

**LUBRIZOL** Fluid technologies for a better world™

## Diesel Fleet & Fuels Options

What can and should we realistically clean up?

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## What keeps regulators up at night?

- Air Emissions
- Climate Change

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## Mobile Sources

- Mobile NOx emissions now exceed 50% of NOx budget in most major urban areas.
- Growing national fleet size/usage patterns offset significant per-vehicle emission reductions (CO<sub>2</sub>, NOx, PM).
- Regulators historically chased stationary sources; only now seriously looking at transport sector as major emissions pool.

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### Mobile Sources (cont'd)

- **Spark Ignition Engines (gasoline)**
  - Emission technology largely in place (mature technology)
  - Issue of expanding use (cars/household) and decreasing mileage
  - Major next steps – new engine technology?
- **Compression Ignition Engines (diesel)**
  - Issue of new engine development (emerging technology)
  - Retrofit options for older, largely uncontrolled, emission sources

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### Diesels – what is to be done?

- Pre-1997 diesel emissions were largely uncontrolled - leading to the stereotypical black plume and corresponding high levels of NOx and PM emissions.
- New engine emission standards address future fleet concerns.
- Clean options exist for the range of diesel engines.

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### How to Choose an Option

- First rule is... there are no rules – each circumstance is unique (engine, application, reduction target) and so are the decision rules.
- There are, however, common questions.
  1. What type/magnitude of reductions must I get?
  2. What does it cost to get an option working?
  3. What does the option cost per ton of reduction?
  4. How does the option work with my application?

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### Current Diesel Options

- **Basket 1 – Transportation Fuels**
  - Compressed Natural Gas (CNG)
  - Diesel Fuel Emulsions
  - Biodiesel and its alternatives
- **Basket 2 – Hardware**
  - Oxidation Catalysts
  - Particulate Filters/Traps

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### CNG – “The Bridge Fuel”

- **US EPA, DOE and many EU countries have viewed CNG as the bridge to the future...**
- **CNG Pros**
  - Significant reductions in NOx
  - Significant reductions in PM
  - Significant reductions in CO2
- **CNG Cons**
  - 20~30% efficiency loss v. diesel (depending on application)
  - Increased maintenance cost
  - \$5~10k capital cost to re-power with a CNG engine
  - \$+200k capital cost to install a CNG fueling station

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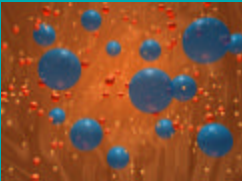
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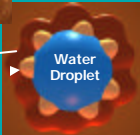
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### Diesel Fuel Emulsions

#### PuriNOx™ Water-in-Diesel Fuel Emulsion



- Low Viscosity
- Fuel in Contact with Tank and Engine
- Efficient Water Dispersion
- Mixes with Diesel Fuel



Water Soluble “Head” of Additive

Water Droplet

Fuel Soluble “Tail” of Additive

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### PuriNOx™ Fuel Emulsion

- **PuriNOx Pros**
  - Can be used immediately by dispensing fuel directly into vehicle tanks
  - Uses existing storage/distribution/fueling facilities
  - Handles like diesel fuel – remains stable in storage and vehicle tanks
  - No capital cost to consumer
- **PuriNOx Cons**
  - Small loss of power (water has no BTUs)
  - Requires increase in fuel volume

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### PuriNOx™ Benefits

	NOx	Particulates
Lubrizol	Up to 30%	Up to 65%
Average Dynamometer	12.6%	46.4%
Average In Use	26.6%	45.3%
ARB Verification	14%	63%
AIR Inc.	19%	54%

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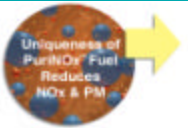
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### PuriNOx™ Features & Benefits



- Reduces NOx by up to 30% and Particulates by up to 65%
- Energy Savings of 1-3%
- Immediate and On-Going Emission Reductions
- Uses Existing Storage, Distribution and Fueling Facilities
- Requires Special Handling and Storage Procedures
- Ideally Suited for Centrally-Fueled Fleets

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### Biodiesel and its Alternatives

- US EPA and many EU countries have viewed Biodiesel as a significant piece in GHG reductions
  - Biodiesel Pros
    - Petroleum avoidance
    - Significant reductions in PM
    - Significant reductions in CO2
  - Biodiesel Cons
    - Increase in NOx
    - Operating cost increase
    - Availability

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### Bio-PuriNOx Benefits

- Overall reduction in NOx
- Added reduction in PM
- Inherent lubricity
- Cold temperature properties similar to diesel
- Renewable resource
- Petroleum avoidance

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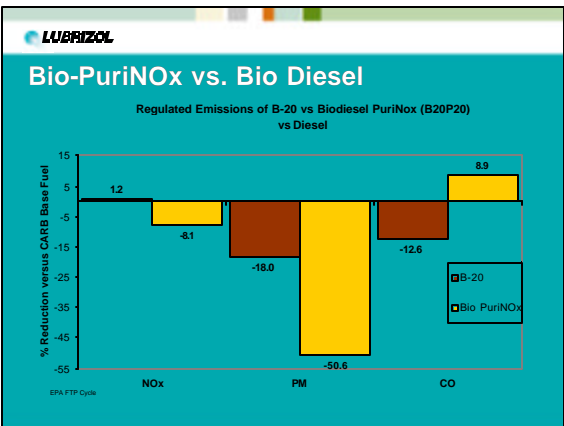
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### Retrofit Hardware Options

- **Hardware characteristics**
  - Tend to resolve one problem at the expense of another (NOx vs. PM tradeoff)
  - Tend to be size limited (no real retrofit options for engines HP > 450)
  - Many need fuel with Sulphur < 30ppm (available outside major urban areas).
- **Principal technology differentiation**
  - Sulfur tolerant technology – no ULSD requirement
  - Sulfur Intolerant – strong ULSD preference

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### ECS Purifilter™

- Silicon carbide substrate
- Precious metal + base metal soot ignition catalyst
- PM, HC and CO emissions reduction of >90%
- 275-320 °C balance point
- Modular “muffler” style product format






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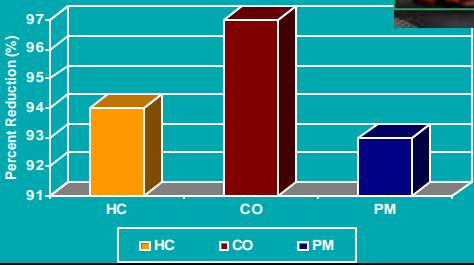
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### ECS Purifilter™ Performance

Routemaster Bus  
Cummins B145 20 Euro II Repower  
Millbrook London Bus Cycle

Pollutant	Percent Reduction (%)
HC	~94
CO	~97
PM	~93

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### Technology Tradeoffs

	Pur/NOx	CNG	Backfeed Pur/NOx	Filter	Particulate (DOC)	Pur/NOx + DOC
Marginal Fuel cost of Tech	\$24/gal	\$25K/bus/yr or \$1.44/mile	\$24	\$0	\$0	\$24/gal
Capital Costs of Tech	\$0	\$25K + \$25K/bus	0	\$4K/veh	\$1.48K/veh	\$1.48K/veh
Marginal Maintenance Cost	\$0	\$ 00/mile or \$1.44/bus	0	\$800/bus/yr	\$0/yr	\$0/bus/yr
Emission Benefits	19% NOx 54%PM	80% NOx 90% PM	0% NOx 50% PM	0% NOx 96% PM	0.59NOx 17% PM	20% NOx 65% PM
Total Vehicle Savings: NOx/PM	380 lbs/yr 36lbs/yr	2,100 lbs/yr 125 lbs/yr	270 lbs/yr 72 lbs/yr	0 lbs/yr 125 lbs/yr	10.5 lbs/yr 46.6 lbs/yr	720 lbs/yr 127 lbs/yr
Marginal Vehicle Cost (\$/year)	\$21,600	\$132,000	\$21,600	\$9,800	\$1,650	\$23,250
Total Fleet Costs	\$1,080,000	\$7,975,000	\$1,080,000	\$790,000	\$82,500	\$1,162,500
Total Fleet Em Savings: NOx/PM	145,000 lbs 19,000 lbs	525,000 lbs 31,250 lbs	67,500 lbs 18,000 lbs	0 31,250 lbs	2,225 lbs 9,000 lbs	182,250 lbs 31,750 lbs
CO2 value	1.3	0.48	1.015	0.3	1.0	1.14

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## Existing Diesel Fleet & Fuels

**Questions?**

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