

horsepower engine and \$320 for a 500 horsepower engine. In the long-term, we estimate these costs at \$140 and \$240, respectively.

iv. Closed-Crankcase Ventilation System (CCV) Costs

We are proposing to eliminate the exemption that allows turbo-charged nonroad diesel engines to vent crankcase gases directly to the environment. Such engines are said to have an open crankcase system. We project that this requirement to close the crankcase on turbo-charged engines would force manufacturers to rely on engineered closed crankcase ventilation systems that filter oil from the blow-by gases prior to routing them into either the engine intake or the exhaust system upstream of the CDPF. We have estimated the initial cost of these systems to be roughly \$40 for low horsepower engines and up to \$100 for very high horsepower engines. These costs are incurred only by turbo-charged engines because today's naturally aspirated engines already have CCV systems.

v. Variable Costs for Engines Below 75 Horsepower and Above 750 Horsepower

This proposal includes standards for engines <25 horsepower that begin in 2008, and two sets of standards for 25 to 75 horsepower engines—one set that begins in 2008 and another that begins in 2013. The 2008 standards for all engines <75 horsepower are of similar stringency and are expected to result in similar technologies (*i.e.*, the addition of a DOC). The 2013 standards for 25 to 75 horsepower engines are considerably more stringent than the 2008 standards and are expected to force the addition of a CDPF along with some other engine hardware to enable the proper functioning of that new technology. More detail on the mix of technologies expected for all engines <75 horsepower is presented in section III. As discussed there, if changes are needed to comply, we expect manufacturers to comply with the 2008 standards through either engine improvements or through the addition of a DOC. From a cost perspective, we have projected that engines would comply by either adding a DOC or by making some engine modifications resulting in engine-out emission reductions. Presumably, the manufacturer would choose the least costly approach that provided the necessary reduction. If engine-out modifications are less costly than a DOC, our estimate here is conservative. If the DOC proves to be less costly, then our estimate is representative of what most manufacturers would do.

Therefore, we have assumed that, beginning in 2008, all engines below 75 horsepower add a DOC. Note that this is a conservative estimate in that we have assumed this cost for all engines when, as discussed in section IV, some engines <75 horsepower already meet the proposed PM standards. We have estimated this added hardware to result in an increased engine cost of \$150 in the near-term and \$140 in the long-term for a 30 horsepower engine.

We have also projected that some engines in the 25 to 75 horsepower range would have to upgrade their fuel systems to accommodate the CDPF. We have estimated the incremental costs for these fuel systems at roughly \$740 in the 25–50 horsepower range, and around \$430 in the 50–75 horsepower range. This difference reflects a different base fuel system, with the smaller engines assumed to have mechanical fuel systems and the larger engines assumed to already be electronic. The electronic systems will incur lower costs because they already have the control unit and electronic fuel pump. Also, we have assumed these fuel changes would occur for only direct injection (DI) engines; indirect injection engines (IDI) are assumed to remain IDI but to add more hardware as part of their CDPF regeneration system to ensure proper regeneration under all operating conditions. Such a regeneration system, described above, is expected to cost roughly twice that expected for DI engines, or around \$320 for a 30 horsepower IDI engine versus \$160 for a DI engine.

We have also projected that engines in the 25–50 horsepower range would add cooled EGR to comply with their new NO_x standard. We have estimated that this would add \$90 in the near-term and \$70 in the long-term to the cost of a 30 horsepower engine.

We believe there are factors that would cause variable hardware costs to decrease over time, making it appropriate to distinguish between near-term and long-term costs. Research in the costs of manufacturing has consistently shown that as manufacturers gain experience in production, they are able to apply innovations to simplify machining and assembly operations, use lower cost materials, and reduce the number or complexity of component parts.²⁸⁹ Our analysis, as described in more detail in the draft RIA, incorporates the effects of this learning curve by projecting that the variable costs of producing the low-

emitting engines decreases by 20 percent starting with the third year of production. For this analysis, we have assumed a baseline that represents such learning already having occurred once due to the 2007 highway rule (*i.e.*, a 20 percent reduction in emission control device costs is reflected in our near-term costs). We have then applied a single learning step from that point in this analysis. We invite comment on this methodology to account for the learning curve phenomenon and also request comment on whether learning is likely to reduce costs even further in this industry (*e.g.*, should a second learning step be applied to our near-term costs?). Additionally, manufacturers are expected to apply ongoing research to make emission controls more effective and to have lower operating costs over time. However, because of the uncertainty involved in forecasting the results of this research, we conservatively have not accounted for it in this analysis.

c. Engine Operating Costs

We are projecting that a variety of new technologies will be introduced to enable nonroad engines to meet the proposed Tier 4 emissions standards. Primary among these are advanced emission control technologies and low-sulfur diesel fuel. The technology enabling benefits of low-sulfur diesel fuel are described in section III, and the incremental cost for low-sulfur fuel is described in section V.A. The new emission control technologies are themselves expected to introduce additional operating costs in the form of increased fuel consumption and increased maintenance demands. Operating costs are estimated in the draft RIA over the life of the engine and are expressed in terms of cents/gallon of fuel consumed. In section V.C.3, we present these lifetime operating costs as a net present value (NPV) in 2001 dollars for several example pieces of equipment.

Total operating cost estimates include the following elements: the change in maintenance costs associated with applying new emission controls to the engines; the change in maintenance costs associated with low sulfur fuel such as extended oil change intervals; the change in fuel costs associated with the incrementally higher costs for low sulfur fuel, and the change in fuel costs due to any fuel consumption impacts associated with applying new emission controls to the engines. This latter cost is attributed to the CDPF and its need for periodic regeneration which we estimate may result in a one percent fuel consumption increase where a NO_x

²⁸⁹ "Learning Curves in Manufacturing," Linda Argote and Dennis Epple, *Science*, February 23, 1990, Vol. 247, pp. 920–924.