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# Draft Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines

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## List of Acronyms

| | |
|---|---|
| ABT | Averaging, Banking, and Trading |
| AEO | Annual Energy Outlook |
| AGME | Above-ground mining equipment |
| AT | Aftertreatment |
| BSFC | Brake Specific Fuel Consumption |
| CCV | Closed crankcase ventilation |
| CDPF | Catalyzed diesel particulate filter |
| CFR | Code of Federal Regulations |
| CI | Compression-Ignition |
| CMV | Commercial Marine Vessel |
| CO | Carbon monoxide |
| DF | Deterioration Factor |
| DI | direct injection |
| DOC | Diesel oxidation catalyst |
| EF | Emission Factor |
| EGR | Exhaust gas recirculation |
| EIA | U. S. Energy Information Administration |
| EIA | Economic Impact Analysis |
| FR | Federal Register |
| FTC | Federal Trade Commission |
| GDP | Gross domestic product |
| HC | Hydrocarbons |
| HD2007 | Heavy-duty 2007 refers to the final rule setting emission standards for 2007 and later engines used in heavy-duty highway vehicles. |
| hp | Horsepower |
| IDI | Indirect injection |
| IRFA | Initial Regulatory Flexibility Analysis |
| kW | kilowatt |
| L&M | Locomotive and marine |
| MPP | marginal physical product |

| | |
|---|---|
| NDEIM | Nonroad Diesel Economic Impact Model |
| NMHC | Non-methane hydrocarbons |
| NPV | Net present value |
| NR | Nonroad |
| NRLM | Nonroad, Locomotive, and Marine diesel fuel |
| O&M | operating and maintenance |
| OMB | Office of Management and Budget |
| PM | Particulate matter |
| ppm | Parts per million |
| PSR | Power Systems Research |
| RIA | Regulatory Impact Analysis |
| SBA | Small Business Administration |
| SBAR | Small Business Advocacy Review |
| SBREFA | Small Business Regulatory Enforcement Fairness Act |
| SER | Small Entity Representative |
| SIC | Standard Industrial Classification |
| stds | standards |
| TAF | Transient Adjustment Factor |
| TPEM | Transition program for engine manufacturers (see 40 CFR 89.102 and the proposed 40 CFR 1039.625) |
| VMP | value of marginal product |
| VOC | Volatile organic compounds |
| ZHL | Zero-Hour Emission Level |

# Executive Summary

The Environmental Protection Agency (EPA) is proposing requirements to reduce emissions of particulate matter (PM) and oxides of nitrogen (NOx) from nonroad diesel engines. This proposal includes emission standards for new nonroad diesel engines. The proposal also addresses the quality of the fuel used in nonroad engines, as well as locomotive and marine engines, by specifying reduced sulfur levels.

This executive summary first highlights the proposed emission standards and fuel requirements, then gives an overview of the analyses in the rest of this document.

## Emission Standards and Engine Technologies

Tables 1 and 2 show the Tier 4 emission standards and when they apply. For most engines, these standards are similar in stringency to the final standards included in the 2007 highway diesel program and are expected to require the use of high-efficiency aftertreatment systems to ensure compliance. As shown in the table, we are phasing in many of the proposed standards over a two- or three-year period to address lead time, workload, and feasibility considerations.

Table 1
Proposed PM Standards (g/bhp-hr) and Schedule

| Engine Power | Model Year | | | | | |
|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| hp < 25 (kW < 19) | 0.30 | | | | | |
| 25 ≤ hp < 75 (19 ≤ kW < 56) | 0.22 | | | | | 0.02 |
| 75 ≤ hp < 175 (56 ≤ kW < 130) | | | | | 0.01 | |
| 175 ≤ hp ≤ 750 (130 ≤ kW ≤ 560) | | | | 0.01 | | |
| hp > 750 (kW > 560) | | | | 0.01 | | |

Table 2
Proposed NOx and NMHC Standards and Schedule

| Engine Power | Standard (g/bhp-hr) | | | |
|---|---|---|---|---|
| | NOx | | NMHC | |
| 25 ≤ hp < 75 (19 ≤ kW < 56) | 3.5 NMHC+NOx | | | |
| 75 ≤ hp < 175 (56 ≤ kW < 130) | 0.30 | | 0.14 | |
| 175 ≤ hp ≤ 750 (130 ≤ kW ≤ 560) | 0.30 | | 0.14 | |
| hp > 750 (kW > 560) | 0.30 | | 0.14 | |
| | Phase-in Schedule | | | |
| | 2011 | 2012 | 2013 | 2014 |
| 25 ≤ hp < 75 (19 ≤ kW < 56) | | | 100% | |
| 75 ≤ hp < 175 (56 ≤ kW < 130) | | 50% | 50% | 100% |
| 175 ≤ hp ≤ 750 (130 ≤ kW ≤ 560) | 50% | 50% | 50% | 100% |
| hp > 750 (kW > 560) | 50% | 50% | 50% | 100% |

The proposal includes new provisions to help ensure that emission-control systems perform as well when operating in actual service conditions as in the laboratory. These procedures will also allow for testing an engine's emission levels while the machinery operates in normal service.

**Controls on In-use Diesel Fuel**

Just as lead was phased out of gasoline because it damages catalytic converters in cars, sulfur can contaminate high-efficiency emission-control systems used on diesel engines. Nonroad diesel fuel currently has sulfur levels up to 3,400 parts per million (ppm). This proposal would reduce these levels by 99 percent, which is an essential step in achieving the emission reductions anticipated under the proposal.

Starting in 2007, fuel sulfur levels in nonroad diesel fuel would be limited to a maximum of 500 ppm, the same as for current highway diesel fuel. This limit also covers fuels used in locomotive and marine applications (though not to the marine residual fuel used by very large engines on ocean-going vessels). Reducing fuel sulfur levels to 500 ppm or lower will provide immediate public health benefits by reducing particulate emissions from engines in the existing fleet of nonroad equipment, with the added benefit of reducing the cost of maintaining engines.

The proposal includes a second step of fuel controls to a 15-ppm limit on sulfur content that would apply in 2010. This additional reduction in sulfur levels will further reduce PM emissions from existing engines. More importantly, the ultra-low sulfur levels will make it possible for engine manufacturers to use advanced emission-control systems that will achieve dramatic reductions in both PM and NOx emissions. In addition, we are seriously considering whether to

establish new emissions standards in the future that would reduce the emissions from locomotive and marine engines by more than 90 percent with the same advanced emission-control technologies included in this proposal.

## Estimated Costs of the Proposal

There are approximately 600 nonroad equipment manufacturers using diesel engines in several thousand different equipment models. Fixed costs consider engine research and development, engine tooling, engine certification, and equipment redesign. Variable costs include estimates for new emission-control hardware. Near-term and long-term costs for some example pieces of equipment are shown in Table 3. Also shown in Table 3 are typical prices for each piece of equipment for reference. See Chapter 6 for additional detailed information related to cost analyses related to engines and equipment.

Table 3
Long-Term Costs for Several Example Pieces of Equipment[a]

| | GenSet | Skid/Steer Loader | Backhoe | Dozer | Agricultural Tractor | Dozer | Off-Highway Truck |
|---|---|---|---|---|---|---|---|
| Horsepower | 9 hp | 33 hp | 76 hp | 175 hp | 250 hp | 503 hp | 1000 hp |
| Displacement (L) | 0.4 | 1.5 | 3.9 | 10.5 | 7.6 | 18 | 28 |
| Incremental Engine & Equipment Cost | | | | | | | |
| Long Term | $120 | $760 | $1,210 | $2,590 | $2,000 | $4,210 | $6,780 |
| Near Term | $170 | $1,100 | $1,680 | $3,710 | $2,950 | $6,120 | $10,100 |
| Estimated Equipment Price[b] | $3,500 | $13,500 | $50,000 | $235,000 | $130,000 | $575,000 | $700,000 |

[a] Near-term costs include both variable costs and fixed costs; long-term costs include only variable costs and represent those costs that remain following recovery of all fixed costs.

Our estimated costs related to upgrading to low-sulfur fuel takes into account all the necessary changes in both refining and distribution practices. We have estimated the cost of producing 500-ppm fuel to be on average 2.5 cents per gallon. Average costs for 15-ppm fuel are estimated to be an additional 2.3 cents per gallon for a combined cost of 4.8 cents per gallon, as shown in Table 4. These ranges consider variations in regional issues in addition to factors that are specific to individual refiners. In addition, engines running on low-sulfur fuel will have reduced maintenance expenses that we estimate will be equivalent to reducing the cost of the fuel by 3.3 cents per gallon.

Table 4
Increased Cost of Providing Nonroad,
Locomotive and Marine Diesel Fuel (cents per gallon of affected fuel)

| | Refining | Distribution | Total |
|---|---|---|---|
| Step One - 500 ppm NRLM diesel fuel | 2.2 | 0.3 | 2.5 |
| Step Two - 15 ppm Nonroad diesel fuel | 4.4 | 0.4 | 4.8 |
| Step Two - 500 ppm Locomotive and Marine diesel fuel | 2.2 | 0.2 | 2.4 |

## Cost per Ton of Reduced Emissions

Chapter 8 describes the analysis of aggregating the incremental fuel costs, operating costs, and the costs for producing compliant engines and equipment, operating costs. Table 5 compares these aggregate costs with the corresponding estimated emission reductions to present cost-per-ton figures for the various pollutants.

Table 5
Aggregate Cost per Ton for the Proposed Two-Step Fuel Program
and Engine Program—2004-2036 Net Present Values at 3% Discount Rate ($2001)

| Pollutant | Aggregate Discounted Lifetime Cost per ton |
|---|---|
| NOx+NMHC | $810 |
| PM | $8,700 |
| $SO_x$ | $200 |

## Estimated Emission Reductions, Air Quality Impacts and Benefits

Based on our most recent nationwide inventory used for this proposal (1996), we estimate that the nonroad diesel engines affected by this proposal contribute about 44 percent of diesel PM emissions and 12 percent of NOx emissions from mobile sources. By 2020, these engines will emit over 60 percent of diesel PM and 20 percent of NOx from mobile sources. When fully implemented, this proposal would reduce PM and NOx emissions from nonroad diesel engines by more than 90 percent. It will also virtually eliminate emissions of sulfur oxides (SOx) from these engines, which amounted to nearly 300,000 tons in 1996, and would otherwise grow to approximately 380,000 tons by 2020. These dramatic emission reductions emissions are a critical part of the effort by federal, state, local, and tribal governments to reduce the health-related impacts of air pollution.

Reducing NOx and PM emissions from nonroad diesel engines by more than 90 percent would provide a wide range of benefits for public health and the environment. We have estimated that, by 2030, controlling these emissions would annually prevent 9,600 premature

deaths, over 8,300 hospitalizations, and almost a million work days lost. All told, the monetized health benefits of this rule would be $81 billion annually once the program is fully phased in. Costs for both the engine and fuel requirements would be significantly less, at approximately $1.5 billion annually. See the fact sheet referenced below for further description of these environmental benefits.

## Economic Impact Analysis

An Economic Impact Analysis was prepared for this proposal to estimate its potential economic impacts on producers and consumers of nonroad engines and equipment and fuels, and related industries. The Economic Impact Analysis has two parts: a market analysis and a welfare analysis. The market analysis explores the impacts of the proposed program on prices and quantities of affected products. The welfare analysis focuses on changes in social welfare and explores which entities will bear the burden of the proposed program. A multi-market partial equilibrium approach was used to track changes in price and quantity for 60 integrated product markets. The model and data inputs are described in Chapter 10.

As shown in Table 6, the market analysis predicts that the overall economic impact of the proposed emission control program on society is expected to be small, on average. According to this analysis, the average prices of goods and services produced using equipment and fuel affected by the proposal (the application markets) are expected to increase about 0.02 percent. Engine prices are expected to increase, on average, about 22.9 percent in 2013, decreasing to about 19.5 percent for 2020 and after. The average price increase for nonroad equipment is expected to be about 5.2 percent in 2013, decreasing to 4.4 percent by 2020. The average price increase for nonroad diesel fuel for all years is expected to be about 4.1 percent. Quantities of products affected by this proposal are expected to decline negligibly, by less that 0.02 percent.

Table 6
Summary of Expected Market Impacts, 2013 and 2020

| Market | 2013 | | | 2020 | | |
|---|---|---|---|---|---|---|
| | Average engineering cost per unit | Price change | Quantity change | Average engineering cost per unit | Price change | Quantity change |
| Engines | $1,087 | 22.9% | -0.013% | $1,028 | 19.5% | -0.013% |
| Equipment | $1,021 | 5.2% | -0.014% | $1,018 | 4.4% | -0.014% |
| Application markets[a] | — | 0.02% | -0.010% | — | 0.02% | -0.010% |
| Nonroad Fuel Markets | $0.039 | 4.1% | -0.013% | $0.039 | 4.1% | -0.014% |

[a]Commodities in the application markets are normalized; only percentage changes are presented

The welfare analysis predicts that consumers and producers in the application markets are expected to bear the burden of this proposed program. In 2013, the total social costs of the rule are estimated to be about $1,202 million. About 82 percent of the total social costs are expected to be borne by producers and consumers in the application markets, indicating a majority of the costs are expected to be passed on in the form of higher prices. When these estimated impacts are broken down, 58 percent are expected to be borne by consumers in the application markets and 42 percent are expected to be borne by producers in the application markets. Equipment manufacturers are expected to bear about 10 percent of the total social costs. These are primarily the costs associated with equipment redesign. Engine manufacturers are expected to bear about 2.5 percent; this is primarily the fixed costs for R&D. Nonroad fuel refiners are expected to bear about 0.5 percent of the total social costs. The remaining 5 percent is accounted for by fuel marker costs and the additional costs of 15 ppm fuel being sold in to markets such as marine diesel, locomotive, and home heating fuel that do not require it.

In 2020, the social costs of the rule are expected to increase to about $1,510 million. Producers and consumers in the applications markets are expected to bear nearly all of these costs, about 94 percent. This is consistent with economic theory, which states that, in the long run, all costs are passed on to the consumers of goods and services.

**Alternative program options**

In the course of designing our proposed program, we investigated several alternative approaches to both the engine and fuel programs. These alternative program options included variations in:

- The applicability of aftertreatment-based standards for different horsepower categories
- The phase-in schedule for engine standards
- The start date for the diesel fuel sulfur standard
- The use of a single-step instead of a two-step approach to fuel sulfur standards
- The applicability of the very-low fuel sulfur standards to fuel used by locomotives and marine engines

Chapter 12 includes a complete evaluation of twelve alternative program options, including an assessment of technical feasibility, cost, cost-effectiveness, inventory impact, and health and welfare benefits for each alternative. Table 12.6.1-1 summarizes the alternative program options, while the accompanying text in Section 12.6 presents our rationale for choosing the proposed program rather than one of the alternatives.