



POLICIES TO PUT GREENER TRUCKS AND BUSES ON THE ROAD

Realizing the potential of greener fuels and technologies will require engine, truck, and fuel companies to be much more aggressive in bringing about change in a century-old industry. And customers—from businesses that use parcel delivery, to grocery store chains, to parents who put their kids on a school bus five days a week—also need to signal that they are ready for change. Aggressive policies are the catalyst that can bring about the transition, giving industry the necessary nudge to invest in cleaner options and consumers the incentive to buy them. A coordinated package of regulations, incentives, and voluntary actions can yield a robust strategy for creating an environment of change.

Regulations

Emission Standards

It is time to ask trucks to pull their own weight in cleaning the air. With new technologies coming to the fore, cutting nitrogen oxide and particulate emissions by a factor of ten is well within reach. The EPA's recently proposed standards, which would begin in 2007, could do just that. But the EPA could secure more gains for public health by encouraging early introduction of cleaner engines and setting optional low-emission standards that encourage manufacturers whose engines go beyond the requirements.

Real-World Emissions

Tighter standards are only part of the solution. Ensuring real-world emission reductions becomes even more critical as engine makers install pollution-control devices on all diesel engines for the first time. Twenty-five years of experience with automotive emission controls have highlighted the clear need for catalysts that last the entire life of the vehicle and operate efficiently under all driving conditions. The EPA must develop testing methods and requirements—such as in-use tests, onboard diagnostic technology as is found on new cars today, and limits on high-power pollution levels—to ensure that cleaner trucks are clean in real-world driving situations and that they stay clean over the vehicle's life.

Should the EPA fail to establish an effective real-world testing and compliance program and trucks fail to stay clean, the loss to air quality would be staggering. In modeling the benefits of tighter truck and fuel standards, the EPA assumes that emissions from future trucks will not deteriorate or

malfunction. In the real world, both truck engines and control technology are likely to do so over time. We analyzed the impact on national emissions in 2030, assuming historic deterioration rates prevail in the future or even double (assuming new exhaust-control technology malfunctions much as today's automotive catalysts sometimes do). Under this scenario, particulate emissions in 2030 would be 2.5 to 4 times higher than in the base case, and smog-forming exhaust 1.7 to 2.3 times higher (Figure 13, opposite). This would substantially cut the benefits of the EPA's proposed rule: trucks that do not deteriorate can cut particulate emissions by over 90 percent by 2030, but the reduction would only be 56 percent if trucks with sophisticated pollution-control technology deteriorate at twice historic rates.

Intrinsically Clean Vehicles

Alternative fuel engines and advanced technologies such as hybrids and fuel cells can provide greater air quality benefits than diesel because they are intrinsically cleaner. As the EPA struggles to ensure that new diesels stay clean over their million-mile lifetimes, alternatives offer a reliable option that the agency must encourage. Figure 13 demonstrates that intrinsically clean vehicles can help offset the impact of diesel deterioration on a national scale. These cleaner options also offer important reductions in heat-trapping emissions, which, although not regulated today, are a clear environmental priority.

Retrofit Requirements

As clean new vehicles move onto the road the air will gradually become cleaner, but cleaning up the fleet of conventional diesel trucks currently on the road can deliver large benefits in the short term. Because these older engines were built to less stringent standards, they are much dirtier than today's new models.

Opportunities to improve the environmental performance of a diesel truck occur every time it is brought in for a major engine overhaul. The engine can be

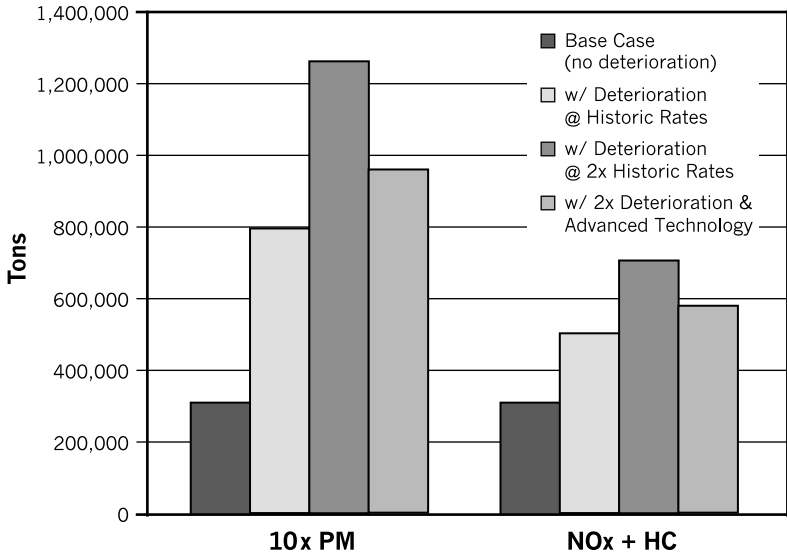
- rebuilt to a cleaner standard using modern equipment
- replaced with a newer engine (called *repowering*)
- retrofitted with cleanup technologies

Retrofits can offer large benefits at a modest cost. For example, particulate traps installed on an older engine can reduce particle emissions by over 90 percent at a cost of just a few thousand dollars (CARB 1999).³⁹ Substantial nitrogen oxide reductions may also be achievable through mandatory retrofits, repowers, or rebuilds.

The EPA currently requires that older transit buses to be retrofitted with particulate controls. Regulators in California recently passed a similar rule that

³⁹ If low-sulfur fuel is also required, drivers may pay a bit more over the vehicle's life for fuel.

Figure 13. Emissions from US Trucks in 2030 Under Various Scenarios of Deterioration



Notes:

1. UCS calculation based on national model for emission levels for engines meeting the EPA's proposed emission standards with and without deterioration.
2. "Historic" deterioration rates based on MY2004 values (EPA 1999a), measured in g/bhp-hr per 10,000 miles.
3. Advanced technology scenario assumes penetration of alternative fuel and advanced technology vehicles with no deterioration, as assumed in the "green truck" scenario (Table A-2).

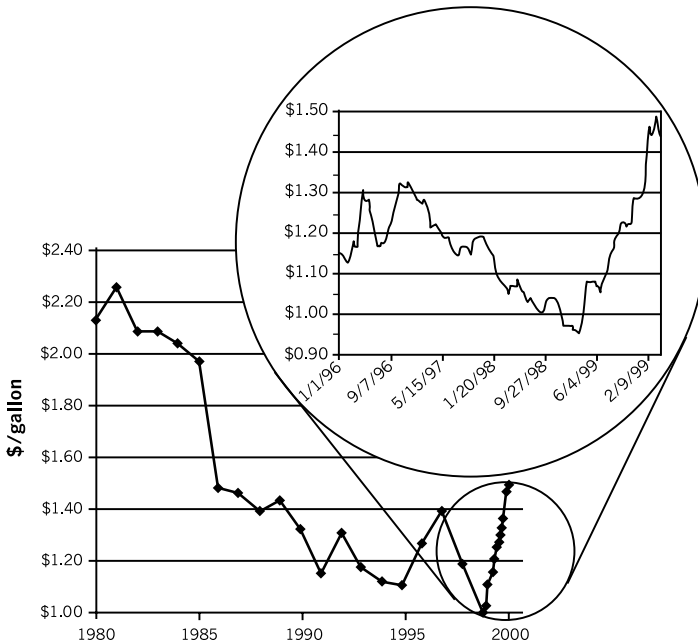
will require even larger reductions, building on recent advances in particulate cleanup technology. Ultimately, all older diesel vehicles should be cleaned up. If new pollution-control technology proves as cheap and effective as both industry and regulators suggest, regulations to require their use on all diesel trucks and buses nationwide will deliver large public health benefits in the near term.

Fuel Standards

To achieve the types of pollution reductions that are technically possible from future diesel engines, the fuel they burn will have to become much cleaner. In particular, data from testing advanced emission-control equipment demonstrates a direct relationship between the sulfur content of diesel fuel and the efficiency and durability of the pollution cleanup technology. Nitrogen oxide traps, the technology that may offer the greatest potential for large gains in control, appear the most sensitive to sulfur. Similarly, particulate traps work best when sulfur levels are low.

Reducing fuel sulfur levels is not free, but the cost increase projected by the EPA to meet their proposed 15 ppm cap is only pennies per gallon (EPA 2000), an amount that Figure 14 shows to be negligible compared with historic variations in the price of diesel fuel.

Figure 14.
Historic Fluctuations in the Price of Diesel Fuel
Surpass Extra Cost for Low Sulfur Diesel



Source: EIA International Energy Annual; EIA Weekly Petroleum Status

Incentives

While tighter standards for engines and fuel will continue to form the backbone of diesel cleanup strategies, voluntary incentives can be a valuable supplement. California has had a statewide diesel cleanup program for several years that provides financial incentives to diesel operators who choose to clean up their engines. To qualify for funding, projects must deliver at least a 30 percent reduction in nitrogen oxide emissions, and particulate reductions are strongly encouraged (and may be required in the future). The incentives have resulted in a demand that far outstrips available funds, highlighting the program's success. Incentive programs being debated at the federal level would

provide tax credits for buying heavy-duty vehicles that run on alternative fuels, as well as for buying the fuel.

Cleanup incentives are an attractive policy avenue, but they require funding (either from general budgets or from user fees, such as fees collected on trucks or fuels) and aggressive marketing by state and local agencies. Further, incentives must contain environmental guarantees to ensure that public funds are delivering progress on the key health threats posed by diesel, namely nitrogen oxides, particulates, and toxic emissions. New programs should also focus on fuel-economy gains or on technologies, such as hybrids or fuel cells, that can simultaneously deliver air quality progress *and* reductions in heat-trapping emissions. Finally, while incentives can offer valuable public gains, they can only augment, not replace, aggressive regulations that require diesel engine cleanup.

Green Fleets

Fleet vehicles offer an early market opportunity for alternative fuels and advanced technologies, helping prove these new options and building sales volumes to help lower costs. Because fleets commonly operate in cities, the extra measure of health protection these technologies can provide is particularly valuable. Regulations that require the use of cleaner technologies, incentive programs, collective bids, and voluntary commitments are just a few of the policy tools available to help make fleets greener.

Research and Development

Strong, publicly funded research and development (R&D) is the necessary foundation for environmental gains in the truck market. Such programs are currently under way at all levels of government across the country. In April 2000, the federal government launched the 21st Century Truck Initiative, aimed at developing smaller heavy trucks with triple the fuel economy of today's vehicles and long-haul trucks with double the fuel economy. Working with industry, this program can develop valuable technologies that will be vital to protecting our economy, air, and climate. To succeed, however, R&D programs must set strong environmental targets that ensure progress in reducing both heat-trapping emissions and air pollution. Furthermore, R&D by itself is not enough. Strong market policies, such as incentives and standards, are the best way to ensure that technologies developed in the lab make it onto the road.



New technologies and fuels promise to substantially reduce the impact of America's trucks on public health and the environment. Improvements to conventional diesel technology are an absolute priority, but clean fuels and advanced technologies offer much-needed supplementary gains.

One of the greatest challenges to delivering on the air quality promise of new truck technology is ensuring that vehicles equipped with sophisticated exhaust controls stay clean over their million-mile lifetimes. Cleaner fuel with virtually zero sulfur will be essential, but regulators must also establish strong in-use monitoring to catch problems. Without such real-world checks, the benefits of cleanup technology could be lost to malfunctioning or deteriorating equipment. One of the most prudent strategies for ensuring trucks remain low polluters is to encourage intrinsically clean vehicles powered by alternative fuels or advanced technologies.

Cutting trucks' pollutant emissions is the immediate priority, but addressing the environmental impact of trucking also means reducing emissions of the heat-trapping gases that cause global warming. Greater fuel economy is the key in the short term. Strategies for improving the fuel economy of diesel trucks must be accelerated. The stretch target is to double the efficiency of today's biggest trucks. But with rising truck travel these improvements will not be enough to substantially reduce heat-trapping emissions below today's levels. In particular, the role of low-carbon, renewable fuels in heavy trucks needs further study.

Strong policies will be needed to put the truck and bus industry on a greener path. Coupled with conventional technology improvements, alternative fuels, and advanced technologies, a green truck strategy could deliver sizeable gains in 2030 when cleaner technologies permeate the truck population:

- Preventing emission of one-quarter of a million tons of toxic soot
- Keeping over 60 million cars-worth of smog-forming exhaust out of the air
- Doubling truck travel without increasing oil use
- Reducing global warming pollution by 26 percent

References

Alternative Fuels Data Center. n.d. Online at www.afdc.doe.gov.

American Thoracic Society (ATS). 1996. "Health Effects of Outdoor Air Pollution." *American Journal of Respiratory Critical Care Medicine*. 153:3-50.

An, F., F. Stodolsky, A. Vyas, R. Cuenca, J.J. Eberhardt. 2000. *Scenario Analysis of Hybrid Class 3-7 Heavy Vehicles*. Warrendale, Penn.: Society of Automotive Engineers. SAE 2000-01-0989.

Arcadis Geraghty & Miller. 1998. *Cost Analysis of Diesel versus LNG Truck Fleets: Operating and Capital Cost Comparison in Grocery Distribution Operations*. Prepared for Coalition for Clean Air. Fullerton, Calif.: Arcadis.

Argonne National Laboratory (ANL). n.d. "Technology Brief: Truckers, Don't Let Your Profits Go Up in Smoke." Online at www.transportation.anl.gov/ttrdc/idling.html.

Bhatia, R., P. Lopipero, A.H. Smith. 1998. "Diesel Exhaust Exposure and Lung Cancer." *Epidemiology*, 9(1):84-91.

Bunting, Bruce. 1998. "Urea SCR for Diesel NO_x Reduction." Presentation at the *1998 Diesel Engine Emissions Reduction Workshop*. Castine, Maine. July.

California Air Resources Board (CARB). 2000a. EMFAC2000 Model Documentation. Sacramento, Calif.: CARB. May.

California Air Resources Board (CARB). 2000b. Model Year 2000 Certification Data for On-Road Heavy-Duty Engines. El Monte, Calif.: CARB.

California Air Resources Board (CARB). 1999. *Proposed Regulation for a Public Transit Bus Fleet Rule and Emission Standards for New Urban Buses, Staff Report: Initial Statement of Reasons*. Sacramento, Calif.

California Air Resources Board (CARB). 1998. "ARB Identifies Diesel Particulate Emissions as a Toxic Air Contaminant," News Release. Sacramento, Calif. August 27.

California Environmental Protection Agency (Cal-EPA). 1998a. *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant: Executive Summary*. Sacramento, Calif. As approved by the Scientific Review Panel.

California Environmental Protection Agency (Cal-EPA). 1998b. *Initial Statement of Reasons for Rulemaking, Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix II: Findings of the Scientific Review Panel*. Sacramento, Calif.

Clark, N., D. Lyons, M. Gautam, J. Kopasko, and W. Xie. 2000. *Emissions Performance Testing of Eight Transit Buses with Different Fuels and Technologies*. Prepared by West Virginia University for the Massachusetts Bay Transportation Authority, Boston.

Davis, S.C. 1999. *Transportation Energy Data Book*. Edition 19. Oak Ridge, Tenn.: Oak Ridge National Laboratory.

DeCicco, J., and J. Mark. 1998. "Meeting the Energy and Climate Challenge for Transportation in the United States." *Energy Policy*, 26(5):395–412.

Department of Commerce (DOC). 2000. Vehicle Inventory and Use Survey, 1997. Microdata file on CD-ROM issued by the US Department of Commerce, Economics, and Statistics Administration. Washington, D.C.

Department of Energy, Office of Heavy Vehicle Technologies (DOE). 2000. *OHVT Technology Roadmap*. Washington, D.C. DOE/OSTI-11690/R1.

Deuel, H.P., P.D. Guthrie, W. Moody, L. Deck, S. Lange, F. Hameed, J. Castle, and L. Mearns. 1999. "Potential Impacts of Climate Change on Air Quality and Human Health." Presented at the Annual Meeting and Exhibition of the Air and Waste Management Association. St. Louis, Mo. June 20–24.

Dickey, D.W., T.W. Ryan, and A.C. Matheaus. 1998. "NO_x Control in Heavy-Duty Diesel Engines—What is the Limit?" Warrendale, Penn.: Society of Automotive Engineers. SAE 980174.

- Dockery, D.W., C.A. Pope, X. Xu, J.D. Spengler, et al. 1993. "An Association Between Air Pollution and Mortality in Six US Cities." *New England Journal of Medicine*, 329:1753–1759.
- Dou, D., and O.H. Bailey. 1998. "Investigation of NO_x Adsorber Catalyst Deactivation." Warrendale, Penn.: Society of Automotive Engineers SAE 982594.
- Eberhardt, J.J. 2000. "21st Century Truck: A Government-Industry Research Partnership." Presented to the National Academy of Sciences Board on Energy and Environmental Systems. Washington, D.C. May 16.
- Energy Information Administration (EIA). 2000. *Annual Energy Outlook 2000*. Washington, D.C.: US Department of Energy.
- Environmental Protection Agency (EPA). 2000. *Heavy-Duty Standards/ Diesel Fuel Draft Regulatory Impact Analysis*.
- Environmental Protection Agency (EPA). 1999a. *Update of Heavy-Duty Emission Levels (Model Years 1988–2004+) for use in Mobile 6*. EPA420-R-99-010.
- Environmental Protection Agency (EPA). 1999b. *Development and Use of Heavy-Duty NO_x Defeat Device Emission Effects for Mobile 5 and Mobile 6*. EPA420-P-99-030.
- Environmental Protection Agency (EPA). 1998a. Health Assessment Document for Diesel Emissions. Washington, DC: US EPA. SAB Review Draft. February.
- Environmental Protection Agency (EPA). 1998b. *Update on Heavy-Duty Engine Emission Conversion Factors for Mobile 6*. EPA420-P-98-015.
- Environmental Protection Agency (EPA). 1997a. "Health and Environmental Effects of Particulate Matter." Fact sheet. Online at www.epa.gov/naaqsfin/pmhealth.htm.
- Environmental Protection Agency (EPA). 1997b. *National Air Pollutant Emission Trends*. EPA-454/R-97-011.
- Environmental Protection Agency (EPA). 1996. *Air Quality Criteria for Particulate Matter*. Final Draft. EPA 600/P-95/001aF.
- Health Effects Institute (HEI). 1995. *Diesel Exhaust: A Critical Analysis of Emissions, Exposure, and Health Effects*. Cambridge, Mass.

- Heywood, J.B. 1988. *Internal Combustion Engine Fundamentals*. New York: McGraw-Hill.
- Hwang, R.J. 1997. *Are Cars Still a Problem? Real-World Emission Reductions from Passenger Vehicles Over the Past 30 Years*. Cambridge, Mass.: Union of Concerned Scientists.
- Kittleson, David B. 1998. "Engines and Nanoparticles: A Review." *Journal of Aerosol Science*, 29(5): 575–588.
- Krieger, R.B., R.M. Stewart, K.A. Pinson, N.E. Gallopoulos, D.L. Hilden, D.R. Monroe, R.B. Rask, A.S.P. Solomon, and P. Zima. 1997. "Diesel Engines: One Option to Power Future Personal Transportation Vehicles," *Proceedings of the 1997 Diesel Engine Emissions Reduction Workshop*. La Jolla, Calif. July 28–31. Washington, D.C.: DOE.
- Kunzli, N., F. Lurmann, M. Segal, L. Ngo, J. Balmes, and I.B. Tager. 1997. "Association between Lifetime Ambient Ozone Exposure and Pulmonary Function in College Freshmen—Results of the Pilot Study." *Environmental Research*, 72:8–23.
- Larson, J. 1997. "Natural Gas Fueling Options for the Transit Market." Presentation to the San Francisco Municipal Railway.
- Mark, J. 1996. *Zeroing Out Pollution: The Promise of Fuel Cell Vehicles*. Cambridge, Mass.: Union of Concerned Scientists.
- Mark, J., and L.R. Davis. 1998. *Shifting Gears: Advanced Technologies and Cleaner Fuels for Transit Buses*. Cambridge, Mass.: Union of Concerned Scientists.
- Mark, J., and C. Morey. 1999. *Diesel Passenger Vehicles and the Environment*. Cambridge, Mass.: Union of Concerned Scientists.
- Marland, G., T.A., Boden R.J. Andres, A.L. Brenkert, and C.A. Johnston. 1996. *Global, Regional, and National Fossil Fuel CO₂ Emissions*. Carbon Dioxide Information Analysis Center. Online at http://cdiac.esd.ornl.gov/trends/emis/em_cont.htm.
- Manufacturers of Emission Controls Association (MECA). 1999. *Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-Duty Engines to Achieve Low Emission Levels*. Washington, D.C.

Northeast Advanced Vehicle Consortium (NAVC). 2000. *Hybrid-Electric Drive Heavy-Duty Vehicle Testing Project: Final Emissions Report*. Prepared by M.J. Bradley & Associates, Inc. Boston, Mass.: NAVC.

Sachs, H.M., J. DeCicco, M. Ledbetter, and U. Mengelberg. 1992. *Heavy Truck Fuel Economy: A Review of Technologies and the Potential for Improvement*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Sawyer, R., and M. Costantini. 1997. "Particulate Measurement for Health Effects Assessments: Summary of the Health Effects Institute Workshop on Particle Characterization," *Proceedings of the 1997 Diesel Engine Emissions Reduction Workshop*. La Jolla, Calif. July 28–31. Washington, D.C.: DOE.

South Coast Air Quality Management District (SCAQMD). 1999. *Multiple Air Toxics Exposure Study in the South Coast Air Basin*. Diamond Bar, Calif.

State and Territorial Air Pollution Program Administrators, Association of Local Air Pollution Control Officials (STAPPA/ALAPCO). 2000. *Cancer Risk from Diesel Particulate: National and Metropolitan Area Estimates for the United States, Executive Summary*.

Tashkin et al. 1994. "The UCLA Population Studies of Chronic Obstructive Respiratory Disease: XI. Impact of Air Pollution and Smoking on Annual Changes in Forced Expiratory Volume in One Second." *American Journal of Respiratory Critical Care Medicine*. 149:1209–17.

Union of Concerned Scientists (UCS). 1997. "Impacts of Global Warming." Online at www.ucsusa.org.

Wang, M.Q., and H.S. Huang. 1999. *A Full Fuel-Cycle Analysis of Energy and Emissions Impacts of Transportation Fuels Produced from Natural Gas*. Argonne, Ill.: Argonne National Laboratory. ANL/ESD-40.

Westport Innovations, Inc. 2000. *Westport Innovations' High Pressure Direct Injection (HPDI) System of Natural Gas for Heavy-Duty and Light-Duty Diesel Engines: Technology Position Summary*. Vancouver, British Columbia.

