



Benefits of Large Engine Replacements

**Midwest Clean Diesel
Initiative
Chicago, IL**

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Generating Benefits with Large Engine Repowers

Topics Covered

Background – Why we pursued this project

What are the benefits and how cost effective are they?

How long-lived are these assets and what are the benefits to local communities?



About Us

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The Diesel Technology Forum is supported by leaders in advanced diesel engines, vehicles, equipment, components and fuels

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- Umicore
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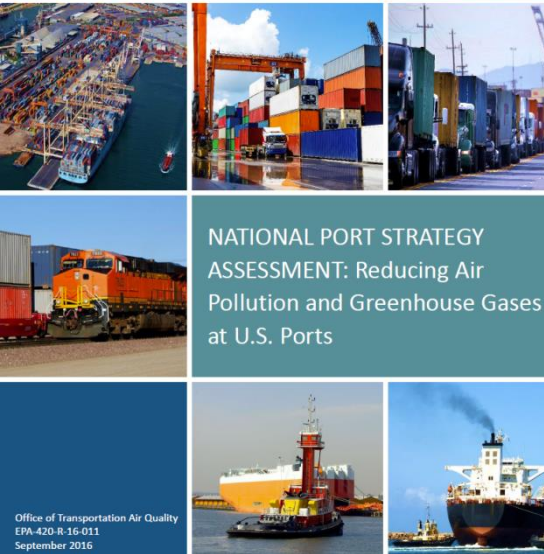
Allied Members

- National Biodiesel Board
- Western States Petroleum Association



Benefits of Large Engine Repowers

- Tier 3, Tier 4 engine replacements yield substantial benefits
 - Workboat repower is similar to 96 dray truck replacements (30 tons NOx per year)
 - Switch locomotive repower is similar to 36 dray truck replacements (9 tons NOx per year)



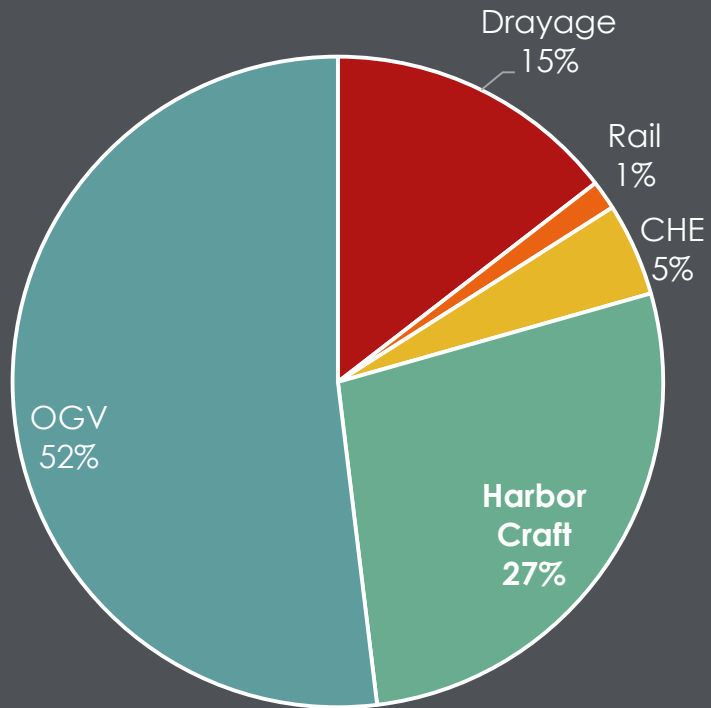
**GET MONEY TO UPGRADE OR
REPLACE YOUR TRUCK OR
EQUIPMENT—AND CLEAR THE AIR!**

Texas Emission Reduction Program =
Large engine replacements are
enormously cost effective

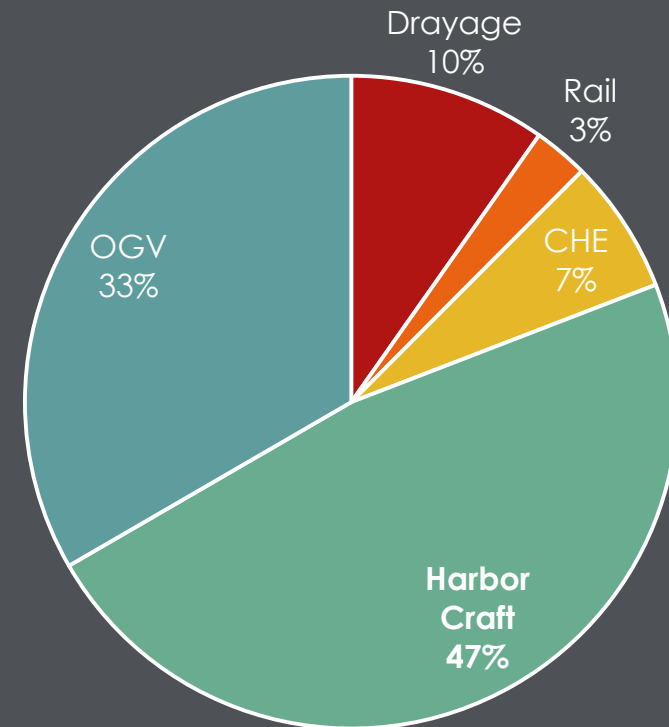


Emission Reductions From Tugs and Switchers Matter

PM 2.5 Emissions (2011)



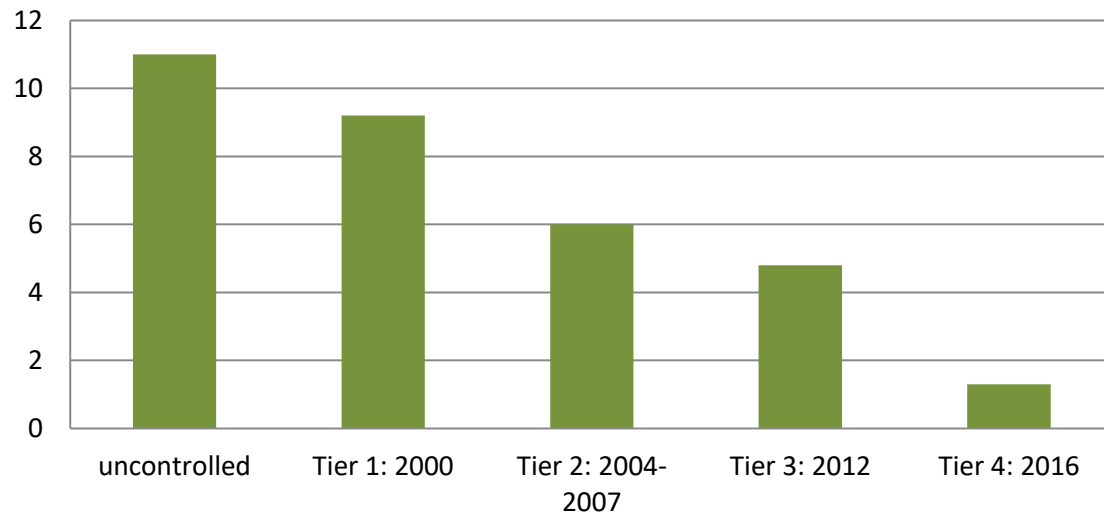
NOx Emissions (2011)



SOURCE: U.S. EPA, *National Port Strategy Assessment* (2016)

Progress to Near Zero Emissions with Clean Diesel Workboats

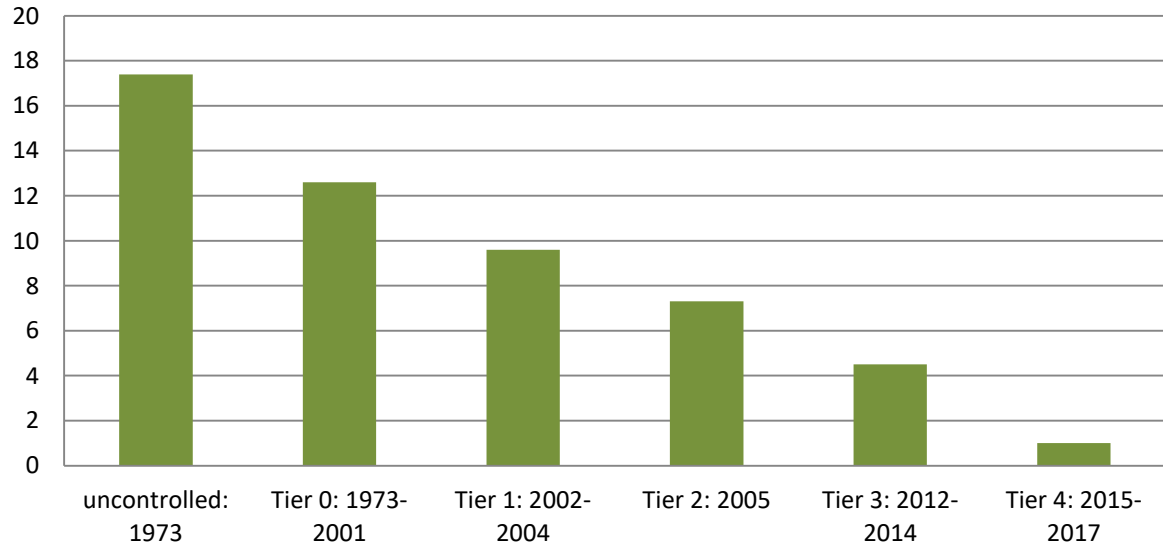
88% Reduction NOx Emissions for Marine Workboats [g/Kw-Hr]



Typically 2 propulsion engines with additional auxiliary engines

Progress to Near Zero Emissions with Switch Locomotives

**94% Reduction NOx Emissions for Switchers
[g/bHp-Hr]**



New switchers typically use a single engine

Large Engine Repowers Are Among the most Cost Effective

The most cost-effective upgrades make the biggest health impact

New Tier 4 engines for switchers reduce NOx emissions by 95%

The \$2.9 billion VW Environmental Mitigation Trust provides funding to upgrade older vehicles and equipment to rapidly reduce nitrogen oxide (NOx) emissions, which contribute to hazardous smog pollution. Upgrading just one of the oldest, dirtiest switchers is like taking tens of thousands

of passenger vehicles off the road per year, bringing substantial health benefits to at-risk communities. With states now deciding how to invest these funds, repowering these older switchers with cleaner Tier 4 engines is a game-changer for delivering immediate and cost-effective air quality benefits.



Upgrading old engines means cleaner air for all

EPA estimates that by 2020, only 5% of switcher engines will be replaced with cleaner Tier 4 engines. The VW Environmental Mitigation Trust provides a rare opportunity to retire the oldest diesel engines still in operation, which can last 70 years or longer. Tier 4 engines will deliver cleaner, healthier air faster to at-risk communities. These new engines also improve fuel efficiency, which reduces CO₂ and black carbon emissions, two important greenhouse gas pollutants.



Switcher projects are a better value



1 ton of NOx reduction costs



1. Ramboll, 2016. Emission reductions and cost effectiveness for marine and locomotive projects
2. EPA, 2016. National Port Strategy Assessment
3. Tier 2 car driven 15,000 miles per year
4. FHWA, 2015 CMAQ Cost Effectiveness Report

1 ton of NOx eliminated = \$15,000

The most cost-effective upgrades make the biggest health impact

New Tier 4 engines for tug boats reduce NOx emissions by 91%

The \$2.9 billion VW Environmental Mitigation Trust provides funding to upgrade older vehicles and equipment to rapidly reduce nitrogen oxide (NOx) emissions, which contribute to hazardous smog pollution. Upgrading just one of the oldest, dirtiest tug boats is like taking tens of thousands

of passenger vehicles off the road per year, bringing substantial health benefits to at-risk communities. With states now deciding how to invest these funds, repowering these older vessels with cleaner Tier 4 engines is a game-changer for delivering immediate and cost-effective air quality benefits.



Upgrading old engines means cleaner air for all

EPA estimates that by 2020, only 3% of tug boats will be replaced with cleaner Tier 4 engines. The VW Environmental Mitigation Trust provides a rare opportunity to retire the oldest diesel engines still in operation, which can last 50 years or longer. Tier 4 or Tier 3 engines will deliver cleaner, healthier air faster to at-risk communities. These new engines also improve fuel efficiency, which reduces CO₂ and black carbon emissions, two important greenhouse gas pollutants.



Tug projects are a better value



1 ton of NOx reduction costs



1. Ramboll, 2016. Emission reductions and cost effectiveness for marine and locomotive projects
2. EPA, 2016. National Port Strategy Assessment
3. Tier 2 car driven 15,000 miles per year
4. FHWA, 2015 CMAQ Cost Effectiveness Report

1 ton of NOx eliminated = \$5,000

Marine Repowers Are Important For Local Communities

Phase 2 Research Finding: Marine Engines have a service life 2X as EPA emission model assume (50 years as opposed to 23 years)

Why is this important? EPA emissions models overestimate anticipated benefits. Introducing new clean diesel engines is important to achieve benefits.

What if marine engines were replaced as quickly as EPA assumed?

Baltimore

Just under 1 ton per day

Houston - Galveston

4 tons per day

New York – New Jersey

8 tons per day

CASE STUDY: Reducing Emissions with Clean Diesel Workboats



"Island Chief" workboat engine replacement

- 2 unregulated propulsion engines replaced with 2 Tier 3
- 1 unregulated auxiliary engine replaced with Tier 4



Cost: \$225,000

Benefits Provided

- Reduced 3.2 tons of NOx per year
- Eliminated 400 lbs of fine particles
- Saved the operator 45,000 gallons of fuel resulting in 1,000 tons of GHG emissions

BIG Co-Benefits

Summing it Up

- Switcher and Marine Engine Replacements are Among the Most Cost Effective Investments for Reducing Emissions on a \$/ton basis
- More emissions can be removed for a single large engine project and deliver immediate benefits to communities
- Category 2 marine engines are 2X as long lived as EPA emissions models assume.
- **Using incentive funds to replace older marine engines faster could go a long way to generate real world benefits as assumed by EPA emissions models.**

Read more about our Large Engine research:

<https://www.dieselforum.org/largeengineupgrades>



Thank You

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KEEP
CALM,
DIESEL
AND
CARRY
ON

