
  - Wall-flow device that physically traps PM in exhaust stream on surface of substrate; PM burned off through regeneration (passive or active)
  - >85% PM reduction
- **Flow-Through Filter**
  - Wire-mesh substrate or metal foil-based substrate with sintered metal sheets that traps a portion of the PM; passive regeneration with catalyst
  - 50-75% PM reduction
- **Diesel Oxidation Catalyst**
  - Flow-through device with catalytic coating on substrate that oxidizes soluble organic fraction of PM
  - 25-50% PM reduction
- **Closed Crankcase Ventilation System**
  - Replaceable filter that reduces engine blow-by emissions
  - >90% PM reduction (crankcase emissions)

# Wider Range of Active DPFs Available for Low Exhaust Temperature Applications



- Suited for on- and off-road applications with low exhaust temperatures.
- Uncatalyzed or catalyzed wall-flow filter with electrical regeneration.
  - Catalyzed filter + electrical element combines passive and active functions
- Wall-flow filter with a fuel burner for regeneration.

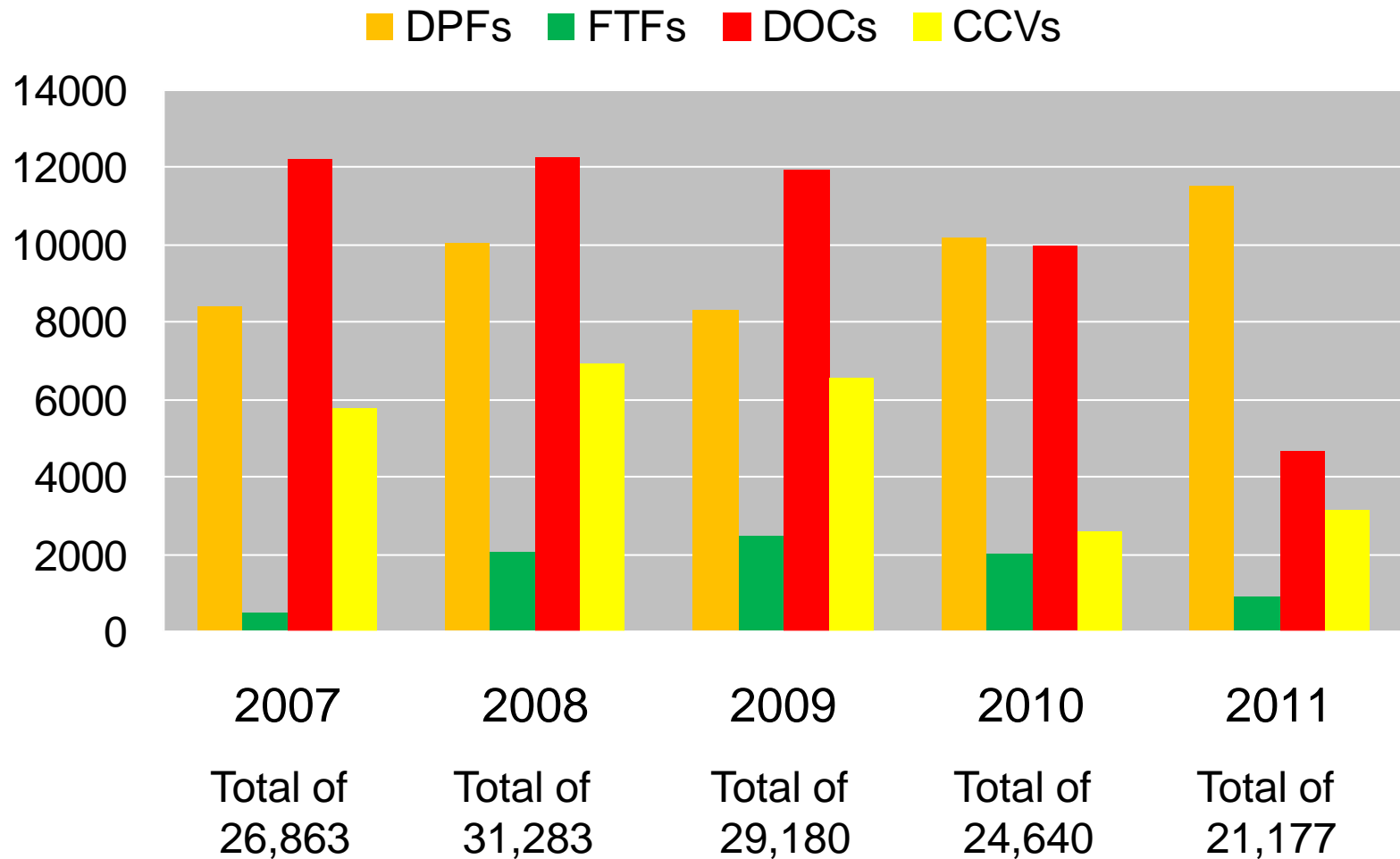


# Types of Diesel Retrofit Technologies

## NOx Reduction

- Selective Catalytic Reduction
  - Flow-through device that reduces NOx with injection of a reductant (urea) over the catalyst
  - 60-90% NOx reduction
- Lean NOx Catalyst
  - Flow-through device that reduces NOx with injection of a reductant (diesel fuel) over the catalyst
  - 25-40% NOx reduction

# MECA Diesel Retrofit Sales Survey Results (U.S.)



# Technical Considerations for Successful Retrofit Projects

- Vehicle should be properly maintained before considering retrofit
- Application engineering – Matching the right technology to the specific piece of equipment and application
- Proper professional installation – Retrofits can be installed safely (visibility concerns addressed)
- On-vehicle monitors – Provide important user feedback on performance (don't ignore warning lights)
- Maintenance – Vehicle/equipment and retrofit device require inspection and maintenance

Successful Retrofits Require a Cooperative Effort Between Fleet Owners, Operators, and Technology Providers



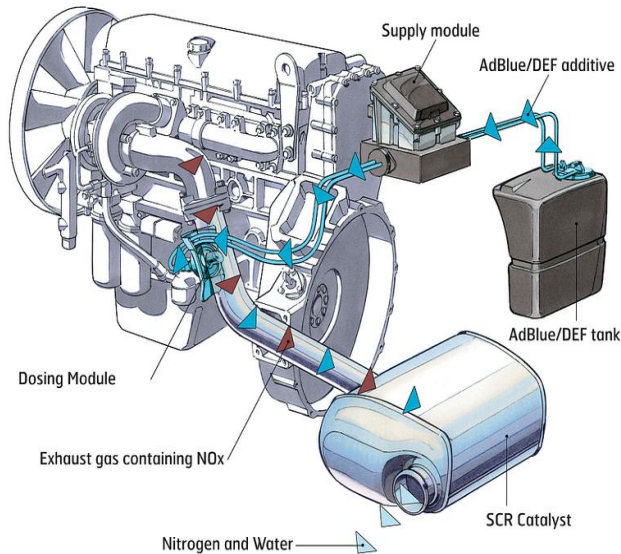
# Experience with Diesel Retrofits Spans a Variety of On-Road Vehicle Applications





# Clean Diesel Technology Expanding into U.S. Off-road Applications

## Tier 4 Interim Tractors with SCR



## Tier 4 Interim Machines with DPFS



## Locomotives Repowered with DPFs

