Reducing Diesel Exhaust Pollution from Ships in the Northeast United States

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Diesel exhaust is a significant source of fine particulate matter (PM) in the northeastern United States. Within the Northeast, 25 counties in Connecticut, New Jersey, and New York do not meet the current health-based National Ambient Air Quality Standards (NAAQS) for fine PM.

The U.S. Environmental Protection Agency (EPA) is under court order to reconsider the existing standards, which may result in their tightening in recognition of the current state-of-knowledge on PM health effects. If the health standards are strengthened, many other urban areas in the Northeast that now only narrowly meet the current standards could fail to meet more protective future standards.

Many health studies have found that populations exposed to fine particles, such as those found in diesel exhaust, experience adverse cardiac and respiratory effects. This can lead to an increased risk of heart attack, aggravated asthmatic conditions, and lung damage. In the Northeast, the childhood asthma rate is above 10% in all six New England states, and rates are near 15% in areas of New York City, giving the region some of the highest asthma rates in the United States.[1] Other health outcomes include the exacerbation of existing cardiopulmonary disease and even premature death.

In addition to its health effects, diesel exhaust is a significant source of directly emitted black carbon (BC) to the atmosphere. BC is a potent climate

forcing agent, with studies indicating that it adds 2–3 orders of magnitude more energy to the climate system than an equivalent mass of carbon dioxide.[2] BC can also be a significant contributor to decreasing snow and ice cover. BC deposited on these surfaces absorbs sunlight rather than reflecting it, leading to enhanced surface melting and diminished cooling of the earth from reflected light off snow and ice. Because BC has a much shorter lifetime (i.e., days to weeks) in the atmosphere than long-lived greenhouse gases (i.e., decades to thousands of years), strategies aimed at reducing BC now can buy time in the short term as measures are developed and implemented to reduce the longer-lived greenhouse gases.

The Northeast Diesel Collaborative

Nationally, as a result of recent measures promulgated by EPA,[3] diesel engines manufactured in the future will be significantly cleaner than those operating today. Existing diesel engines, however, can stay in service for decades, and thus represent a continuing risk to the public's health and environment. In recognition of this continuing problem, the Northeast States for Coordinated Air Use Management (NESCAUM), EPA, and eight northeastern states established the Northeast Diesel Collaborative (NEDC) that works with private-sector participants to provide a coordinated strategy for reducing and eliminating pollution from older diesel engines.

The NEDC has been targeting diesel emissions through innovative pilot projects, laws, voluntary measures, and mandatory programs. These include efforts within the following sectors:

- Municipal (e.g., school buses, garbage trucks, and other public works vehicles);
- Transit (e.g., transit buses and commuter locomotives);
- Ports/Authorities (e.g., ferries, tugboats, large ocean-going vessels, and port vehicles and equipment);
- Construction (e.g., vehicles and equipment, such as cranes, pavers, excavators, and front loaders); and
- Freight (e.g., trucks, locomotives and locomotive switchers).

Some activities undertaken through the NEDC include retrofitting, retiring, and replacing polluting engines; electrifying truck stops to enable truckers to shut down their parked engines; creating and enforcing measures to reduce engine idling; and requiring clean diesel in contracts.[1]

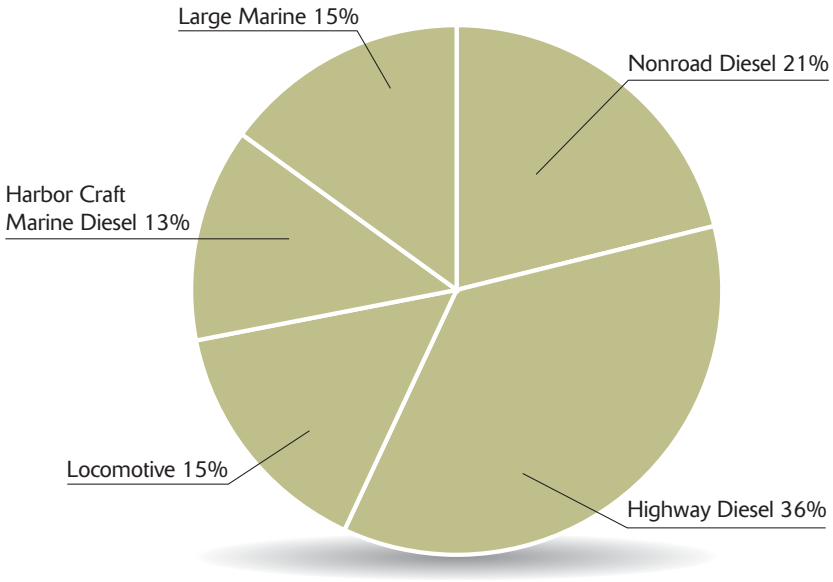

Figure 1. *2009 NO_x mobile source diesel emissions for 50 states (6,400,000 tons).[4]*

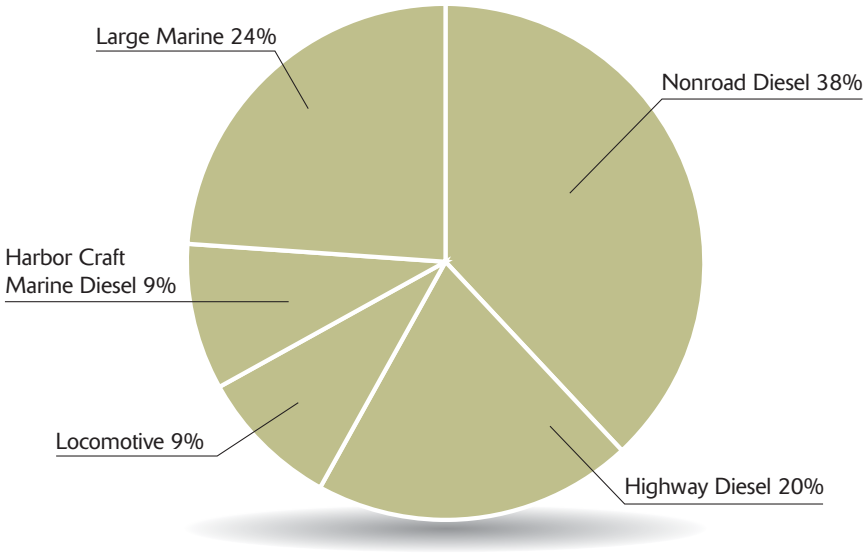

Figure 2. *2009 directly emitted $PM_{2.5}$ mobile source diesel emissions for 50 states (300,000 tons).[4]*

<< *The* M/S Mount Washington*, a motor ship operating on Lake Winnipesaukee, New Hampshire, will have its vintage 1946 diesel motors replaced during the 2009–2010 winter season with new diesel motors that meet or exceed EPA's Tier 2 standards. The ship's original hull dates to 1888 (photo courtesy of Mount Washington Cruises, www.cruisenh.com).*

Figure 3. The Champlain*, a passenger and car/truck ferry on Lake Champlain running between the states of New York and Vermont (photo courtesy of Lake Champlain Transportation).*

Marine Projects by the NEDC

The Northeast has an active marine shipping infrastructure that includes fishing boats, lake and harbor ferries, tugboats, intracoastal barges, cruise ships, ocean-going cargo vessels, and the associated landside facilities needed to support them. Nationally, harbor craft and marine diesel comprise 28% of the mobile source diesel nitrogen oxides (NO_x) emissions (approximately 1,800,000 tons; see Figure 1) and 33% of the directly emitted fine PM (i.e., particles equal to or less than 2.5 micron; $PM_{2.5}$) emissions (approximately 99,000 tons; see Figure 2).[4]

In light of the importance of marine diesel emissions in the Northeast, NEDC participants took a number of early steps to demonstrate emission reduction options for marine vessels and port operations. For example, in New York Harbor, the NEDC helped retrofit and repower public and private ferries and tugboats to significantly reduce NO_x emissions. At the Port Authority of New York/New Jersey and its private terminals, NEDC projects repowered and upgraded cargo-handling equipment and instituted gate management efficiencies. At the New York Container Terminal, NEDC participants installed diesel particulate filters on cargo handling equipment and piloted idle reduction technology on locomotives. The NEDC purchased an electric crane for the South Jersey Port Corporation in Camden, NJ. At Boston's Conley Container Terminal, the NEDC retrofitted yard and cargo-handling equipment, introduced ultra-low-sulfur diesel, and systematically acquired new equipment with maximum-efficiency engines.[1]

Figure 4. The 1929 Fairbanks Morse engine in the ferry Champlain *to be replaced with a new cleaner and more fuel efficient Tier 2-compliant engine (photo by Harold Garabedian).*

Building upon these projects, the NEDC embarked in 2009 on several new initiatives to demonstrate the cost effectiveness of repowering engines in marine vessels. In one project, the NEDC is replacing 13 pre-regulation engines with new engines in four marine vessels: two excursion/ferry vessels operating in the Hudson River and New York Harbor in and around New York City, and two tug boats operating from the port of San Juan, Puerto Rico. The combined impact of the engine replacements is a projected annual reduction in NO_x emissions of 30 tons, an annual reduction in PM emissions of 2.9 tons, and an annual fuel savings of 41,500 gallons.[5]

In a second project, NEDC participants will replace four pre-regulation engines with new engines in one marine tugboat that operates in the New York Harbor, Long Island Sound, and the Delaware River. Over a period of 20 years, the engine replacements are projected to reduce NO_x emissions by 39.7 tons per year, PM by 2.9 tons per year (2.06 tons in years 6 through 20), and annual fuel use by 2,697 gallons.[5]

A third NEDC project will replace currently unregulated Tier 0 engines with EPA-certified Tier 2 engines in five ferries and three tugboats operating in Maine, New Hampshire, and Vermont. A total of 11 main engines and 7 auxiliary generators will be repowered or replaced. This is projected to reduce annual NO_x emissions by 32.8 tons, PM by 2.3 tons, and fuel use by 6,640 gallons.[5]

Vintage Vessels Bring Unique Challenges

Of special note in this set of vessels are the age, history, and unique aspects of two of them. One vessel is the motor ship *M/S Mount Washington*, an iconic excursion vessel operating on New

Hampshire's Lake Winnipesaukee that currently runs on 1946 vintage 8-cylinder 4-stroke main engines with no transmission, making it unique by today's standards. This vessel's original hull was constructed in 1888 utilizing 19th century designs. It began operation on Lake Champlain where it was the lake's first iron-hulled steamboat, before later being sectioned and shipped to Lake Winnipesaukee and re-launched in 1940. The hull was extended by 25 feet in 1982, increasing the complexity of the vessel architecture and requiring special expertise in determining where to cut the hull for the replacement engines along with their new gearboxes.

The second vessel is the *Champlain*, a passenger and car/truck ferry on Lake Champlain running between the states of New York and Vermont (see Figures 3 and 4). The *Champlain* was built in 1930 and is powered by a 1929 Fairbanks Morse diesel engine that also has no transmission. In repowering this vessel, the challenge will be to fit two new Tier 2-compliant engines each outfitted with a transmission in the available space. In completing these modifications, it will be critical to maintain U.S. Coast Guard certification by demonstrating the repowered vessel balance will operate in a safe and effective manner.

These older vintage vessels and the unique engineering challenges they pose demonstrate that older vessels, often among the dirtiest and least fuel-efficient in the fleet, can be viable candidates for modern, cleaner engines and fuels.

Summary

The NEDC now has a successful track record of demonstrating first-in-the-nation pilot projects and innovative policies and programs leading to cleaner diesel technologies and practices. With the combined experience of EPA, state air quality agencies, and private-sector participants, the NEDC is now pursuing new opportunities to demonstrate cleaner technologies in a variety of marine vessel applications, such as tugboats, ferries, and excursion vessels. Notable among these is a demonstration project that will repower a vessel older than the *Titanic*. By openly taking on these engineering challenges, the NEDC is demonstrating not only the viability of cleaner engines and fuels on every-day workhorses like tugboats and ferries, but also that repowering works for older vessels from a bygone era. With newer, cleaner, more fuel-efficient engines, these projects are reducing air pollution and lowering fuel costs while extending the operating lifetime of these ships for years to come. em

References

1. The Northeast Diesel Collaborative. See www.northeastdiesel.org/index.htm (accessed November 2009).
2. *Hearing on Black Carbon and Climate Change*; Hearings before the House Committee on Oversight and Government Reform, U.S. House of Representatives: Washington, DC, October 18, 2007 (testimony of Professor Tami Bond, University of Illinois at Urbana-Champaign).
3. See www.epa.gov/otaq/diesel/index.htm.
4. *Report to Congress: Highlights of the Diesel Emissions Reduction Program*; EPA-420-R-09-006; U.S. Environmental Protection Agency, Office of Transportation and Air Quality: Washington, DC, August 2009; available at www.epa.gov/otaq/diesel/documents/420r09006.pdf (accessed December 2009).
5. Current baseline emissions of NO_x and PM, and projected emissions after repower, were calculated using the same method as that used in EPA's Diesel Emissions Quantifier (http://cfpub.epa.gov/quantifier/view/welcome.cfm). Projected fuel use after repower is based on fuel rate data published by the manufacturers of the new engines and an assumed average load factor calculated based on installed engine power and historical annual operating hours and fuel use.