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REGULATING BY LITIGATION: THE EPA'S REGULATION OF HEAVY- DUTY DIESEL ENGINES

ANDREW P. MORRISS,* BRUCE YANDLE,** & ANDREW DORCHAK***

TABLE OF CONTENTS

Abstract.....	404
Introduction	404
I. The Clean Air Act Context	407
A. The State-Federal Division of Authority	408
B. Growth in NO _x Emissions	409
C. The Mobile-Stationary Source Distinction.....	412
D. The EPA's Reliance on Modeling	415
E. Technology-forcing	421
F. Reliance on Fleet Turnover	424

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G. Summary.....	427
II. Diesel Engines & Air Pollution	429
A. Regulatory Consequences.....	432
B. Emissions Controls.....	437
C. Tradeoffs in Controls.....	442
D. Industry Characteristics' Influence on Regulation	450
E. Summary.....	456
III. Explaining the EPA's Regulation of Heavy-Duty Diesel Engines	456
A. Early Air Pollution Regulatory Efforts.....	458
B. Regulation-by-Rulemaking: 1967 to the 1990s.....	460
1. The Air Quality Act of 1967	460
2. Regulation-by-Rulemaking Under the 1970 Clean Air Act & the EPA.....	462
3. Regulation-by-Rulemaking Under the 1977 Clean Air Act Amendments	465
4. Regulation-by-Negotiation	476
5. Regulation-by-Rulemaking Under the 1990 Clean Air Act Amendments	478
6. Negotiations over Principles.....	480
7. Regulation-by-Litigation & Engine Controllers	481
a. The Engine-Controller Issue	483
b. Settling the litigation.....	488
c. Choice of Technology	493
d. Impact on Air Quality	500
e. Explaining the EPA's Choices.....	506
8. Regulation-by-Rulemaking Since the Consent Decree.....	511
Conclusion.....	514
Table 1: Diesel Emissions Standards.....	518

ABSTRACT

In this Article, the authors provide a case study of heavy-duty diesel engine regulation under the Clean Air Act, which reveals how the Environmental Protection Agency (EPA) chooses various means of regulation at different times. The Article relates the EPA's choices to the incentives the agency faces. The Article also shows how the different forms of regulatory activity influence agency regulations. Finally, the Article concludes with a critique of regulation-by-litigation as a means of imposing substantive rules.

INTRODUCTION

Administrative agencies in the United States traditionally have carried out their regulatory duties by issuing regulations that inform regulated entities how they must conduct various aspects of their business.¹ For

1. We use the term "regulation-by-rulemaking" to mean the kind of regulation that is

example, the Environmental Protection Agency issues rules that describe what sort of pollution control equipment must be attached to particular types of industrial equipment (e.g., "scrubbers" on coal-fired power plant smokestacks) and the Occupational Safety and Health Administration (OSHA) issues rules that specify safety measures employers must take in their facilities. The agencies issue these regulations through a process in which the regulated entities and other interest groups have the opportunity to comment on proposals,² to seek judicial review of the agencies' procedures and compliance with the statutory framework created by the legislature, and to seek action by the political branches to alter the agencies' actions.³

Recently a new form of regulatory activity has appeared: imposing regulatory measures through litigation. In 1998 the attorneys general of 46 states signed a \$246 billion settlement with the tobacco industry that specified, among other things, how the firms would market their products.⁴ Also in 1998, the major producers of heavy-duty diesel engines signed a \$1 billion settlement with the EPA, which specifies when and how the industry will regulate nitrogen oxide (NO_x) emissions. The EPA—the most aggressive federal regulator through litigation—has also used litigation to impose substantive regulatory provisions on major refinery operators,⁵ electric utilities,⁶ and wood product firms.⁷ In each case, the

associated with official notices of rulemaking, public comments, and final notices of rules. At the federal level, this procedure is constrained by the Administrative Procedure Act and other statutes and regulations. At the state government level, administrative rulemaking procedures vary from state-to-state but include elements of notice and public comment that allow for the rules of due process to be met. See Jim Rossi, *Overcoming Parochialism: State Administrative Procedure and Institutional Design*, 53 ADMIN. L. REV. 551 (2001) (describing institutional reasons for differences in federal and state rule making) (citing Arthur Earl Bonfield, *The Federal APA and State Administrative Law*, 72 VA. L. REV. 297 (1986) (describing relationship between federal and model state administrative procedure acts)).

2. 5 U.S.C. § 553(c) (2000).

3. The OSHA's ergonomic regulations, for example, were overturned by congressional action under the Congressional Review Act, 5 U.S.C. §§ 801-08 (2000). See Kelli L. Dutrow, Comment, *Working At Home At Your Own Risk: Employer Liability For Teleworkers Under The Occupational Safety And Health Act Of 1970*, 18 GA. ST. U. L. REV. 955, 958 (2002) (noting that first use of act was to overturn ergonomics rule).

4. See Master Settlement Agreement, available at <http://www.naag.org/upload/103246860Scigmsa.pdf> (last visited Mar. 19, 2003), at 18-36 (describing restrictions on defendants' behavior agreed to as part of the settlement).

5. See J. Hill, *Consider New Refinery Compliance Standards Now Being Set Through Litigation Actions*, 82(8) HYDROCARBON PROCESSING 76 (2002) [2002 WL 18661916] ("Recently, enforcement actions against several petroleum refiners have made them subject to additional standards and regulatory supervision without the typical rule-making process.").

6. See *US, Power Plant Settle Up*, 50(222) THE OIL DAILY (2000) [2000 WL 23421073] (noting suits against seventeen utilities).

7. See Brent Hunsberger, *Boise Cascade Will Settle Suit with Government Over Clean Air Act*, THE OREGONIAN (Mar. 14, 2002) [2002 WL 17180641] (noting settlements with five wood products companies).

firms involved have paid or expect to pay huge fines and accepted new regulations as part of a settlement of litigation.⁸ They have been regulated by litigation.⁹

Regulation-by-litigation replaces notice-and-comment rulemaking procedures with litigation in creating a substantive rule of behavior for regulated entities. It substitutes a complaint in a legal action for a notice of proposed rulemaking, courtroom proceedings and closed settlement negotiations for an agency public proceeding, the rules of evidence for the open rulemaking record, and a limited list of parties largely chosen by the agency for open access public participation. It changes the function of appellate review of agency action, shifting the appeals court to review of the terms of a settlement rather than the agency's compliance with the substantive law the agency is charged with enforcing, and eliminates challenges to the agency's compliance with the Administrative Procedure Act (APA)¹⁰ as a basis for review. As a result, public participation is limited, oversight of agency action by Congress is reduced, and agencies can operate outside the statutory restrictions imposed upon them by

8. See Hunsberger, *supra* note 7 (noting fines from \$1.3 million to \$11 million and required environmental spending up to \$17.9 million for wood products firms); Hill, *supra* note 5 (noting \$600 million per individual refinery in additional costs); US, *Power Plant Settle Up*, *supra* note 6 (noting \$1.2 billion spending required under settlement with a single utility). Of course, these estimates may overestimate the impact, as settlements routinely include spending on mitigation efforts that are not the result of new regulatory requirements, since it is the EPA's interest to announce as large a fine as possible. *Id.*

9. As we use the term, we intend for "regulation-by-litigation" to be used to describe those situations where suits are brought by government organizations against private parties for the purpose of regulating the private parties' behavior in ways that could be accomplished by regulation-by-rulemaking but have not been. Our definition is different than some commentators have used in the past. For example, the Center for Regulatory Effectiveness described a process that fits the tobacco industry suits and settlement, but not some other regulation-by-litigation episodes. See THE CTR. FOR REGULATORY EFFECTIVENESS, REGULATION THROUGH PRIVATE LITIGATION—THE SMITHFIELD HAMS LAWSUIT AS AN ESCALATION OF AN EXISTING TREND, at <http://www.thecre.com/rebbylit/private20011220.html> (last visited Apr. 29, 2002). The CRE description focused on instances where government officials used private litigators to circumvent the unwillingness of legislatures to allow the officials to regulate as they wished. The CRE thus included in its defining characteristics that if a government office "determines that it can circumvent the lack of legislative authorization, it will work with private trial attorneys to prosecute lawsuits that would coerce the industry into complying with the agency's goals" and that "plaintiffs and their government sponsors openly acknowledge that a key goal in filing the law suit is to achieve a stated policy or regulatory goal (e.g., forcing gun manufacturers to install "trigger locks" in all guns)." *Id.* Similarly, Professor Viscusi edited a volume of case studies of regulation-by-litigation that defined the process more broadly than we do, including instances in which private litigation over alleged harms sparked regulatory action such as the breast implant litigation in the 1980s and 1990s and ongoing asbestos litigation. See W. KIP VISCUSI, *Overview*, in REGULATION THROUGH LITIGATION 3 (W. Kip Viscusi ed., 2002) ("If, however, regulations do not exist for a product, litigation can often help address gaps in the regulatory structure and stimulate regulatory activity."). We do not include these within our definition because the agency must still choose a means of imposing regulations once the private litigation has inspired it to fill a gap and may proceed to impose substantive rules in any of the variety of ways we describe in this Article.

10. 5 U.S.C. § 551 et seq. (2000).

Congress. Regulation-by-litigation is thus a means of imposing substantive regulatory provisions on regulated entities without the public participation and the checks and balances of the rulemaking process.¹¹

In this Article, we describe and analyze the rise of regulation-by-litigation through a case study of the regulation of heavy duty diesel engines. Over time, the EPA has regulated the manufacture of heavy-duty diesel engines through traditional rulemaking, through negotiated rulemaking, and through litigation, offering a chance to compare how the regulatory process handles similar issues under each method.¹² We conclude that regulation-by-litigation is a major new form of government action, offering significant advantages to politicians and regulators but that are outweighed by its disadvantages to the public and regulated entities. Because of its advantages for bureaucrats and politicians, however, regulation-by-litigation is likely to play an increasingly important role in the regulatory landscape in the future unless elected officials (and their appointees) and courts take action to limit agencies' use of it.

The first part of this Article sets the stage for our case study by examining how the Clean Air Act and administrative law constrained the EPA's regulation of heavy-duty diesel engines and describing the incentives the Clean Air Act provides for the agency to act in particular ways. The second part examines how diesel technology affects regulatory choices. The third part uses the first two to explain the regulatory history of heavy duty diesel engines. Our conclusion then assesses the use of litigation to regulate.

I. THE CLEAN AIR ACT CONTEXT

To understand the story of heavy-duty diesel emissions regulation, we must place the regulations in the context of the Clean Air Act, the Statute that frames the regulatory environment within which the EPA's regulatory choices were made. The Clean Air Act both requires the EPA to act and constrains how the EPA may act. Six features of the Clean Air Act are critical to understanding the EPA's choices in the heavy-duty diesel engine regulations: the state-federal division of authority; the growth in NO_x emissions; the mobile-stationary source distinction; the EPA's reliance on modeling; technology-forcing; and reliance on fleet turnover.

11. See Viscusi, *supra* note 9, at 1 ("The policies that result from litigation almost invariably involve less public input and accountability than government regulation.").

12. Our analysis thus attempts to respond to the call by Professor Gary Schwartz for taking regulation-by-negotiation into account in explaining regulation-by-litigation. See Gary T. Schwartz, *Comment*, in REGULATION THROUGH LITIGATION 348, at 350 (W. Kip Viscusi ed., 2002).

A. *The State-Federal Division of Authority*

Starting in 1970 the Clean Air Act required the EPA to establish “national primary and secondary ambient air quality standards” (NAAQS) for pollutants that endanger public health or welfare.¹³ The EPA has established NAAQS for CO, SO₂, particulates, NO_x, ozone, and lead.¹⁴ Once the EPA established the NAAQS, the states were required to develop a “state implementation plan” (SIP) describing how each would ensure air quality met the NAAQS within its borders.¹⁵ This plan must then be regularly updated to take into account new sources, changed conditions, and newer data.¹⁶ For our purposes, what is important is that the total emissions from all sources within a state must not cause air quality to fall below the relevant EPA-set NAAQS—if air quality deteriorates below NAAQS for any pollutant, a region becomes a nonattainment area for that pollutant.¹⁷ The full range of Clean Air Act penalties against states with nonattainment regions¹⁸ include increased federal regulation, preclusion of new sources,¹⁹ and loss of federal highway funds.²⁰ These threaten to dampen economic growth in the state, so states strive to avoid the penalties. Although the EPA has been reluctant to impose the more drastic penalties, there are negative consequences to nonattainment status short of an economic death sentence that the EPA is willing to impose.²¹ In short, states must keep the total emissions from all sources, including natural sources and population growth, to a level that ensures the NAAQS are met.²² If air quality falls below the NAAQS, states must have a plan to

13. 42 U.S.C. § 7408(a)(1) (2000).

14. 40 C.F.R. § 50 (2003).

15. 42 U.S.C. § 7410(a) (2000). For an overview of the SIP process, see Andrew P. Morriss, *The Politics of the Clean Air Act*, in *POLITICAL ENVIRONMENTALISM, GOING BEHIND THE GREEN CURTAIN* 263 (Terry L. Anderson ed., 2000) [hereinafter Morriss, *Politics*].

16. See *id.* at 271 (“SIPs are in a constant state of flux.”).

17. 42 U.S.C. § 7407(d)(1)(A)(i) (2000).

18. See WILLIAM H. RODGERS, JR., *ENVIRONMENTAL LAW* 210 (2d ed. 1994) (describing failure of the EPA to invoke full penalties). The EPA’s similarly drastic authority to shut down the automobile industry has also not been used, and some evidence exists that it was never intended to be used. See David P. Currie, *The Mobile-Source Provisions of the Clean Air Act*, 46 U. CHI. L. REV. 811, 818 (1979) [hereinafter *Mobile-Source*].

19. 42 U.S.C. § 7509 (2000) (describing penalties, including requirement of increased offsets, for nonattainment areas). There are other negative consequences as well. See Arnold W. Reitze, Jr., *Federalism and the Inspection and Maintenance Program Under the Clean Air Act*, 27 PAC. L.J. 1461, 1479 (1996) (“The amount of emissions necessary to qualify as a major source drops for ozone nonattainment areas classified as serious This has the effect of expanding the number of stationary sources subject to the more stringent emission limitations imposed on major sources.”) [hereinafter Reitze, *I&M*].

20. RODGERS, *supra* note 18, at 210 (stating that an original consequence of nonattainment was to be “a shutdown of industrial growth in many parts of the nation”).

21. See Reitze, *I&M*, *supra* note 19, at 1477-81 (describing actions required in nonattainment areas); see also RODGERS, *supra* note 18, at 215-21 (same).

22. There are also “significant deterioration” requirements to prevent cleaner areas where air quality exceeds the NAAQS from polluting more to reduce air quality to the levels

reduce emissions so that air quality is improved until it meets the NAAQS. Imposing penalties is also politically costly for the EPA, since the sanctions are unpopular in the target states. The EPA will therefore prefer to avoid invoking sanctions, particularly against a large number of states who might jointly be able to persuade Congress to override the EPA.

B. Growth in NO_x Emissions

NO_x is the one EPA-criteria-related pollutant whose emissions continue to grow in spite of extraordinary efforts made to control it.²³ In part this is because those efforts were slow to begin—ozone-control efforts initially focused on hydrocarbons rather than NO_x.²⁴ NO_x emissions have grown over time,²⁵ in part because diesel's share of fuel consumed has grown and because fuel usage has increased.²⁶ As a result, ozone control strategies built around NO_x reduction "must pay greater attention to reducing NO_x from heavy-duty sources."²⁷ (As discussed below, sometimes reductions lead to NO_x increased ozone levels.)²⁸ The turning point in NO_x nationally occurred in the late 1980s, with total emissions trending upward.²⁹ These trends are expected to continue.³⁰

NO_x emissions are a precursor to ozone,³¹ and ozone levels were so large

required by the NAAQS. See 42 U.S.C. § 7470 et seq. (2000). For a discussion of the current issues surrounding the NAAQS, see William F. Pedersen, *Science and Public Policy: New Ambient Air Quality Standards Under the Clean Air Act*, 16 PACE ENVTL. L. REV. 15 (1999). Their qualitative impact is similar to the NAAQS/nonattainment dynamic, however, so we need not consider further the additional levels of complexity they introduce. *Id.*

23. LARRY B. PARKER & JOHN E. BLODGETT, AIR QUALITY AND ELECTRICITY: INITIATIVES TO INCREASE POLLUTION CONTROLS, CRS REPORT FOR CONGRESS, CONGRESSIONAL RESEARCH SERVICE, THE LIBRARY OF CONGRESS (2002); *New Source Review: Refining "Routine Maintenance" Definition Considered in Program Reform*, *Official Says*, ENV'T REP., Jan. 5, 2001, at 34.

24. Russell Clemings, *Dirty Diesels Face Regulations*, THE FRESNO BEE, Dec. 15, 2002, at 20.

25. American Lung Association, *State of the Air: 2003* 17 (2003) (noting NO_x emissions up 17% since 1970).

26. R.F. Sawyer et al., *Mobile Sources Critical Review: 1998 NARSTO Assessment*, 34 ATMOSPHERIC ENV'T 2161, 2162-63 (2000); Alan C. Lloyd & Thomas A. Cackette, *Diesel Engines: Environmental Impact and Control*, 51 J. AIR & WASTE MGMT. ASS'N 809, 811 (2001) (indicating that NO_x emissions for heavy-duty non-road vehicles decreased in late 1980s but "during the 1990s, the increasing numbers of diesel vehicles and mileage traveled countered reductions from individual vehicles").

27. Sawyer et al., *supra* note 26, at 2179.

28. See *infra* notes 79-80 and accompanying text.

29. Lloyd & Cackette, *supra* note 26, at 812, Fig. 4a.

30. Sawyer et al., *supra* note 26, at 2162-63; K.G. Duleep, *Keep on Truckin'—Sustainably?*, in TRANSPORTATION, ENERGY & ENVIRONMENT: HOW FAR CAN TECHNOLOGY TAKE US? 193 (John DeCicco & Mark Delucchi eds., 1997) (noting estimates that "fuel consumption will grow by 29 to 42 percent by 2015").

31. Ozone is a form of oxygen, O₃, which has been linked to a number of health and environmental issues. For more information, see U.S. Environmental Protection Agency, *Ground Level Ozone (O₃)*, 1997 Summary Report, at <http://www.epa.gov/air/aqtrnd97/brochure/o3.html> (last visited Mar. 11, 2004); AM. LUNG

in the 1980s that a major region of the northeastern United States was declared “nonattainment” with respect to the ozone standard.³² Because of this declaration, a group of northeastern states first sought a NO_x SIP call for revisions³³ and then petitioned the EPA to limit the NO_x emissions from upwind states through “[s]ection 126” petitions.³⁴ The northeastern, downwind states argued that, based on prevailing wind patterns, upwind states’ NO_x emissions made their way to the northeast and so affected the downwind states’ abilities to meet the NO_x NAAQS. In effect, the downwind states argued that the upwind states were exporting the impact of their NO_x emissions to the downwind states, reducing the NO_x emissions possible in the downwind states if they were to meet the NAAQS requirements for their area. The EPA ordered the downwind states to revise their air quality control plans in order to reduce the level of uncontrolled and controlled NO_x emissions and also searched for ways to procure significant NO_x emission reductions in upwind areas, including seeking to reduce mobile source NO_x emissions.³⁵ Obtaining sufficient reductions to solve the problem from car and stationary source emissions was not feasible politically or practically.³⁶ This meant the EPA was under

Ass., What is Ozone Air Pollution?, available at <http://www.lungusa.org/air/envozone.html> (last visited Mar. 11, 2004).

32. Consider the following description of the steps necessary in nonattainment regions and the scope of the nonattainment problem:

53.8 million people live in counties violating the O₃ one-hour NAAQS. Ozone nonattainment areas are subject to SIP revisions to meet CAA requirements. Moreover, the northeastern states, from northern Virginia to Maine, are subject to ozone transport region requirements. Facilities located upwind of a nonattainment area for ozone that are in a “ozone transport region” may be subject to controls if the facility emits more than fifty tons per year of NO_x. Since 1990, O₃ nonattainment areas require the use of stringent controls on Volatile Organic Compounds (VOC) and NO_x sources. Moderate or worse O₃ nonattainment areas require the use of reasonably available control technology (RACT) on existing sources. For areas that are serious or worse, a 9% reduction of VOC or NO_x emissions for each three-year period from 1996 through the attainment date is required. For extreme areas, additional NO_x controls are required. CAA section 182(f) imposes on the states a duty to control emissions of NO_x unless reductions would not contribute to the attainment of the ozone standard.

Arnold W. Reitze, Jr., *State and Federal Command-And-Control Regulation Of Emissions From Fossil-Fuel Electric Power Generating Plants*, 32 ENVTL. L. 369, 377 (2002) [hereinafter Reitze, *State and Federal*].

33. See *Michigan v. EPA*, 213 F.3d 663, 672 (D.C. Cir. 2000) (describing dispute and SIP call); *Appalachian Power Co. v. EPA*, 249 F.3d 1032, 1037 (D.C. Cir. 2001) (describing “section 126” actions).

34. Reitze, *State and Federal*, *supra* note 32, at 411 (describing petitions and results).

35. John C. Parker, *EPA Knew Its Engine Tests Were Flawed, Volvo Says*, TRANSPORT TOPICS 1, 25 (1998) (“There was a problem with the northeastern states in 1997 not being able to meet their clean air requirements’ Mr. Nyman [of Volvo] said. ‘They claimed they had done everything possible to control NO_x from fixed sites and they were going to lose federal funds if they were not in compliance.’”) [hereinafter Parker, *Engine Tests*]. The EPA and northeastern state officials denied the charge. *Id.*

36. Chris Bowman, *EPA Off On Diesel Rigs’ Emissions? Clean-air Goals May Be Tougher to Meet*, SACRAMENTO BEE, Oct. 18, 1997, at A1, A22, reprinted in U.S. HOUSE OF

pressure from both the upwind and downwind states to find a means of reducing NO_x levels in the Northeast and other nonattainment areas that did not place the burden of doing so on either the upwind or the downwind states. This played a role in the EPA's regulation of diesel NO_x emissions.³⁷ Other regions were also experiencing NO_x problems from intra-region sources leading them to focus on heavy duty diesels as well.³⁸

In addition to the pressure from the upwind and downwind states, ozone is also a high profile air pollution issue for environmental pressure groups because ozone is "smog," the paradigmatic air pollution issue. The American Lung Association (ALA), for example, chose ozone as "the focus" of its *State of the Air* reports, reporting on county level ozone levels,³⁹ and the ALA also used litigation to pressure the EPA to make the ozone NAAQS more restrictive.⁴⁰ That more restrictive NAAQS increased the need for reductions in NO_x; environmental pressure groups continued to use litigation to pressure the EPA to enforce the stricter NAAQS by designating nonattainment regions.⁴¹ Environmental pressure groups also specifically targeted heavy-duty diesel engines.⁴² As a result, by the late 1990s, the EPA had a severe NO_x emissions problem and heavy-duty diesel engines were a major potential source of reductions.

This problem was compounded by the nature of the prior NO_x emissions control strategy adopted by the EPA. Economist Lawrence White found that the structure of the EPA's mobile source program created an incentive to choose high cost, high probability of success, quick technologies over strategies which might yield better success in the long run.⁴³ The quick

REPRESENTATIVES, COMM. ON COMMERCE, ASLEEP AT THE WHEEL: THE ENVIRONMENTAL PROTECTION AGENCY'S FAILURE TO ENFORCE POLLUTION STANDARDS FOR HEAVY-DUTY DIESEL TRUCKS app. G (2000) (noting air pollution control officials finding that it would be "politically and logistically improbable" to make up lost emissions controls resulting from mobile source over-emissions from cars and businesses) [hereinafter Bowman, *EPA Off*].

37. See Final Rule, 65 Fed. Reg. 59,896, 59,904 (Oct. 6, 2000) (asserting importance of reducing NO_x emissions to assist ten areas with compliance with NAAQS for ozone and to avoid more costly measures of NO_x reduction).

38. Clemings, *supra* note 24, at 20 ("Control of heavy-duty diesel engines is one of the main things that needs to happen for us to meet air quality standards," said Tom Jordan, senior air quality planner at the San Joaquin Valley Air Pollution Control District.)

39. See American Lung Association, *State of the Air: 2003* 17 (2003) ("The American Lung Association has chosen ozone as the focus of the *State of the Air* reports because it is one of the most damaging and most pervasive of the common outdoor air pollutants.")

40. *Id.* at 22 ("In 1997, the EPA issued a revised National Ambient Air Quality Standard for ozone, in large part due to constant legal pressure from the American Lung Association.")

41. *Id.* at 23 ("On May 20, 2002, the American Lung Association and eight environmental groups took legal action against the EPA to force them to start designating nonattainment areas. On November 13, 2002, the EPA agreed that it would make those official designations by April 2004.")

42. Clemings, *supra* note 24, at 20 (quoting environmental pressure group representatives on the "Dump Dirty Diesels" campaign).

43. LAWRENCE J. WHITE, THE REGULATION OF AIR POLLUTANT EMISSIONS FROM MOTOR VEHICLES 72-77 (1982). White concluded in 1981 that "the stringent NO_x standard has been

fixes adopted by the EPA in the 1970s, therefore did not continue to yield improvements in NO_x emissions thereafter. Thus, NO_x represented a growing problem to which mobile sources generally and heavy-duty diesels in particular were contributing a substantial portion and whose control was relatively costly.

C. *The Mobile-Stationary Source Distinction*

The Clean Air Act has different regulatory regimes for emissions from stationary and mobile sources. Stationary sources, such as coal-fired electricity generators, are regulated through state-issued permits for emissions, and states are responsible for determining how much each stationary source is allowed to emit of each pollutant, subject to technology controls required of particular source categories by the EPA.⁴⁴ For example, a coal-fired power plant must both install emissions scrubbers on its smokestacks under an EPA-mandated technology standard and limit its emissions to the level specified in the relevant state SIP. Mobile sources, on the other hand, are regulated largely through EPA-mandated regulations requiring vehicles or engines, depending on type, to meet emissions controls. (States can also opt to adopt a separate set of standards created by California, whose regulatory activity predates the EPA's.⁴⁵) Sample light-duty vehicles and heavy-duty engines are tested by the producer using EPA-approved test procedures. Product lines are then certified as meeting the EPA requirements.⁴⁶ There is no individual permit requirement for each mobile source, as there is for each stationary source.

The states' primary means of controlling mobile source emissions are to impose controls on vehicle use—a politically unpopular route.⁴⁷ When either states or the EPA have incorporated such controls in SIPs, they have generally been criticized as unrealistic. For example, the EPA's 1975

one of the costliest standards in the entire Clean Air Act—not only in the static sense . . . but also by discouraging productive research on alternative technologies.” *Id.* at 74. White estimated NO_x standards added almost \$600 per car to automobile prices in the early 1970s, including an 8% fuel economy penalty. *Id.* The switch to catalyst technology for the 1975 standards lowered the cost to \$280 per car. *Id.* at 61-62. The model year (MY) 1984 standards cost was \$1500 per car. *Id.* at 87-88.

44. A caveat or two is needed here about the many layers of control imposed by the Clean Air Act. To the extent that they are relevant, we will deal with those later. Our intent here is to present the broad picture.

45. A slight caveat concerning California's (and now other states') ability to impose additional requirements on mobile sources is necessary. We will discuss this in more detail later—for now the important thing is that mobile sources are mostly regulated at the national level. See 42 U.S.C. § 7507.

46. See 40 C.F.R. § 86.090-24 (2003) (discussing test vehicles and engine families); § 86.1848-01 (2001) (discussing certification).

47. See Sawyer et al., *supra* note 26, at 2178 (“Attempts to constrain or reduce private vehicle use through transportation control measures (TCMs) have met resistance and produced minimal results.”). States may also adopt fuel regulations or clean-fuel fleet requirements.

mandate to Los Angeles to reduce auto traffic by 70-80 percent was widely seen as impossible to implement.⁴⁸ Even indirect controls on vehicle use, such as inspection and maintenance programs aimed at ensuring that individual vehicles' emissions controls are properly functioning, have proven politically unpopular.⁴⁹ Thus, unlike stationary sources, mobile sources are primarily regulated indirectly through regulation of manufacturers rather than directly through regulation of the sources' emissions. Mobile sources are also relatively unregulated by the states, largely because the political costs of use restrictions are too high for state regulators to pay.

This division of authority and approach is logical—mobile sources are, by definition, mobile and their contribution to pollution affects multiple states as cars and trucks drive the nation's highways. There are also enormous numbers of mobile sources, making individual source level regulation administratively costly to implement.⁵⁰ It also provides the EPA with a political benefit, since it grants the EPA authority over the relatively politically popular (at least outside of Michigan) regulatory target of mobile source manufacturers, while leaving to the states the unpalatable regulation of consumers' use of mobile sources.⁵¹ National regulation comes at a cost, however, since reducing mobile source emissions anywhere requires reducing them everywhere, even if reductions are only

48. See Carolyn McNiven, *Using Severability Clauses to Solve the Attainment Deadline Dilemma in Environmental Statutes*, 80 CAL. L. REV. 1255, 1279-80 (1992) (“[The] EPA began promulgating plans that fulfilled its legal obligations but that were totally unrealistic. EPA’s transportation control plan for the Los Angeles area included such draconian control measures as gasoline rationing of up to eighty-two percent of then-current consumption levels. Needless to say, such rationing was completely unacceptable to the residents and businesses of the Basin which were (and still are) vehicle-dependent.”); see also Eli Chernow, *Implementing the Clean Air Act in Los Angeles: The Duty to Achieve the Impossible*, 4 ECOLOGY L.Q. 537, 538 (1975); Roger Strelow, *Reviewing the Clean Air Act*, 4 ECOLOGY L.Q. 583, 584 (1975). On problems with transportation controls, see generally John Quarles, *Time Extensions Not the Answer to Problems with Clean Air Act*, THE OIL DAILY, June 18, 1987, at 4:

The reality is that in several areas, particularly Los Angeles, the NAAQS for ozone is not going to be attained—not by Dec. 31, 1987, not five years thereafter, not 10 years thereafter, not by the year 2000, not within anyone’s ability to see the horizon. The reality is that the statute commands and achievement the cost and pain of which exceeds its value to the public. The public has rejected that command. The statutory framework does not work.

49. See generally Todd A. Stewart, Comment, *E-Check: A Dirty Word in Ohio’s Clean Air Debate—Ohio’s Battle Over Automobile Emissions Testing*, 29 CAP. U. L. REV. 265, 268-270 (2001) (discussing debate over state I&M program).

50. Technology may be reducing such costs. See Ken Livingstone’s *Gamble*, THE ECONOMIST (Feb. 15, 2003) (describing how technology is being used in London to implement congestion charges for driving in the center city); *Ken’s Coup*, THE ECONOMIST (Mar. 22, 2003) (describing success of congestion charges). Such programs reduce traffic and lessen emissions. *Id.* Advances in remote sensing programs may also produce less costly transportation controls in the future by cheaply identifying “dirty” vehicles. *Id.*

51. WHITE, *supra* note 43, at 68 (“[T]he political stance of aiming one’s regulatory fire (and ire) at the manufacturers, rather than at users, has surely been a more popular one.”).

necessary in some areas, such as those out of attainment with air quality standards.⁵²

The division is important for understanding the diesel regulations because it creates a distinction between mobile and stationary sources in terms of regulators and regulatory approaches. It also creates an unequal competition between the categories for the ability to emit pollutants since states' SIPs must account for emissions from both categories⁵³ but states lack control over manufacturers of mobile sources. The EPA and the states are thus regularly put in a position of trading off mobile source emission reductions and stationary source emission reductions. In these tradeoffs, states must rely on the EPA to generate mobile source reductions that can offset other increases from population growth or new industry.⁵⁴ Without such tradeoffs, states cannot increase other categories of emissions. For example, the EPA's "mobile source tech review subcommittee" is examining ways to cut heavy-duty diesel emissions to help states earn "state implementation plan credits,"⁵⁵ which can be used to allow new

52. See REGULATORY STUDIES PROGRAM, MERCATUS CENTER, GEORGE MASON UNIVERSITY, PUBLIC INTEREST COMMENTS ON CONTROL OF EMISSIONS FROM NONROAD LARGE SPARK IGNITION ENGINES AND RECREATIONAL ENGINES (MARINE & LAND BASED) SUBMITTED TO ENVIRONMENTAL PROTECTION AGENCY 6 (Dec. 19, 2001) (discussing issue in context of other regulations and concluding that "[c]ost effectiveness—based on nationwide emission reductions—cannot capture likely benefits because most areas of the country now meet health-based air quality standards") [hereinafter RSP, NONROAD]; see also WHITE, *supra* note 43, at 67 ("The drawback to uniform standards is that vehicle purchasers in areas that do not have serious pollution problems are paying substantial sums for control systems that are unnecessary or at least more stringent than are needed."). This effect has been widespread at least in some periods. *Id.* For instance, a 1974 National Academy of Sciences study found that 63% of U.S. cars probably did not require the MY 1981 standards over the MY 1977 standards. *Id.* Not having uniform national regulation, on the other hand, leads to claims of unfairness by those regulated more heavily. See, e.g., *Air Pollution: Commenters at California Hearing Urge EPA to Strengthen Diesel Regulation*, 126 DAILY ENV'T REPORT A-4 (June 29, 2000) ("A group of independent truckers testified that [the] EPA's proposed regulation [requiring low sulfur fuel nationwide] would finally 'level the playing field' for California-based operations."); Jess Nicholas, *Low-Sulfur Diesel Meets Opposition*, 40 OVERDRIVE 131 (Nov. 2000) ("[f]rom an economic standpoint, California truckers would benefit from the proposal" for national low-sulfur rules).

53. See, e.g., *Diesel Fuel/Emissions 'Unified Model' Opens 'Boutique' Can of Worms*, DIESEL FUEL NEWS, Sept. 3, 2001, at 1, 5 (noting truckers' objections to fuel requirements, arguing that regulators "ignored other measures—such as tougher electric utility emissions controls in areas upwind of major cities—that would do far more to cut NO_x without causing fuel-supply crises or disrupting interstate truck commerce") [hereinafter *Boutique*, DIESEL FUEL NEWS]; Reitze, *I&M*, *supra* note 19, at 1480 (noting that where nonattainment provisions for reductions in emissions, "affected sources can be expected to attempt to shift the required reduction to some other source or category of source using the political, administrative, and judicial forums that may be available").

54. See, e.g., *Control of Air Pollution from Heavy-Duty Engines*, 60 Fed. Reg. 45,580, 45,581 (Aug. 31, 1995) (indicating that state regulators are "looking to the national mobile source emission control program as a necessary complement to their efforts to reduce NO_x, PM, HC, and other emissions").

55. See *EPA Launching Heavy-Duty In-Use Emissions Testing Workgroup for SIP Credits*, DIESEL FUEL NEWS, Nov. 12, 2001, at 6; see also Ralph Kisiel, *Cloud Hovers Over Proposed Diesel Rules*, AUTOMOTIVE NEWS, Jan. 27, 1997, at 34 (quoting the Engine

stationary sources or maintain current stationary source emission levels. Disputes within categories of sources also occur, as different interest groups attempt to allocate the cost of emissions reductions to others.⁵⁶ Economic or population growth may also require changes in SIPs. States must therefore continually rebalance emissions allocations amongst sources in their states.

D. The EPA's Reliance on Modeling

The EPA and the states depend primarily on environmental modeling rather than direct measurement for implementing the regulatory structure.⁵⁷ The use of models is logical in a world with an incomplete air quality monitoring system and positive costs to data collection and analysis. Collecting sufficient accurate data on air quality to regulate the entire country's air through command-and-control regulation would be so costly as to preclude the entire effort if models could not be used.⁵⁸ Modeling is

Manufacturers Association executive director that "[w]e very strongly suspect that various states will want to hit the bank and go for more reductions from mobile sources").

56. See, e.g., Arnold W. Reitze, Jr., *Mobile Source Air Pollution Control*, 6 ENVTL. L. 309, 369 (2000) (describing dispute between gas stations and car manufacturers over whether to require onboard vehicle evaporation controls or "Stage II" vapor recovery systems on gasoline pumps: "The choice of Stage II or onboard controls pitted the petroleum industry against the automobile industry, both of whom assured the motivation and the money for a protracted political and legal battle") [hereinafter Reitze, *Mobile Source*]; GEN. ACCT. OFF., GAO/RCED-87-151, EPA'S EFFORTS TO CONTROL VEHICLE REFUELING AND EVAPORATIVE EMISSIONS 4-5 (1987) (describing differences between oil and motor vehicle companies). The EPA studied the issue for 14 years before issuing a proposed regulation. *Id.* at 14. A good example of how sources compete for emissions is the passage of laws in Maryland and Illinois forbidding state regulators from adopting "Stage II" refueling controls unless required to do so by the EPA. *Id.* at 15.

57. See Reitze, *Mobile Source*, *supra* note 56, at 357 ("Mobile models are used to construct the motor vehicle portion of emissions inventories, to create control strategies, to produce SIPs, and to demonstrate control strategy effectiveness."). For information on the EPA's model for highway emissions, see OFFICE OF TRANSPORTATION AND AIR QUALITY, AP-42: COMPILATION OF AIR POLLUTANT EMISSION FACTORS, at <http://www.epa.gov/otaq/ap42.htm> (accessed Feb. 8, 2002), and Reitze, *Mobile Source*, *supra* note 56, at 357-58. For a discussion of the complexity of emissions modeling, primarily in the context of Germany, see HANS PETER LENZ & CHRISTIAN COZZARINI, EMISSIONS AND AIR QUALITY 76-82 (1999). See also INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY, ENVIRONMENTAL HEALTH CRITERIA 171: DIESEL FUEL AND EXHAUST EMISSIONS 93 (1996) ("[t]he contribution of diesel exhaust to total pollution by traffic combustion products is generally calculated on the basis of emission factors and the percentage of diesel fueled-vehicles.") [hereinafter IPCS, CRITERIA 171].

58. For example, the National Research Council committee reviewing the EPA's modeling of mobile sources summarized the information demands for air pollution regulation as:

An effective air-quality improvement program requires the identification, inventory, and control of emissions sources, including mobile sources. This requires not only a broad understanding of which pollutants are derived from which sources, but also details about their spatial and temporal variation, the contributions of subsets of sources, the chemical and physical characteristics that determine their propensity to form secondary pollutants, their levels of exposure and toxicity, and the actual effectiveness of strategies to control emissions. The large number of

thus a necessary component of command-and-control air pollution control and the EPA makes heavy use of modeling through its official program known as MOBILE.⁵⁹

The result is that it is the model that governs how emissions control measures are evaluated, not their actual results. States, for example, must construct SIPs that satisfy the EPA's model of air quality, not deliver actual levels of emissions.⁶⁰ As developing the data to design the model is expensive and the test procedures do not represent all driving conditions,⁶¹ models will inevitably inaccurately predict actual emissions.

For example, if laboratory measurements of the efficacy of a type of control did not accurately predict real-world use results (exactly what happened in the case of heavy-duty diesel engine emissions controls),⁶² the

individual sources, the large variability of emissions characteristics among these sources, and the need for emissions estimation methods to fulfill many applications creates daunting challenges.

See COMMITTEE TO REVIEW EPA'S MOBILE SOURCE EMISSIONS FACTOR (MOBILE) MODEL, MODELING MOBILE SOURCE EMISSIONS 20-21 (2000) [hereinafter COMMITTEE TO REVIEW].

59. The EPA's official mobile source air quality modeling program, known as MOBILE, "is used in the development of national, regional, and urban emissions inventories; the simulation of regional air chemistry and microscale dispersion of pollutants; the assessment of the effectiveness of control strategies; the documentation of emissions reductions in State Implementation Plans (SIPs); the assessment of air-quality impacts of transportation projects, including the demonstration of conformity of transportation and air-quality plans; and the assessment of air-quality impacts of transportation-control measures and projects."

COMMITTEE TO REVIEW, *supra* note 58, at 33.

60. See *id.* at 58, at 29 ("Outside of California, the MOBILE model is used to estimate emissions from on-road mobile sources as part of the SIP."); *Id.* at 52 ("States and, in some cases, metropolitan planning organizations (MPOs) are required to develop a demonstration of attainment for SIPs in ozone and CO nonattainment regions. These must be submitted to and approved by EPA.")

61. Sawyer et al., *supra* note 26, at 2173.

62. Janet Yanowitz et al., *Prediction of In-Use Emissions of Heavy-Duty Diesel Vehicles from Engine Testing*, in 36 ENVTL. SCI. & TECH. 270, 270 (2002) ("[A] recent review . . . found that the measured emissions trends from in-use heavy-duty vehicles differ considerably from those predicted from the results of the certification engine tests and also vary considerably from those predicted by the MOBILE5 and PART5 models on a model year basis."); see also Nigel N. Clark et al., *Emissions Modeling of Heavy-Duty Conventional and Hybrid Electric Vehicles*, in DIESEL EMISSION CONTROL SYSTEMS (SP-1641) 121, 121 (2001) ("Prediction of emissions and fuel consumption from vehicles driven through a cycle or route is not well developed or accurate. This is especially true in the heavy-duty sector, where engines are certified for emissions separately from the vehicle and few data are available to describe the emissions performance of the whole vehicle.") [hereinafter Clark et al., *Emissions Modeling*]; Nigel N. Clark et al., *Factors Affecting Heavy-Duty Diesel Vehicle Emissions*, 52 J. AIR & WASTE MGMT. ASS'N 84, 84 (2002) ("Presently, the heavy-duty diesel emissions inventory is based on emissions factors developed from certification data gained using a stationary engine dynamometer, and there is no sophisticated accounting for the application of that engine in the vehicle or the nature of vehicle behavior.") [hereinafter Clark et al., *Factors Affecting*]; *id.* at 92 ("All present-day truck emissions values used for inventory prediction rely on the certification data, but . . . certification data will underestimate NO_x emissions in off-cycle operation The real NO_x value in this case was 1.8 times higher than the expected value."); Janet Yanowitz et al., *Chassis Dynamometer Study of Emissions from 21 In-Use Heavy-Duty Diesel Vehicles*, 33 ENVTL. SCI. & TECH. 209, 215 (1999) (noting that analysis of 21 engines found

model's predictions would not match output. If the model overpredicted control, the result would be dirtier air than predicted,⁶³ if it underpredicted control,⁶⁴ the result would be cleaner air.⁶⁵ The divergence between model and reality need not be solely due to errors; incomplete knowledge may also hamper relating models to reality.⁶⁶ To the extent that the model's predictions are used to target a legal standard, such as the NAAQS, inaccuracies in the model could mean the standard was not met in the

that emissions for NO_x and particulates "do not reflect emissions improvements expected based on the stricter engine certification test put into effect since 1985"); Nigel N. Clark & David L. McKain, *A Chassis Test Procedure to Mimic the Heavy-Duty Engine Transient Emissions Certification Test*, 51 J. AIR & WASTE MGMT. ASS'N 432, 437 (2001) (noting differences in idle power levels in chassis and engine-only tests mean engines produce greater emissions in chassis tests).

63. This happened with respect to evaporative emissions from mobile sources, as initial estimates of evaporative losses were too low. Reitze, *Mobile Source*, *supra* note 56, at 319-20 ("By the late 1980s, evaporative losses became a subject of renewed concern as new information became available that indicated evaporative losses had been underestimated."); *see also* U.S. GEN. ACCT. OFFICE, GAO/RCED-87-151, AIR POLLUTION, EPA'S EFFORTS TO CONTROL VEHICLE REFUELING AND EVAPORATIVE EMISSIONS 31 (1987) (noting the EPA's use of inappropriate testing assumptions: "The widespread differences between the volatility levels of commercial and certification gasoline are a major cause of the problem with evaporative hydrocarbon emissions, according to [the] EPA"); *id.* at 45 (remarking that the EPA certification test used lower volatility gasoline than used in operation, resulting in lower emissions). It also happened with respect to automobile emissions systems, where "in-use emission control systems deteriorate at a rate significantly greater than projected" by the EPA models. *See* Reitze, *Mobile Source*, *supra* note 56, at 351 (noting three-fourths of in-use vehicles tested during the late 1980s failed to meet emissions standards); GEN. ACCT. OFFICE, GAO/RCED-90-128, AIR POLLUTION, EPA NOT ADEQUATELY ENSURING VEHICLES COMPLY WITH EMISSIONS STANDARDS 4 (1990).

64. This is possible because engineers commonly build in safety margins in emissions controls. *See* DIESEL ENGINE REFERENCE BOOK 556 (Bernard Challen & Rodica Baranescu, eds., 2d ed. 1999) (noting that "engineers generally set emission targets below the [Clean Air Act] standards to be sure all requirements are met. This margin is typically 80 to 90 percent of the standard limit") [hereinafter DIESEL ENGINE REFERENCE BOOK]; MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, ASSEMBLY OF ENGINEERING, NATIONAL RESEARCH COUNCIL, NO_x EMISSION CONTROLS FOR HEAVY-DUTY VEHICLES: TOWARD MEETING A 1986 STANDARD 7 (1981) [hereinafter MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE] ("Emissions of new production engines must be lower than the standards with which they are intended to comply by a deterioration factor that accounts for any increase in emissions as the engines age and a safety factor to account for production line variability during enforcement audits."); *id.* at 43 ("The audit requirement, plus appropriate allowance for deterioration, requires low-mileage emission targets for individual engines to be 20-40 percent below the value of the standard.").

65. *See* COMMITTEE TO REVIEW, *supra* note 58, at 1 ("Possible consequences of inaccurately characterizing motor vehicle emissions include the implementation of insufficient controls that endanger the environment and public health or the implementation of ineffective policies that impose excessive control costs.").

66. *See* MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 18 (explaining that translating emissions reductions into changes in atmospheric concentrations "requires a knowledge of the emission source patterns for the region in question, the total atmospheric loading of emissions from all sources in the region, and the detailed transformation processes," and noting that "[s]uch knowledge is not available now"); COMMITTEE TO REVIEW, *supra* note 58, at 38 ("The multiple adjustments of travel activity results needed to produce estimates of [heavy-duty vehicle] activity by time of day introduces an unknown level of uncertainty to emissions and air quality simulations.").

model but was met in reality or vice versa.⁶⁷ “Real world vehicle emissions are difficult to predict because many factors are involved.”⁶⁸ In particular, aging vehicles and deterioration of emissions control systems can lead to significantly increased emissions. “In some high emitting vehicles HC [hydrocarbons] and CO emissions per kilometer are over two orders of magnitude higher than when those same vehicles were new.”⁶⁹

Unfortunately, these problems are more than theoretical with respect to the EPA’s air quality monitoring. As a 1998 review concluded, “[a]t present, large and significant uncertainties exist in the estimates of the mobile source emissions inventory. These uncertainties exist for all vehicle types and classes throughout North America.”⁷⁰ Similarly, another study concluded that “[i]n recent years, it has become very obvious that significant improvements are needed in the characterization of emissions from heavy-duty vehicles (HDVs) operating in real-world conditions, and in the models used to generate mobile source emissions inventories. Emission inventories have grossly underestimated the emissions from mobile sources.”⁷¹ This underestimate has been old news for quite some time, as most of the research that uncovered it was funded by either the EPA or California’s air regulators.⁷² Although “[b]illions of dollars per year in transportation funding are linked to air quality attainment plans,”⁷³ the EPA’s models were labeled “geriatric” in 2001 by the head of the EPA’s Office of Air Quality and Monitoring.⁷⁴ A committee appointed by the National Research Council to review MOBILE concluded that

Questions have been raised about MOBILE’s capability to evaluate reliably the impacts of air-quality-improvement initiatives

. . . .

Previous and current versions of the model have been criticized for their lack of adequate documentation on underlying methodologies and data. There has also been criticism by the U.S. General Accounting Office that [the] EPA’s policy on peer review had not been fully followed during the

67. The same problem would arise if states used some other standard, such as the “efficient” level of air quality. Modeling issues can be addressed in part by improved data collection. See Sawyer et al., *supra* note 26, at 2168 (describing use of remote sensing equipment and data).

68. *Id.* at 2167.

69. *Id.*

70. *Id.* at 2178.

71. Mridul Gautam et al., *Uncertainty in Real-World Particulate Matter Emission Measurements from a Transportable Heavy-Duty Vehicle Emissions Testing Laboratory*, 5 HEAVY VEHICLE SYSTEMS INST. J. OF VEHICLE DESIGN 399, 400 (1998).

72. E-mail from Joel Schwartz, Reason Public Policy Foundation (Jan. 17, 2003) (on file with the authors).

73. COMMITTEE TO REVIEW, *supra* note 58, at 1.

74. Microsoft Powerpoint presentation by Gene Tierney, *MOBILE6 and the NGM*, slide 6, at <http://www.ncvecs.colostate.edu/cac.docs/cac18.docs/cac17pres/Tierney.pdf> (last visited June 28, 2002).

development of current and past versions of MOBILE.⁷⁵

Indeed, the EPA's current model was explicitly criticized in 2000 for its inaccurate modeling of heavy-duty vehicle emissions because those emissions were "expected to be a major target" of SIP revisions.⁷⁶ For heavy-duty engines, the EPA's models (as well as California's separate models) were even less accurate, because "little effort has been made to describe truck travel explicitly within travel demand models. In current modeling practice, it is common to estimate heavy-duty truck travel as a fixed percentage of predicted traffic volumes" despite differences in traffic patterns from light duty traffic.⁷⁷ One estimate based on fuel consumption put on-road NO_x emissions at twice what the EPA predicted in 1996.⁷⁸

Moreover, the ozone-NO_x relationship is complex, undoubtedly more so than the EPA's models can currently incorporate. As just one example, research has found that daily levels of ozone exhibit different patterns in different cities and while some regions experience increases in ozone from a reduction in NO_x, others experience a decrease, depending on whether ozone levels are more sensitive to the levels of NO_x or the levels of volatile organic compounds (VOCs).⁷⁹ The relationship between NO_x, VOCs, and ozone is not yet fully understood and cannot yet be incorporated into models. There is evidence of increases in ozone levels in some cities on weekends when NO_x levels typically fall dramatically due to the drop off in heavy-duty truck traffic. But VOC levels, which are primarily from cars, do not drop.⁸⁰ This pattern is consistent with the hypothesis that lowering NO_x levels in VOC-sensitive areas increases ozone. In short, where regions are more sensitive to VOCs than to NO_x, reducing NO_x levels may increase ozone levels with the result that real-world ozone levels may rise

75. COMMITTEE TO REVIEW, *supra* note 58, at 2.

76. *Id.* at 9; see also Lloyd & Cackette, *supra* note 26, at 830 (summarizing critiques of the EPA and California models); W. Harrington et al., U.S. DEP'T OF TRANSP., DISCUSSION PAPER 98-47, *A Behavioral Analysis of EPA's Mobile Emission Factor Model* (1998) (detailing problems with the EPA MOBILE vehicle emissions model); W. R. Pierson et al., *Assessment of Nontailpipe Hydrocarbon Emissions from Motor Vehicles*, 49 J. AIR & WASTE MGMT. ASS'N 498 (1999) (comparing and contrasting uncertainties and biases in estimates of non-tailpipe and tailpipe VOC emissions from vehicles).

77. David B. Dreher & Robert A. Harley, *A Fuel-Based Inventory for Heavy-Duty Diesel Truck Emissions*, 48 J. AIR & WASTE MGMT. ASS'N 352, 352 (1998) (footnote omitted).

78. See Andrew J. Kean et al., *A Fuel Based Assessment of Off-Road Diesel Engine Emissions*, 50 J. AIR & WASTE MGMT. ASS'N 1929, 1937 (2000) [hereinafter Kean et al., *Assessment*].

79. See BETTY K. PUN ET AL., ENVTL. RESEARCH, INC., DATA ANALYSIS FOR A BETTER UNDERSTANDING OF THE WEEKDAY/WEEKEND OZONE AND PM DIFFERENCES (2001), at <http://www.crcao.com/reports/recentstudies00-02/A36B%20Final%20Report/FINAL.Data.analysis.for.a.better.understanding.doc> (last visited Aug. 23, 2003).

80. See Linsey C. Marr & Robert A. Harley, *Spectral Analysis of Weekday-Weekend Differences in Ambient Ozone, Nitrogen Oxide, and Non-methane Hydrocarbon Time Series in California*, 36 ATMOSPHERIC ENV'T 2327, 2334 (2002) [hereinafter Marr & Harley, *Spectral Analysis*].

due to NO_x reduction measures even as model levels fall.

There are two important consequences of the necessary simplification of modeling. First, as a result of the differences between the models and reality, model characteristics can come to drive regulatory measures unrelated to improvements in actual environmental quality.⁸¹ Failure to update models to incorporate new information or new knowledge of model inaccuracies can prevent states from receiving appropriate credit in their SIPs for control measures that work in reality but which are not reflected in the model,⁸² and so discourage effective measures. Second, control of models' assumptions gives the EPA "significant influence" over abatement strategies "because the agency's modeling techniques determine the number of tons of emission reduction that will be credited for each measure selected."⁸³ For example, the EPA discounts emissions reductions by 50 percent for inspection and maintenance programs that are conducted on a decentralized basis compared to centralized programs, although there is little empirical basis for such a dramatic difference in treatment.⁸⁴ This 50 percent "discount" is "hardwired" into MOBILE.⁸⁵ Changes in models, because of improvements in modeling technology or new measurements of actual conditions, can lead to states being required to reallocate emissions in their SIPs.⁸⁶ In addition, there is a third consequence that flowed from

81. See, e.g., *Boutique*, DIESEL FUEL NEWS, *supra* note 53, at 1 (noting refiners' and truckers' contention that inaccuracies in the EPA's model of the impact of fuel characteristics may cause states to adopt specific fuel requirements for diesels that actually detract from environmental quality); see also GEN. ACCT. OFFICE, GAO/RCED-00-72, AIR POLLUTION, STATUS OF IMPLEMENTATION AND ISSUES OF THE CLEAN AIR ACT AMENDMENTS OF 1990 25 (2000) (noting that states receive SIP credit for instituting inspection and maintenance programs for motor vehicles, but that these credits are "based solely on [the] EPA's model—not on validating actual emissions testing").

82. See COMMITTEE TO REVIEW, *supra* note 58, at 11 ("[E]missions inventories and control strategies being developed are based on out-of-date assumptions and inaccurate predictions, perhaps resulting in the selection and propagation of inefficient or ineffective controls."); *id.* at 51 ("The development of SIPs requires accuracy in emissions inventories and crediting of emissions reductions from controls, both of which are particularly sensitive to errors. Little has been done to address this issue . . . Users need updates [of MOBILE] that incorporate the latest findings on factors that affect emissions and the effectiveness of control strategies so that SIPs can be based on the most accurate information."). This also applies to transportation plans states are required to develop under the Intermodal Surface Transportation Efficiency Act of 1991. *Id.* at 54 ("Specific out-year technological assumptions used when MOBILE5 was developed in 1993 may not be accurately represent current assumptions. This could cause an unnecessary strain on regions, as they are forced to meet transportation plan budget tests based on outdated forecasts.").

83. See Reitze, *I&M*, *supra* note 19, at 1482.

84. See JOEL SCHWARTZ, CAL. INSPECTOR & MAINT. REVIEW COMM., AN ANALYSIS OF USEPA'S 50-PERCENT DISCOUNT FOR DECENTRALIZED I/M PROGRAMS (1995).

85. See *id.* at Appendix A ("[T]he 50-percent discount for test-and-repair programs is an *input* to the model and not an *output* of the model.").

86. See COMMITTEE TO REVIEW, *supra* note 58, at 62 ("Changes in the databases underlying the models and changes in modeling methodology in each successive version result in changes to predicted total on-road vehicle emissions. From one model version to the next, these changes can be either increases or decreases in emissions factors, and the

the specifics of the EPA's MOBILE model in the 1980s and 1990s: the model overpredicted control of NO_x from heavy-duty diesel engines because it relied on emissions tests done under a limited set of circumstances.⁸⁷ This contributed to the nonattainment of the ozone standard and presented the EPA with a regulatory problem: If the EPA revised its model to accurately predict NO_x emissions from heavy-duty diesels, the nonattainment problem would get worse. That is, either or both groups of affected states would have to make more cuts in other sources of NO_x emissions.⁸⁸ If it did not revise MOBILE, however, the model would continue to underpredict emissions.

E. Technology-forcing

The Clean Air Act relies heavily on "technology-forcing" regulations for mobile sources, an approach that was chosen in part because of regulators' distrust of the automobile industry.⁸⁹ Technology-forcing regulations require implementation of technology that does not exist at the time of the adoption of the regulations, with the intent of stimulating innovation "by setting future requirements that cannot be met by existing technology."⁹⁰ This strategy has successfully forced the development of new technology. For example, in reaction to the model year (MY) 1980 and 1981 automobile standards, car manufacturers equipped cars

with newly designed engines whose cylinders, pistons, and other essential components were engineered to produce fewer emissions. Engine operating parameters were controlled more precisely through vacuum and electronic controls and the use of fuel injection systems became widespread. Computer systems also were used to control engine operation, and became an important technology for controlling emissions.⁹¹

Heavy-duty diesel regulations have been at least perceived at times as technology forcing by the industry⁹² and regulators continue to call for

changes are not always in the same direction for all three pollutants (NO_x, CO, and VOCs).").

87. We discuss this issue in greater detail below. See *infra* notes 262-263.

88. We discuss the issue of why the EPA could not revise the heavy-duty diesel engine standard itself for immediate gains below at note 417 and associated text.

89. ROBERT W. CRANDALL ET AL., REGULATING THE AUTOMOBILE 1 (1986).

90. Currie, *Mobile-Source*, *supra* note 18, at 902.

91. Reitze, *Mobile Source*, *supra* note 56, at 327.

92. See, e.g., John H. Johnson et al., *Preface*, in DIESEL PARTICULATE EMISSIONS: MEASUREMENT TECHNIQUES, FUEL EFFECTS AND CONTROL TECHNOLOGY (PT-42) i, i (1994) (stating that "[t]he main driving force for control of diesel particulate and NO_x emissions reductions has come from the need for manufacturers to meet the U.S. Environmental Protection Agency (EPA) mobile source on-highway heavy-duty diesel standards for 1994. The 1994 standards were promulgated in 1985 and were technology forcing"); P. Zelenka et al., *Ways Toward the Clean Heavy-Duty Diesel*, in DIESEL PARTICULATE EMISSIONS: MEASUREMENT TECHNIQUES, FUEL EFFECTS AND CONTROL TECHNOLOGY (PT-42) 3, 3 (1994)

additional technology forcing.⁹³

Forcing technological change has important consequences for regulation. Because the regulatory regime depends on predicting the pace of innovation, there is a danger that the regulators would underestimate the time necessary to produce the needed innovations, leading to a situation in which there is widespread non-compliance with the regulations. Indeed, there has been a regular series of battles between source manufacturers (especially automobile manufacturers), regulators, and environmental pressure groups over whether the deadlines were technologically feasible, with the EPA and Congress attempting to determine whether sources' claims that the technology was not yet ready were legitimate or the result of underinvestment in developing new technology.⁹⁴ This is further complicated by the interdependent nature of mobile source manufacturers' choices regarding investment in technology and in efforts to delay heightened regulatory standards. Investments in the former made the latter less likely to succeed, since new technologies would undercut the claim that the standards were impossible to attain.⁹⁵ A good example of the problems in trying to force the development of technology is the tortured history of California's attempts to require production of all-electric cars.⁹⁶

(stating that MY 1991 standards, proposed in 1981, were "understood as a 'technology forcing standard'") [hereinafter Zelenka et al., *Clean*]. *But see* ENVTL. LAW INSTITUTE, 2 LAW OF ENVIRONMENTAL PROTECTION § 11.07[2], at 11-186 (2001) (suggesting light duty regulations were "merely 'technology-nudging'" and heavy-duty regulations were even more flexible); EPA, SUMMARY AND ANALYSIS OF COMMENTS TO THE NPRM "1983 AND LATER MODEL YEAR HEAVY-DUTY ENGINES PROPOSED GASEOUS EMISSION REGULATIONS," 230 (1979) [hereinafter EPA, SUMMARY AND ANALYSIS] (copy on file with authors) (noting that "a large percentage of diesel engines on the market [in 1979] meet the 1984 target HC levels for a 10 percent [acceptable quality level]"); National Resources Defense Council v. Thomas, 805 F.2d 410 (D.C. Cir. 1986) (rejecting claim that Clean Air Act required adopting industry leader technology and allowing the EPA to consider industry-wide considerations).

93. See Lloyd & Cackette, *supra* note 26, at 840.

94. See Reitze, *Mobile Source*, *supra* note 56, at 332 (describing delays in implementing automobile standards during 1970s and 1980s).

95. Lawrence J. White discussed the incentive in his examination of early emissions control efforts in California:

In the case of emissions control, it is clear that the industry's joint interests lay in discouraging research, delaying the development of control technology, and controlling the flow of information to outsiders, especially to government officials who might impose regulation. Since emissions control could only add to the cost of a vehicle or degrade its performance, the industry's interests were in making control look as impracticable and costly as possible.

WHITE, *supra* note 43, at 13.

96. For example, even a generally pro-regulatory review of California's program concluded that the state's program pushed the wrong technology, concluding that while the technology forcing "accelerated the development of clean vehicle technology" and despite the initial beliefs of "both regulators and industry insiders . . . that battery technology would progress far and fast enough to be the primary technology used to satisfy the requirements of the mandate. The anticipated breakthrough, however, never occurred. Battery electric vehicle technology progressed, but still remains too expensive and inconvenient for the majority of the public." Matthew Peak, *Improper Incentives: Modifying the California Zero*

Moreover, although technology-forcing clearly produced new technology, inducing technological change by regulation affects the type of technology developed. For example, differences in the testing standards, not just different emissions standards, in Europe and the United States require different pollution control strategies and different technologies to meet them.⁹⁷ More generally, technology-forcing creates an incentive for vehicle manufacturers to design vehicles simply to meet standards, instead of creating pollution control technology to reduce emissions.⁹⁸

In particular, as pollution control requirements grew more stringent and emissions control technology grew more complex, manufacturers had an increasing incentive to view federal emissions tests as the blueprint for their products. In other words, technology-forcing regulations require manufacturers to invest in developing features not demanded (and possibly even rejected by) customers. Their profit-maximizing strategy, therefore, consists of minimizing those investments as well as minimizing the negative features introduced into the vehicle by the new technology. Again, investing in political means of delaying requirements is one strategy for accomplishing this goal, and was the strategy used effectively by automobile manufacturers in the 1960s and 1970s. Investment in new emissions control technology that both minimizes the aspects of pollution control that customers dislike (e.g., reduced fuel economy and performance) and which does not waste resources by over-complying with regulations (e.g., reducing emissions outside of testing parameters) is another.⁹⁹

Gaining increased control over combustion offered a solution to this dilemma—it both promised the ability to reduce emissions by increasing the efficiency of combustion and provided features desired by customers such as increased mileage.¹⁰⁰ Mobile source manufacturers quickly focused on this new technology. As Lee Iacocca, then president of Ford,

Emission Vehicle Mandate with Regards to Regulatory, Technological, and Market Forces: 1990-2001, GEO. PUB. POL'Y REV. 137, 144 (2002).

97. See Piotr Bielaczyc & Kerzy Merkisz, *Euro III/Euro IV Emissions-A Study of Cold Start and Warm up Phases with a SI (Spark Ignition) Engine*, in EMISSIONS: TECHNOLOGY, MEASUREMENT, AND TESTING (SP-1420) 117, 127 (1999) ("Because of the differences between the FTP75 cycle in the USA and the new cycle in Europe, solutions for Euro III and Euro IV limits could differ from those applied in the USA to fulfil the requirements of LEV and ULEV regulations.").

98. Reitze, *Mobile Source*, *supra* note 56, at 327 (noting that 1980s standards did not lead to new pollution control technologies but "[r]ather, motor vehicles were designed around the applicable emission limits").

99. Of course these investment decisions consider the probable future course of regulations, and so may appear to over invest in control today in order to reduce costs in meeting regulations expected tomorrow.

100. See Tom Berg, *How to Justify the Cost of Fuel Economy Options*, TRANSPORT TOPICS, Mar. 25, 1996, at 9 (stating that electronic controllers increased fuel economy by 7-15%).

put it in 1976: "If we cannot save ourselves from unrealistic government requirements in fuel economy and emissions, our greatest hope in meeting these requirements is through electronics."¹⁰¹ By MY 1994, almost every truck had electronic controllers.¹⁰² As control over combustion developed, however, engine makers could improve their designs' quality from the customers' point of view by focusing emissions control on the tested conditions and maximizing customer-demanded characteristics, such as fuel economy, elsewhere in the operating cycle. As we will see, this is exactly what the engine manufacturers did.

F. Reliance on Fleet Turnover

Mobile source regulations based on introducing changes in the design of new vehicles require turnover in fleets before controls yield improved air quality. For example, if a vehicle's average life is ten years, vehicles sold in 2000 under regulations in effect at that time will still be emitting pollutants in 2005, even if new vehicles in 2005 must meet stricter emissions control levels.¹⁰³ Regulating only new vehicles, instead of requiring retrofits of older vehicles, is easier politically for the EPA since "[o]wners of existing equipment can organize to fight regulation that adversely affects their interests [while] . . . [i]n contrast, future purchasers of new equipment do not constitute as cohesive an interest group"¹⁰⁴

101. *Detroit Finally Wakes Up to Electronics*, BUS. WK., Oct. 11, 1976, at 90; *Integration of Truck Electronics: A Look at the 90's*, AUTOMOTIVE ENGINEERING, Feb. 1988 ("EPA standards are forcing engine manufacturers to use electronics to meet emissions limits for the 1990s."); George D. Hamilton & Scott Henjum, *Electronics: The Wait is Over*, FLEET OWNER, June 1985, at 50, 51 (stating that engine manufacturers have been working on electronic fuel controls "since the late 1970s, when the Environmental Protection Agency first threatened to greatly reduce the emissions from heavy-duty diesel trucks").

102. Kenneth Stadden, *Engines with Brains*, HEAVY DUTY TRUCKING, Feb. 1994, at 54.

103. Regulators were aware of this from the start. For example, in 1966, Larsen discussed the "effects from pollutants emitted from motor vehicles," specifying carbon monoxide, nitrogen oxides, oxidants (unburned and partially burned hydrocarbons), sulfur dioxide, lead, and total suspended particulates. Dr. Ralph I. Larsen, *Air Pollution from Motor Vehicles*, ANNALS OF THE NEW YORK ACADEMY OF SCIENCES, 136 Art. 12, 275-301, 282-92 (1966) (stating that sulfur content in fuel would subsequently be limited, most recently due to its negative effects on equipment that limit engine emissions). Lead, of course, would subsequently be eliminated entirely from the fuel supply.

Previous discussion indicates that about 95% reduction of carbon monoxide, hydrocarbons, and nitrogen oxides will probably be needed by about 1985. Since the life span of an automobile is about ten years, vehicles produced in 1975 would need to meet such reductions if air quality in 1985 is to meet present standards. This might be a good research goal: to strive for 95% reduction of carbon monoxide, hydrocarbons, and nitrogen oxides from all new vehicles by 1975.

Id. at 297; see also 45 Fed. Reg. 4140 (Jan. 21, 1980) ("Heavy-duty engines, particularly diesel engines, tend to last longer than light-duty vehicles The end of the useful life of a given heavy-duty engine, then, is defined by one of two limits, whichever is reached first. Either the engine exceeds the average amount of service seen by its engine family or it deteriorates to the point of needing to be rebuilt.").

104. CRANDALL ET AL., *supra* note 89, at 89.

As a result, "even if the mobile source program as currently designed worked perfectly, large reductions in total emissions from the fleet and in the consequent pollutant concentrations could not be achieved quickly."¹⁰⁵ This is particularly important with respect to heavy-duty diesel engines since "[d]iesel engines have long useful lives [with the result that] . . . the fleet turnover is slow."¹⁰⁶ Heavy duty trucks' longer lives are keeping older trucks on the road longer. This fact, combined with fleet management practices at many companies that sell trucks as they come out of warranty, means that used trucks hit the market only halfway through their expected service lives.¹⁰⁷ Large fleets have also increased use of older trucks.¹⁰⁸ As a result, trucks tend to move from initial service in long haul fleets to regional and short-haul fleets later in their lives. Older and thus dirtier trucks are thus mostly found in short-haul, primarily urban markets. Newer, cleaner trucks spend more time in highway driving. Introducing new technology thus first reduces emissions in rural areas and only years later reaches urban areas.

To illustrate the dynamics of large truck replacement, consider these simplified calculations. In 1997, according to government reports, there were 4,302,915 trucks on the road in the size six to eight categories, which covers 19,500 to 33,001 pound vehicles.¹⁰⁹ Over the years 1995 through 2000, there were, on average, 291,000 new vehicles purchased in the size six to eight categories. A back of envelope calculation suggests that at this average replacement rate, without accounting for some expansion, it would take slightly less than 15 years to replace the existing stock. If only the larger size eight vehicles are considered, there were 2,211,283 on the road in 1997.¹¹⁰ Then, on average, there were 205,000 trucks in that category added each year from 1995-2000. Again, a rough calculation indicates it would take slightly more than ten years to turn over the existing stock on

105. WHITE, *supra* note 43, at 54.

106. Timothy V. Johnson, *Diesel Emission Control – Last 12 Months in Review*, in DIESEL AFTERTREATMENT (SP-1561) 33 (2001) [hereinafter Johnson, *Review*]; see also HEALTH EFFECTS INSTITUTE, DIESEL EXHAUST: A CRITICAL ANALYSIS OF EMISSIONS, EXPOSURE, AND HEALTH EFFECTS 5 (1995) ("[R]eductions in exposure will be gradual because of the long life of existing heavy-duty diesel engines, and will be offset as the use of diesel engine grows."). Heavy-duty diesel engines have remained in service up to 30 years. Robert F. Sawyer & John H. Johnson, *Diesel Emissions and Control Technology*, in HEALTH EFFECTS INSTITUTE, DIESEL EXHAUST: A CRITICAL ANALYSIS OF EMISSIONS, EXPOSURE, AND HEALTH EFFECTS 65, 72 (1995).

107. Tom Moore, *The Used Truck Market Presents Wide Selection and Increased Quality—An Attractive Value for Fleets*, FLEET OWNER, July 1996, at 98, 99.

108. Ed Thomas & Greg Berg, *Equipment Maintenance: How to Run It Longer*, in HEAVY DUTY TRUCKING 48 (2001).

109. U.S. DEP'T OF COMMERCE, BUREAU OF THE CENSUS, 1997 VEHICLE INVENTORY AND USE SURVEY, available at <http://www.census.gov> (last visited Apr. 6, 2003).

110. *Id.*

the road in 1997.¹¹¹ If we assume that the diesel share of the total market remains about constant over the interval of the calculation, we can use the crude turnover estimate as the number of years necessary to bring cleaner technologies to the diesel fleet.

Fleet turnover is not quite this simple, however, for two reasons. First, mobile source purchasers have choices among different types of mobile sources that present different combinations of upfront costs, maintenance costs, and vehicle life. The more complex emissions systems now in use are more strongly affected by deterioration and maintenance than earlier, simpler systems.¹¹² Consider the stereotypical Volvo and Kia owners. Volvo owners must invest heavily in regular maintenance, but are rewarded with lengthy vehicle lives—hundreds of thousands of miles longer than the typical Kia. The extended life of a Volvo requires both a greater initial investment and regular maintenance beyond that necessary for a Kia, however. Volvos are not “better” than Kias; they merely present a different combination of maintenance costs, vehicle life, and other vehicle characteristics including safety, luxury, status, and so forth.

Second, and more importantly, vehicle life is endogenous with respect to regulations. If new cars are more expensive, consumers will delay purchasing a new vehicle. If emissions controls increase vehicle costs, older vehicles with lesser controls will operate longer as consumers delay purchasing new vehicles because of the additional expense.¹¹³ Most importantly for our purposes, vehicle consumers’ choices can be affected by regulatory behavior.¹¹⁴ Turnover can be delayed by requiring new emissions controls that increase user-costs¹¹⁵ or sped up through incentives to retire older vehicles.¹¹⁶ If the purchase of a new vehicle is made more

111. Our calculation underestimates the time for turnover, as in 1997 the average age of a truck was 8.3 years and 19% were more than 15 years old. Sawyer et al., *supra* note 26, at 2163.

112. *Id.*

113. See CRANDALL ET AL., *supra* note 89, at 116 (noting that auto emissions control program slowed new car sales in the 1970s and early 1980s).

114. See Howard K. Gruenspecht, *Differentiated Regulation: The Case of Auto Emission Standards*, 72 AM. ECON. REV. 328, 330-31 (1982) (discussing how regulatory costs on new vehicles result in longer lives for older vehicles).

115. See WHITE, *supra* note 43, at 68 (noting that the regulations have had the effects of new source performance standards—differentially increasing the costs of new vehicles, discouraging their purchase, and encouraging the retention of the older vehicles that are the heavy emitters in the fleet). Jeffrey Ball, *Truck Firms Go on Buying Binge to Circumvent a New EPA Rule*, WALL ST. J., May 28, 2002 at A1, A12 (indicating truck firms are buying new engines early to avoid engines that meet new standards coming into effect) [hereinafter Ball, *Buying Binge*]; *Up in the Air*, DAIRY FOODS, April 1992, at 97, 98 (stating that the EPA emissions standards may make maintenance more expensive, and escalate “the current trend toward transportation outsourcing, allowing fleet operators to avoid a direct investment in specialized training for mechanics and sophisticated diagnostic equipment”).

116. See Jack Dolan & Lisa Chedekel, *Dirty, But Legal, Old Cars Offset Progress*, THE HARTFORD COURANT, June 3, 2001, at A1 (discussing how older cars that still pass emission tests detract from any progress that regulations may cause and describing an old-car buy-

expensive or otherwise less desirable by regulators (e.g., by requiring emissions controls that reduce mileage), current vehicle owners will invest in maintaining their existing vehicles' lives.¹¹⁷ Using older engines tends to increase emissions, both because older engines tend to be dirtier than newer engines of the same design¹¹⁸ and because of the trend toward requiring engines designed to run cleaner. Increasing the cost of new engines by requiring stricter emissions controls brings in cleaner new engines but also has an offsetting impact by increasing the length of time older vehicles are used and delaying their replacement by newer, cleaner vehicles.

G. Summary

To see how these fit together to shape the EPA's incentives, consider the following situation: Suppose some, but not all, regions of the country are nonattainment for a particular NAAQS related to emissions that come from both mobile and stationary sources. The EPA can require all mobile sources in the country to be built to a more stringent standard to move the noncomplying regions towards compliance. The impact on the noncompliant regions of any such change will be limited, however, because the new equipment will be phased in over time as fleets turn over. To the extent that the new standard is technology-forcing, the delay will be extended as time must be allowed for the technology to develop. The benefits of raising mobile source standards will thus take time to be realized. Moreover, mobile source regulations will only partially benefit the nonattainment regions, as some of the reduction that results will occur in regions already in attainment with the NAAQS. Reduced emissions in those regions may be useful to offset growth due to emissions increases related to population or economic growth, but such reductions are worth less than the reductions in nonattainment regions, if only because the NAAQS is not a binding constraint in attainment regions.

back program in Maine that gives people \$1,000-\$2,000 for their old car); Santa Barbara Old Car Buyback Program, available at <http://www.sbcapcd.org/ocbb.htm> (last accessed June 28, 2002) (describing old car buy back program in Santa Barbara County).

117. Ball, *Buying Binge*, *supra* note 115, at A12; see also *U.S. Truck Fleet Hesitant About 2002 Trucks*, DIESEL FUEL NEWS, Jan. 7, 2002, at 18 (stating that "fleet managers worried about the performance of EPA-compliant, low-NO_x trucks debuting in October . . . will postpone purchases"); *Diesel Technology for the 21st Century: Hearing Before the Subcomm. on Energy & Env't of the House Comm. on Science*, 105th Cong. 31 (1998), (testimony of Robert J. Crites, Condor Freight Lines) ("Like many companies, our decisions about when to buy new equipment is based on many factors, including profitability, depreciation, market resale value, changing customer needs, new government regulations, driver's satisfaction, and recruitment, and manufacture warranty periods, to name just a few.") [hereinafter *Diesel Hearings*].

118. IPCS, CRITERIA 171, *supra* note 57, at 124 ("Increased emissions of hydrocarbons, particulates, and PAHs have been reported from older, more intensively used light- and heavy-duty vehicle engines in comparison with newer ones.").

Per unit reduction of emissions in nonattainment regions is thus more expensive if done by mobile source reductions because “extra” reductions in attainment regions will have to be purchased along with the desired reductions in the nonattainment areas. Per unit of reduction in nonattainment regions, therefore, mobile source reductions are more expensive than they would be if they could be more narrowly targeted. The EPA will have a choice between slow-to-appear benefits from mobile source technology-forcing regulations and requirements for stationary sources.¹¹⁹ The relative speed at which various benefits will appear will play an important role in actual environmental quality improvement. The EPA’s models’ assumptions about the speed at which benefits will appear will determine the regulatory advantage of one method over another. The crucial issue for states deciding how to allocate emissions among sources will be how the EPA’s models treat the allocations, not how the allocations actually affect emissions. A policy change that cuts model emissions by five percent but real world emissions by one percent will be preferred to a policy change that cuts model emissions by one percent and real world emissions by five percent. States allocating reductions will have a choice between unpopular mobile source use restrictions and stationary source restrictions.

The EPA has come under increasing pressure to reduce NO_x emissions because of the conflict between the upwind and downwind states, the upward trend in NO_x, and because the EPA’s models overpredicted the impact of control measures. Heavy-duty diesel engines, a comparatively unregulated source of emissions in the mid-1990s, offered an obvious target for the EPA’s attention. Gaining additional reductions from heavy-duty diesel engines would mean the EPA could avoid politically costly nonattainment penalties against a large number of states, help states avoid politically unpopular mobile source use controls, and promised to be cheaper than squeezing more out of stationary sources. Getting new reductions from heavy-duty diesels would take a relatively long time, however, because of the need for the fleet to turn over before new, cleaner engines could cut NO_x emissions. Before examining how these constraints and incentives played out in the EPA’s regulatory choices, however, we must explore how diesel engines pollute and how that pollution is controlled.

119. Of course, it will take time to phase in new stationary source standards as well, and there are regulatory problems with the incentives created by grandfathering old sources. See generally Heidi Gorovitz Robinson, *If Your Grandfather Could Pollute, So Can You: Environmental “Grandfather” Clauses and Their Role in Environmental Inequity*, 45 CATH. U. L. REV. 131 (1995) (cataloging problems with grandfather clauses).

II. DIESEL ENGINES & AIR POLLUTION

Diesel engines, a "mature and well-developed technology,"¹²⁰ operate differently from gasoline engines.¹²¹ In a diesel engine, fuel is injected directly into high-pressure air in the combustion chamber.¹²² The fuel self-ignites from the heat caused by the compression of the air within the cylinder.¹²³ In a gasoline engine, by contrast, carburetion or injection outside the cylinder is performed and the fuel-air mixture is then ignited within the cylinder by a spark. As a result of this difference in combustion, diesel engines require a significantly different fuel from gasoline engines¹²⁴ and have quite different combustion processes.¹²⁵ They also have different emissions, with important consequences for pollution control.¹²⁶ For example, diesels emit more particulates and NO_x¹²⁷ but less Carbon

120. 5 WILEY ENCYCLOPEDIA OF ELECTRICAL AND ELECTRONICS ENGINEERING 356 (John G. Webster ed., 1999) [hereinafter WILEY, ENGINEERING].

121. For a basic overview of diesel technology, see Marshall Brain, *How Diesel Engines Work*, at <http://www.howstuffworks.com/diesel1.htm> (accessed June 17, 2002); see also Kathleen M. Nauss and the HIE Diesel Working Group, *Critical Issues in Assessing the Carcinogenicity of Diesel Exhaust: A Synthesis of Current Knowledge*, in HEALTH EFFECTS INSTITUTE, DIESEL EXHAUST: A CRITICAL ANALYSIS OF EMISSIONS, EXPOSURE, AND HEALTH EFFECTS 11, 13-14 (1995) [hereinafter Nauss et al., *Diesel Exhaust*]; WILEY, ENGINEERING, *supra* note 120, at 357-58.

122. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 473.

123. *Id.*

124. Gasoline and diesel fuel are both distilled from petroleum, but diesel is made from heavy components. Gasoline is a mixture of hydrocarbon chains from C₇H₁₆ to C₁₁H₂₄, while diesel fuel comes from heavier components above C₁₅. Marshall Brain, *What Is the Difference Between Gasoline, Kerosene, Diesel Fuel, Etc.?*, available at <http://www.howstuffworks.com/question105.htm> (accessed June 22, 2002); see also IPCS, CRITERIA 171, *supra* note 57, at 1. Perhaps the easiest way to appreciate the difference between diesel fuel and gasoline is to consider that biodiesel, made from soybean or rapeseed oils, can be substituted into diesel engines with few modifications to the engine, but not into gasoline engines. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 104. Biodiesel is considerably more expensive than diesel, however. Sharon Steele, *Alternative Fuel Vehicle Fleet Mandate*, PUBLIC WORKS, March 1998, at 44, 48 (stating that the cost of biodiesel is two to three times as great as regular diesel fuel).

125. The diesel combustion process remains poorly understood:

The processes that occur during diesel combustion are still somewhat mysterious in spite of extensive attempts at photography and other, more advanced, optical diagnostics. The environment in the diesel combustion chamber appears to be designed to resist detailed investigation. It is small, hot, and subject to high pressure and intense vibration. When windows are installed in the chamber to observe the combustion, soot blocks the passage of light and quickly deposits on the window, obscuring further investigation. The combustion involves gas, liquid, and solid phases as well as complex physical processes and chemical reactions.

DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 91.

126. See Nauss et al., *Diesel Exhaust*, *supra* note 121, at 14 ("The diesel engine's unique combustion process plays a large role in the output of pollutants."); James C. Clerc, *Catalytic Diesel Exhaust Aftertreatment*, 10 APPLIED CATALYSIS B: ENVIRONMENTAL 99, 99-102 (1996) [hereinafter Clerc, *Catalytic*] (noting differences in emissions); "The requirements for diesel exhaust aftertreatment are unique from gasoline passenger car catalysis due to emissions performance requirements, engine exhaust conditions, vehicle application, and increased durability requirements." *Id.* at 113.

127. See IPCS, CRITERIA 171, *supra* note 57, at 91 (up to 20 times as many particulates);

Monoxide (CO),¹²⁸ and are more fuel efficient¹²⁹ than gasoline engines.

One important result of the differences in combustion technology is that diesels have a higher compression ratio¹³⁰ than gasoline engines, making them more efficient¹³¹—so much so that the *Diesel Engine Reference Book* terms them “the most efficient liquid fuel burning prime mover yet derived.”¹³² This substantial fuel savings advantage is a major reason for the transportation industry’s preference for diesels over other possible engine types (most notably gasoline-fueled spark ignition engines),¹³³ with diesels accounting for 80 percent of the trucks that haul freight across the United States. Diesels are also “comparatively easy to maintain on site without the need for fully skilled personnel except for certain nonroutine tasks.”¹³⁴ Relative to gasoline engines, diesel use saves truckers as much as \$6,600,000 in fuel costs every year,¹³⁵ and use only 70 percent of the fuel that a comparable gasoline engine uses to provide the same power output.¹³⁶ Diesel fuel economy for heavy duty engines has increased sharply, with the typical fuel economy rising from 4.5-5 miles per gallon (mpg) to 6.5-7 mpg between 1980 and 1990 due to aerodynamic improvements, tire improvements, and engine improvements, particularly electronic engine controllers.¹³⁷ Fuel efficiency, however, is not the only advantage diesels have over spark ignition engines. Diesel engines also have greater packaging efficiency,¹³⁸ durability,¹³⁹ and safety.¹⁴⁰ As a

Nauss et al., *Diesel Exhaust*, *supra* note 121, at 14 (stating that NO_x and particulates are the “problem emissions” from diesels).

128. See Zelenka et al., *Clean*, *supra* note 92, at 11 (“The diesel principle is by far the best choice to minimize CO₂-emissions.”).

129. See Kean et al., *Assessment*, *supra* note 78, at 1937 and accompanying text.

130. The high compression ratios are needed to ensure autoignition of the fuel. See DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 473.

131. On average, diesel engines are around 25-35% more efficient than electric spark ignition engines. See CHARLES RIVER ASSOCIATES, DIESEL TECHNOLOGY AND THE AMERICAN ECONOMY 2 (2000); see also IPCS, CRITERIA 171, *supra* note 57, at 111 (“Diesel engines are the most efficient of all common types of combustion engines . . .”).

132. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 5. Diesel fuel requires less energy than gasoline to manufacture and has a higher energy content per gallon than gasoline. *Id.* See also *Diesel Hearings*, *supra* note 117, at 8 (testimony of Dan Reicher, Dep’t of Energy) (“Most of the increase in highway transportation energy use since 1973 can be attributed to trucks.”).

133. See *id.* at 13 (testimony of John C. Wall, Cummins Engine Co., Dep’t of Energy) (stating that diesel’s fuel economy advantage is “one of the major economic factors that drove the transition of heavy-duty trucks from gasoline to diesel in the 1970s”).

134. WILEY, ENGINEERING, *supra* note 120, at 356.

135. The trucking industry uses over \$11,000,000,000 worth of diesel fuel per year. See CHARLES RIVER ASSOCIATES, *supra* note 131, at 58. Without the 35% fuel efficiency savings, that would be \$16,500,000. The difference (5.5 bn) calculated at an average US gasoline price of \$1.34 per gallon equates to \$7,370,000 in savings. See U.S. Dep’t of Energy, Energy Info. Admin., available at <http://www.eia.doe.gov> (online data for U.S. petroleum sales from 1994-2002).

136. See Lloyd & Cackette, *supra* note 26, at 810.

137. See Jim Mele, *Good News for Fuel Economy*, FLEET OWNER, Jan. 1991, at 80, 81.

138. Packaging efficiency refers to the higher power output levels, at low speeds, that

result of these advantages, diesel's market share has increased significantly since the 1970s, with its share of total highway fuel use increasing from 8.9 percent in 1973 to 20.6 percent in 2000.¹⁴¹ Diesel's growth in market share was accompanied by a shift in diesel combustion technology,¹⁴² with turbocharged, after-cooled engines becoming dominant in the U.S. after the 1970s.¹⁴³ Although the use of turbochargers reduced NO_x and particulate emissions by approximately one-third,¹⁴⁴ the large increase in diesel's market share and its greater NO_x emissions relative to gasoline engines are one of the reasons the EPA's models did not accurately predict the increase in NO_x emissions in the 1980s. Moreover, trucking deregulation brought an increase in the volume of heavy-duty truck traffic in the 1980s and 1990s,¹⁴⁵ again boosting emissions outside the parameters of the EPA's

diesels are able to achieve. Diesels require less cooling than spark ignition engines and for this reason they can generate more power at lower speeds. In the exhaust system of a typical compression-ignition engine the temperature will average between 200 and 500 degrees Celsius, whereas in the exhaust system of a typical spark-ignition engine the temperature will average 400-600 degrees Celsius, and will rise to about 900 degrees Celsius at maximum power. See CHARLES RIVER ASSOCIATES, *supra* note 131, at 2.

139. Diesel engines are extremely durable, with an average heavy-duty truck engine annually putting on 46,000 miles at average loads of 80,000 pounds, with average driving speeds of 63.1 mph. See CHARLES RIVER ASSOCIATES, *supra* note 131, at 2, 11.

140. The fuel used in diesel engines is less volatile and safer to store than other fuels. This safety aspect to diesel engine use is attractive for certain applications including trucks that ferry hazardous material, in fire fighting equipment, ambulances, military vehicles, and school buses. See CHARLES RIVER ASSOCIATES, *supra* note 131, at 2.

141. See U.S. DEP'T OF TRANSP. FED. HIGHWAY ADMIN., HIGHWAY STATISTICS 1999 (2000), tbls. MF-21, MF-33E annual. (Additional resources available at <http://www.fhwa.dot.gov>). This increase is virtually entirely due to engines in trucking. See Hearing Before the Subcommittee on Diesel Hearings, *supra* note 117, at 3 (testimony of Dan Reicher) ("[M]ost of the increase in highway transportation energy use since 1973 can be attributed to trucks."). While diesel engines and diesel fuel use in passenger cars has virtually ceased in the United States since 1988, their use in the trucking industry has gone in the opposite direction. Today 100% of Class 8 trucks are diesel and Classes 1-7 are increasingly diesel. Diesel use grew significantly in a relatively short period—a study of Los Angeles trucks, for example, found 47% were diesel in 1971, up from only 22% in 1959. See WILBUR SMITH AND ASSOCIATES, HEAVY DUTY VEHICLE DRIVING PATTERN AND USE SURVEY: PART II. LOS ANGELES BASIN 23-25 (1974) (copy on file with authors). During the 1970s diesel-powered heavy-duty trucks grew from 133,065 in 1972 to 210,144 at the end of the decade, while gasoline-powered heavy-duty trucks fell from 433,105 to 322,015 over the same period. See OFFICE OF MOBILE SOURCE AIR POLLUTION CONTROL, EPA, REGULATORY ANALYSIS, ENVIRONMENTAL IMPACT STATEMENT, AND NO_x POLLUTANT SPECIFIC STUDY FOR PROPOSED GASEOUS EMISSION REGULATIONS FOR 1985 AND LATER MODEL YEAR LIGHT-DUTY TRUCKS AND 1986 AND LATER MODEL YEAR HEAVY-DUTY ENGINES 36-37 (1981).

142. Heavy-duty diesel engines have undergone "major advances" in technology over the past 30 years, according to an EPA presentation. These include: "Near universal turbocharging/Intercooling; Injection pressures have increased dramatically over time; Sophisticated injection control; Completely redesigned combustion chambers; Dramatic reductions in oil consumption; [and] Active electronic engine management." Chet France, Engine Programs and Compliance Division, EPA Office of Mobile Sources, *Accounting for Off-Cycle NO_x Emissions from Heavy-duty Diesels* 4 (n.d.) (copy on file with authors).

143. Johnson, *Review*, *supra* note 106, at 79.

144. Lloyd & Cackette, *supra* note 26, at 827.

145. Truck registrations have grown by 70% in the past three decades, while miles

modeling.¹⁴⁶

A. Regulatory Consequences

Diesel's advantages are at least partially offset by some disadvantages. Two California regulators recently labeled diesel engines "inherently dirty."¹⁴⁷ Diesel emissions are unpleasant to breathe and considered "probably carcinogenic to humans," although "no quantitative data are available for estimating human risk."¹⁴⁸ Diesel emissions appear to present some risk to humans: in particular, diesel particulate emissions are "very small . . . making them readily respirable" and have "hundreds of chemicals adsorbed onto their surfaces, including many known or suspected mutagens and carcinogens."¹⁴⁹

The EPA, like the regulatory agencies of most other industrialized countries, regulates four components of diesel exhaust: CO, hydrocarbons, particulates, and NO_x. The first three are the result of incomplete

traveled and fuel used has more than doubled. See U.S. DEP'T OF TRANSP., FED. HIGHWAY ADMIN., HIGHWAY STATISTICS 1999, (2001) tbl. MV1 and annual. (Additional resources available at <http://www.fhwa.dot.gov>). Freight activity through the single-mode transportation of trucks has grown 20.6% between just 1993 and 1997; U.S. DEP'T OF TRANSP., BUREAU OF TRANSP. STATISTICS, FREIGHT USA, (2000). (Additional resources available at: <http://www.bts.gov/cfs>). To give some idea of the importance of the sector to the overall economy, in 1997 there were 104,000 establishments involved primarily in truck transportation, employing 1.3 million people and garnering revenues totaling \$141 billion. See U.S. CENSUS BUREAU, 1997 ECONOMIC CENSUS, SUMMARY STATISTICS FOR THE UNITED STATES: 1997, tbl. 1 (2000). Trucking and warehousing accounted for 1.2% of the nation's GDP in 1997. CHARLES RIVER ASSOCIATES, *supra* note 131, at 9.

146. See *supra* note 77.

147. Lloyd & Cackette, *supra* note 26, at 811.

148. IPCS, CRITERIA 171, *supra* note 57, at 98; see also *id.* at 240 ("A quantitative assessment of the risk for humans of non-carcinogenic effects of exposure to diesel exhaust cannot be made on the basis of studies in humans."); *id.* at 254 (stating that for lung cancer "historical measurements of exposure to diesel exhaust are unreliable and exist only for current workers in two industries. A quantitative risk assessment cannot be conducted on the basis of epidemiological data in which job title was used as a surrogate of exposure Consequently, there are no human data suitable for estimating unit risk"). *Id.* at 254 ("The risk for urinary bladder cancer cannot be assessed from the available epidemiological data."). Risk can only be based on animal studies and suggests increased risk of lung cancer with increased exposure. *Id.* at 273-76. However, caution is needed in relying on animal studies because tumors appear in rat but not mouse or hamster studies. See HEALTH EFFECTS INST., DIESEL EXHAUST: A CRITICAL ANALYSIS OF EMISSIONS, EXPOSURE, AND HEALTH EFFECTS 5, 7 (1995); see also Lloyd & Cackette, *supra* note 26, at 815-21 (discussing literature on health effects). The health effects of diesel emissions continue to spark controversy. See W.K.C. Morgan et al., *Health Effects of Diesel Emissions*, 41 ANN. OCC. HYG. 643, 655-56 (1997) ("Summing up, in spite of the vast number of published epidemiological studies, none has provided convincing evidence that there is an increased risk of cancer from diesel exhaust emissions."); Michel P. Guillemin, *Letter to the Editor*, 42 ANN. OCC. HYG. 63 (1998) ("[I]t is unacceptable to assert that the weight of the evidence is against" the hypothesis that diesel emissions cause cancer.); W.K.C. Morgan & R.B. Reger, *Reply*, ANN. OCC. HYG. 65 (1998) (disagreeing with Guillemin).

149. HEALTH EFFECTS INST., DIESEL EXHAUST: A CRITICAL ANALYSIS OF EMISSIONS, EXPOSURE, AND HEALTH EFFECTS 5 (1995).

combustion; NO_x, however, is a side effect of combustion.¹⁵⁰ CO emissions are not a significant problem for diesel engines.¹⁵¹ Hydrocarbon emissions can be solved by measures to reduce particulate emissions or improve fuel efficiency with diesel engines.¹⁵² Particulate and NO_x emissions are thus the major problems.¹⁵³

Diesel emissions are the result of complex processes and, consequently, are difficult to model.¹⁵⁴ Even today, modeling of diesel emissions lags behind gasoline engine emissions modeling,¹⁵⁵ complicating regulation and control. Briefly, exhaust emissions are the sum of the emissions formulated in the initial fuel spray, together with additional formations from the cylinder and the exhaust system, less emissions eliminated in the cylinder and exhaust system due to further combustion and chemical reactions.¹⁵⁶ Different pollutants form at different locations in the

150. See DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 479.

151. See *id.* (stating that diesel CO emissions "are normally well below legislated limits and not of much concern" due to lean fuel mixture).

152. See *id.* ("Engine changes that reduce particulate emissions and fuel consumption also tend to reduce HC emissions: all derive from combustion inefficiency.")

153. See *id.* at 480 ("Particulate matter (PM) is the other diesel emission—along with NO_x—of most concern."); see also IPCS, CRITERIA 171, *supra* note 57, at 138 ("Particulate matter appears to be the most relevant fraction of diesel exhaust for the general population."). Trucks also contribute disproportionately to NO_x problems. For example, in 1991 trucks were estimated to contribute 33% of NO_x emissions but only 8% of smog constituent gases in the Los Angeles area. Mark Larson, *Truckers Warily Eye Proposed Clean-Air Standards*, THE BUSINESS JOURNAL SERVING GREATER SACRAMENTO 16 (1991). They also contribute significantly to particulate emissions, with 1998 data suggesting diesel emissions make up 6% of total ambient regulated particulates and 23% of particulates excluding "natural and miscellaneous sources." U.S. EPA, NAT'L CTR. FOR ENVTL. ASSESSMENT, OFFICE OF RESEARCH AND DEV., EPA/600/8-90/057E, HEALTH ASSESSMENT DOCUMENT FOR DIESEL EXHAUST 1-2 (draft July 2000).

154. Clark et al., *Emissions Modeling*, *supra* note 62, at 122, states that:

The task of emissions modeling is quite complex given the high number of factors that affect the emissions signature of an engine during operation. Clearly an engine's emissions will vary as a function of engine operating conditions (i.e. speed, load, and their transients), engine operating temperature, ambient atmospheric conditions, engine control, and fuel. Design variations between different engine models such as port and piston-head geometry, fuel injectors, and fuel injection control strategies will also effect emissions. Research . . . showed emissions to vary slightly for the same engine exercised through the same test cycle with a different stock electronic controller.

See also IPCS, CRITERIA 171, *supra* note 57, at 93 ("[D]iesel exhaust is a complex mix of a great variety of compounds . . ."); HEALTH EFFECTS INST., DIESEL EXHAUST: A CRITICAL ANALYSIS OF EMISSIONS, EXPOSURE, AND HEALTH EFFECTS 5 (1995) ("Diesel engine emissions are highly complex mixtures. They consist of a wide range of organic and inorganic compounds distributed among the gaseous and particulate phases.").

155. See Clark et al., *Factors Affecting*, *supra* note 62, at 84 ("Prediction of heavy-duty diesel vehicle emissions inventory is substantially less mature than the prediction of gasoline passenger car emissions.").

156. The effect of further reactions during the process generally adds NO_x and eliminates incomplete oxidation products. See N.A. Henein, *Diesel Engines Combustion and Emissions*, in ENGINE EMISSIONS: POLLUTANT FORMATION AND MEASUREMENT (George S. Springer & Donald J. Patterson, eds., 1973) 211, 228 [hereinafter Henein, *Combustion*].

process.¹⁵⁷ How much of each is produced and emitted depends on a variety of factors, including oxygen concentration, temperature, timing, the amount of mixing of fuel and air, and fuel characteristics.¹⁵⁸ As an engine operates, conditions change and therefore the amount and mix of emissions change.¹⁵⁹ Thus, as the load on the engine increases, the emissions of total unburned hydrocarbons falls but the mixture of types of hydrocarbons changes, with more of some and less of others.¹⁶⁰ Other emissions are similarly affected in complex ways.¹⁶¹ The impact of various technologies varies with operating conditions.¹⁶² Multiple characteristics of diesel fuel also have an impact on emissions.¹⁶³ Finally, as with all mobile sources,

157. See P.S. Myers et al., *Engine Exhaust Emissions*, in ENGINE EMISSIONS: POLLUTANT FORMATION AND MEASUREMENT (George S. Springer and Donald J. Patterson, eds., 1973) 1, 9-10 [hereinafter Myers et al., *Engine Exhaust*] (stating that NO_x emissions are determined by their level of formation during the early, high-temperature portion of the combustion process.); Zelenka et al., *Clean*, *supra* note 92, at 6.

158. See Henein, *Combustion*, *supra* note 156, at 228; Myers et al., *Engine Exhaust*, *supra* note 157, at 11 (“[I]gnition timing exerts a strong influence on NO levels due both to its influence on the time available for NO formation and on temperatures.”); DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 461 (“[F]uel properties are also capable of influencing smoke emissions.”); IPCS, CRITERIA 171, *supra* note 57, at 1 (“The quality and composition of diesel fuel influence the emissions of pollutants from diesel engines considerably.”); Lloyd & Cackette, *supra* note 26, at 813 (“The exact composition of exhaust depends on operational parameters, such as speed, motor load, engine and vehicle type, fuel composition, ambient temperature, and relative humidity.”).

159. See IPCS, CRITERIA 171, *supra* note 57, at 92 (discussing that “exhaust emissions depend on driving cycle (transient or steady state), engine conditions (injection and aspiration techniques, maintenance, total mileage), and fuel composition (sulfur content, aromaticity, volatility); adjustment of the engine plays a major role”).

160. See Henein, *Combustion*, *supra* note 156, at 229-32; see also Clark et al., *Emissions Modeling*, *supra* note 62, at 122 (stating that “[c]learly an engine’s emissions will vary as a function of engine operating conditions (i.e. speed, load, and their transients), engine operating temperature, ambient atmospheric conditions, engine control, and fuel. Design variations between different engine models such as port and piston-head geometry, fuel injectors, and fuel injection control strategies will also effect emissions. Research . . . showed emissions to vary slightly for the same engine exercised through the same test cycle with a different stock electronic controller”). Myers et al., *Engine Exhaust*, *supra* note 157, at 11 (“Nitric oxide formation rates tend to increase with increasing pressure. Therefore engine emissions tend to increase with increasing load.”).

161. Increasing the fuel-air ratio first lowers, then increases CO emissions. See Henein, *Combustion*, *supra* note 156, at 234. Likewise, “nitric oxide formation in the diesel engine is influenced by the combustion pressure and temperature, and by the time available for combustion. For this reason, nitric oxide levels tend to increase with advanced injection timing and with increased compression ratio or increased manifold temperature.” See also Myers et al., *supra* note 157, at 14. Smoke emissions, the first diesel emission regulated by the federal government, are affected by factors such as injection timing, nozzle size, ratio of nozzle hole length to diameter, air temperature, and after-injection of fuel. See Henein, *supra* note 156, at 238-240.

162. See Zelenka et al., *Clean*, *supra* note 92, at 6 (“At full load . . . decreasing fuelling results in reduced NO_x emission, whereas at part load . . . NO_x initially increases before diminishing later on.”); see also Johnson, *Review*, *supra* note 106, at 25 (“[A]mbient temperatures can impact nanoparticle number, wherein the colder temperatures result in higher nanoparticle concentrations.”).

163. See Rob Lee et al., *Fuel Quality Impact on Heavy Duty Diesel Emissions: A Literature Review*, in DIESEL EMISSIONS (SP-1397) 13, 14 (1998) [hereinafter Lee et al., *Fuel Quality*].

driver behavior dramatically affects emissions.¹⁶⁴ Control strategies and emissions modeling must consider all these factors. The key point to take from this discussion is that diesel combustion has been and continues to be poorly understood compared to spark ignition engines' combustion and therefore the solutions to emissions problems require relatively larger advances in scientific understanding. Moreover, diesel exhaust's characteristics make post-combustion treatment more difficult than for spark-ignition engines.

Because of the differences in technology and combustion between diesel and gasoline engines, regulators in the United States, European Union, and Japan have regulated diesel emissions separately from gasoline engine emissions.¹⁶⁵ Although today diesels are recognized as a significant source of air pollution,¹⁶⁶ diesels were initially regulated much less heavily than gasoline engines.¹⁶⁷ Indeed, at least one early report on air pollution depicted diesels as preferable to contemporaneous gasoline engines.¹⁶⁸ As

164. See LENZ & COZZARINI, *supra* note 57, at 96-97 (1999).

165. Diesel emissions are different from gasoline engines:

Diesel-powered engines emit significantly less CO than comparable gasoline engines. HC emissions from diesels are comparable to those of gasoline vehicles, but diesel engines generally produce more of the kinds of HC emissions associated with cancer. NO_x emissions from diesels, however, are considerably higher than from comparable gasoline vehicles due to the higher temperature combustion, the oxygen concentration, and residence time of the fuel.

Reitze, *Mobile Source*, *supra* note 56, at 395 (citations omitted). Particulate emissions are much greater from diesel engines. *Id.* at 396.

166. See, e.g., Michael P. Walsh, *Global Trends in Diesel Emissions Regulation—A 2001 Update*, in DIESEL EXHAUST EMISSIONS CONTROL: DEVELOPMENTS IN REGULATION AND CATALYTIC SYSTEMS (SP-1581) 1, 2 (2001) [hereinafter Walsh, *Global Trends*] (Diesel vehicle emissions are a significant source of both NO_x and particulate pollution problems); Union of Concerned Scientists, *Diesel Engines and Public Health*, at http://www.ucsusa.org/cleanvehicles/trucks_and_buses/page.cfm?pageID=238 (accessed June 17, 2002) ("With mounting evidence that diesel exhaust poses major health hazards, reducing diesel pollution has become a public priority."). Ambient data is "sparse" but measurements in Los Angeles in the 1980s found "diesel emissions accounted for approximately 3% of the mass of total particulate matter and 7% of the mass of fine particles emitted into the atmosphere," results that accord with the EPA models. HEALTH EFFECTS INST., DIESEL EXHAUST: A CRITICAL ANALYSIS OF EMISSIONS, EXPOSURE, AND HEALTH EFFECTS 6 (1995).

167. See U.S. DEP'T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERV., ENVTL. HEALTH SERV., NAT'L AIR POLLUTION CONTROL ADMIN., CONTROL TECHNIQUES FOR CARBON MONOXIDE, NITROGEN OXIDE, AND HYDROCARBON EMISSIONS FROM MOBILE SOURCES 3-6 (1970) ("By comparison with the effort expended with respect to the gasoline engine, very little has been done regarding control of hydrocarbon, CO and NO_x emissions from diesel engines.").

168. See Ralph I. Larsen, *Motor Vehicle Emissions and Their Effects*, 77 PUB. HEALTH REP. 963, 968 (1962) (noting that automobiles are "far" from meeting California air quality standards, while "lean-fuel" engines, including diesels, "can meet both carbon monoxide and hydrocarbon standards"); see also MARTHA JOHNSON, IMPROVING MOTOR TRUCK SOCIAL, ENVIRONMENTAL, AND ECONOMIC UTILIZATION: A LITERATURE REVIEW 86 (1975) ("One of the major areas of research in recent years has been the search for alternative powerplants to replace the gasoline engine."); PHILIP S. MYERS, THE DIESEL ENGINE FOR TRUCK APPLICATION 4 (1975) (making only the brief note during a lecture surveying diesel engines that they must be "ecologically acceptable under the determined operating

a result, diesel emissions control standards and technology have lagged behind gasoline engine control standards and technology.¹⁶⁹ As total and per-engine emissions from gasoline engines declined due to control measures, the relative share of diesel engine emissions in total pollutant loadings has increased. The absolute and relative share of diesel engines in the marketplace also increased, prompting the *Los Angeles Times* to call it "one of the last great problems in complying with federal clean air mandates."¹⁷⁰

Reasons for the difference in treatment include diesel's small market share in the 1970s and the perception that diesel engines had fewer emissions problems than gasoline engines,¹⁷¹ which focused regulators' attentions elsewhere. Consequently, most scientific attention was focused on gasoline engine emissions, and relatively little was known about the science of diesel engine emissions into the 1970s.¹⁷² Even today the *Diesel*

conditions—it must not put out unacceptable exhaust emissions or noise while providing the performance demanded of it").

169. Sawyer & Johnson, *supra* note 106, at 69 ("Heavy-duty vehicle emission standards have lagged behind those for light-duty vehicles, both in time of introduction and stringency.").

170. See *Bravo for Diesel Emission Rules*, L.A. TIMES, Oct. 12, 1999, at B8; see also Sawyer and Johnson, *supra* note 106, at 66; MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at x ("Both the U.S. Environmental Protection Agency (EPA) and the California Air Resources Board predict that, because of reductions in NO_x emissions from other sources, the relative importance of NO_x emissions from heavy-duty vehicles will increase over the next decade."); Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines: Certification and Test Procedures, 41 Fed. Reg. 21,292 (May 24, 1976) ("As standards on light duty vehicles and light duty trucks are made more stringent, a larger portion of these pollutants will come from heavy duty vehicles."). In 1968 diesel emissions from all diesel motor vehicles were estimated to be 400,000 tons/year out of 32,000,000 tons/year of hydrocarbons (1.25%); 200,000 tons/year out of 100,100,000 tons/year of CO (0.2%); and 600,000 tons/year out of 20,700,000 tons/year of NO_x (2.89%). U.S. DEP'T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERVICE, ENVTL. HEALTH SERVICE, NAT'L AIR POLLUTION CONTROL ADMIN., CONTROL TECHNIQUES FOR CARBON MONOXIDE, NITROGEN OXIDE, AND HYDROCARBON EMISSIONS FROM MOBILE SOURCES 2-15, tbl. 2-3 (1970). By 1995, on road heavy duty diesel engines accounted for approximately one quarter of US mobile source NO_x emissions and one twelfth of total man-made emissions of NO_x. Sawyer et al., *supra* note 26, at 2174.

171. See, e.g., NAT'L AIR POLLUTION CONTROL ADMIN., U.S. DEP'T OF HEALTH, EDUC., AND WELFARE, CONTROL TECHNIQUES FOR CARBON MONOXIDE, NITROGEN OXIDE, AND HYDROCARBON EMISSIONS FROM MOBILE SOURCES 5-19 to 5-21 (1970) (reporting expert opinion that prospects for developing emissions control techniques for diesels were poor in most cases); Myers et al., *Engine Exhaust*, *supra* note 157, at 16 ("Generally, in well-designed diffusion combustion systems, . . . total hydrocarbon emissions are not a serious problem, at least relative to the spark-ignition engine."); CRANDALL ET AL., *supra* note 89, at 1 (noting that the distrust of automobile manufacturers that drove some of the regulatory agenda of the 1960s and 1970s may not have extended to the heavy-duty engine industry).

172. See Henein, *Combustion*, *supra* note 156, at 212 ("A review of the literature on transportation engine emissions shows that most of the work has been related to the spark-ignition (SI) engine in which a flame propagates in a homogeneous fuel-air mixture. Few studies have been directed to the mechanisms of emission formation in other systems, such as diesel engines and gas turbines, in which the mixture is heterogeneous."). "Most of the data related to [spray formation and droplet size distribution in] diesel engines was published about 35 years ago." *Id.* at 260. A review of testing procedures in 1979 noted

Engine Reference Book describes diesel combustion processes "still somewhat mysterious."¹⁷³ "Only in the late 1970s, when domestic and foreign motor vehicle manufacturers announced that they would be introducing diesel-powered passenger cars into the United States, did the research and regulatory communities become concerned about the carcinogenic potential of diesel exhaust"¹⁷⁴ and launch major research programs into the health effects of diesel exhausts.¹⁷⁵ Diesel emissions regulation is thus a relatively late development in Clean Air Act mobile source regulation.

B. Emissions Controls

Emissions controls for diesel engines were initially relatively primitive. For example, the odor of diesel engines has long been a problem,¹⁷⁶ but the EPA initially regulated only "soot" emissions.¹⁷⁷ Since the 1970s it has been known that engine conditions, including whether the engine is accelerating or decelerating, significantly affect diesel emissions.¹⁷⁸ This, coupled with customer demand for fuel efficiency,¹⁷⁹ led to the initial control of diesel emissions being done largely through changes in the combustion process rather than changes in the postcombustion techniques.¹⁸⁰ These combustion process controls were relatively

that much of the development of measurement techniques for SO_x and particulates developed during the mid-to-late 1970s as the result of the EPA-initiated research. See Harry E. Dietzmann & Frank M. Black, *Unregulated Emissions Measurement Methodology*, in THE MEASUREMENT AND CONTROL OF DIESEL PARTICULATE EMISSIONS, PART 2 165, 180 (1981).

173. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 91.

174. Nauss et al., *supra* note 121, at 16.

175. *Id.* The EPA's "first comprehensive review of the potential health effects from ambient exposure to exhaust from diesel engines" did not even reach draft form until mid-2000. See EPA, NAT'L CTR. FOR ENVTL. ASSESSMENT, OFFICE OF RESEARCH & DEV., EPA/600/8-90/057E, HEALTH ASSESSMENT FOR DIESEL EXHAUST 1-1 (draft July 2000).

176. See, e.g., Myers et al., *Engine Exhaust*, *supra* note 157, at 21 ("Ever since the first diesel engine was developed, the odor from its exhaust has been recognized as undesirable.").

177. See Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines, 33 Fed. Reg. 8306 (June 4, 1968) (establishing that hydrocarbon and CO standards for heavy-duty gasoline powered engines (Subpart D) differentiated from heavy-duty diesel exhaust emissions standards contained in Subpart E. "Attention on the visible sooty exhaust emissions, and their associated health risks, typically associated with diesel engines, led to the introduction of controls on smoke and particulates." DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 473.

178. See, e.g., Myers et al., *Engine Exhaust*, *supra* note 157, at 25 (describing emissions cycles for naturally aspirated and turbocharged diesel engines).

179. Market demand for fuel efficiency rose to 7-8 mpg in 1994, up from 5-6 mpg five years earlier. See DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 555 (comparing 1994 market demand of 7-8 miles per gallon to market demand of 5-6 miles per gallon five years earlier).

180. See Henein, *Combustion*, *supra* note 156, at 260; Sawyer & Johnson, *supra* note 106, at 73 ("emissions reductions to date have resulted from modifications to the combustion processes.").

inexpensive.¹⁸¹ By comparison, emissions control of gasoline engines was largely accomplished with post-combustion techniques, such as catalytic converters and fuel modifications, such as removing lead from gasoline. The more stringent diesel standards of the future will likely require new post-combustion techniques,¹⁸² and hence, new technologies.¹⁸³ These controls are more expensive. For example, lifetime costs for the pull-ahead MY 2004 engine standards, including fuel economy penalties caused by emissions controls, are estimated to be between \$3,000 and \$5,000.¹⁸⁴ Emissions control regulations now dominate engine manufacturers' decision making; in fact, one independent industry analyst concluded that "[i]t is redundant to say that almost every action taken by the diesel engine

181. Lawrence White estimated their cost at approximately \$500 per vehicle in 1981. See WHITE, *supra* note 43, at 65-66.

182. See Don Lang, *Suppliers Doubt They Can Meet 2007 Diesel Emission Standards*, TRANSPORT TOPICS 1, 11 (Dec. 18, 2000) (2007 standards cannot be met by changes to engine alone according to two engine manufacturers). Franz X. Moser, Theodor Sams and Wolfgang Cartellieri, *Impact of Future Exhaust Gas Emission Legislation on the Heavy Duty Truck Engine*, in DIESEL EXHAUST EMISSIONS CONTROL: DEVELOPMENTS IN REGULATION AND CATALYTIC SYSTEMS (SP-1581) 53 (2001) [hereinafter Moser et al., *Impact*] (mandated emissions reductions "cannot be achieved by internal engine measures alone"); Charles Schenk et al., *High-Efficiency NO_x and PM Exhaust Emission Control for Heavy-Duty On-Highway Diesel Engines—Part Two* in DIESEL EMISSION CONTROL SYSTEMS (SP-1641) 39 (2001) [hereinafter Schenk et al., *High-Efficiency*] (MY 2007 standards "will likely require highly efficient catalysts and other exhaust emission controls that can provide an order of magnitude reduction in diesel emissions beyond the 2004 emissions standards"); P. Zelenka et al., *Clean*, *supra* note 92, at 9 (discussing need for aftertreatment of exhausts); see also *Diesel Technology for the 21st Century I*, Hearing Before the Subcomm. on Energy & Env't of the House Comm. on Science, 105th Cong., 14 (1998) (testimony of John C. Wall, Cummins Engine Company, Inc.) ("We're working on two fronts to try to reduce emissions. One is working on combustion development The second is after-treatment technology, where we process the exhaust after the combustion process with essentially chemical plants, if you will, in the exhaust system."); Sawyer et al., *supra* note 26, at 2169 ("[N]ew after treatment systems will likely be required" to meet new standards.)

183. See José M. Desantes et al., *Influence of the EGR Rate, Oxygen Concentration and Equivalent Fuel/Air Ratio on the Combustion Behaviour and Pollutant Emissions of a Heavy-Duty Diesel Engine*, in COMBUSTION IN DIESEL AND SI ENGINES (SP-1549) 51 (2000) ("To meet these future emission standards, the introduction of new technologies seems to be mandatory, considering that specific fuel consumption must, at least, be kept at current levels, if not improved."); Schenk et al., *High-Efficiency*, *supra* note 182, at 39 (stating that MY 2007 standards "will likely require highly efficient catalysts and other exhaust emission controls that can provide an order of magnitude reduction in diesel emissions beyond the 2004 emissions standard"); Zelenka et al., *Clean*, *supra* note 92, at 6 ("It is obvious that current fuel systems cannot fulfil the ideal requirements. Herein new systems are needed. Further reductions in NO_x-emission standards may well force the development of new injection systems with rate shaping techniques"); Walsh, *Global Trends*, *supra* note 166, at 10 (indicating that the MY 2007 particulate standard "is projected to require the addition of highly efficient PM traps to diesel engines;" NO_x standard "is projected to require the addition of a highly efficient NO_x emission control system to diesel engines"). The EPA acknowledged that new technologies will be needed to meet the NO_x standard in its proposal: "our proposed NO_x standard represents an ambitious target for this technology." 65 Fed. Reg. 35,430, 35,435 (June 2, 2000).

184. See David Cullen, *The '02 Engine Decision: High Stakes at Risk*, FLEET OWNER, April 2002, at 20-21.

manufacturer is related to or governed by emissions issues.”¹⁸⁵

Because of the importance of combustion techniques in controlling diesel emissions,¹⁸⁶ the development of engine controls has been, and will continue to be, critical to the ability to improve emissions control.¹⁸⁷ Electronic engine controls created an entirely new level of ability to control combustion in both diesel and gasoline engines and eventually did so relatively inexpensively.¹⁸⁸ As microprocessor costs fell, the use of electronic controls became viable in more vehicles.¹⁸⁹ “Since the first

185. RHEIN ASSOCS., INC., *THE FUTURE OF DIESEL ENGINES* 16 (5th ed., 2002) [hereinafter RHEIN, 5TH EDITION]. Rhein continued to consider this to be true, repeating the statement in the November 2003 edition of its report. RHEIN ASSOCS., INC., *THE FUTURE OF DIESEL ENGINES* 16 (7th ed., Nov. 2003) [hereinafter RHEIN, 7TH EDITION].

186. See Steve Sturgess, *On-Highway Emissions Drive New Intros*, CONSTRUCTION EQUIPMENT, Apr. 1994, at 26, 27, stating that to achieve emissions reductions:

[E]xtremely sensitive fuel controls have been developed along with internal engine hardware changes. Fortunately, the adoption of more-accurate fuel control, made possible in part through the use of electronics, addresses many of the areas that cause NO_x and particulates while positively impacting fuel economy. Hence the widespread adoption of on-engine electronics for 1994.

187. Moser et al., *Impact*, *supra* note 182, at 53 (noting that “sophisticated electronic control strategies will be required” to meet future emissions requirements). “The electronic fuel system control offers the well known freedom to minimize the various trade-offs (HC-NO_x-Particulates-BSFC) as a function of speed, load and ambient conditions in steady state and in transient operation. For the latter, the control of fuel metering and injection timing during cold starting, warming-up, acceleration (load pick-up), and at altitude operations will be a necessity for the clean diesel engine.” Zelenka et al., *Clean*, *supra* note 92, at 5. Ruud Verbeek et al., *DAF Euro-4 Heavy Duty Diesel Engine with TNO EGR System and CRT Particulates Filter*, in *DIESEL EMISSIONS TECHNOLOGY* (SP-1626) 89, 91 (2001) (“The control of EGR during transients is very important, because it affects NO_x and PM emission and driveability. For example, if EGR is continuously enabled during a step-load (0 to 100% torque), the NO_x emission will be very low, however the PM emission will dramatically increase and/or the torque response will deteriorate. Therefore EGR needs to be disabled during these kinds of transients.”); Sturgess, *supra* note 186, at 27 (“Adoption of electronic controls has meant more accurate injection. Timing and duration are now varied to tailor the engines’ performance and economy characteristics.”); Bowman, *EPA Off*, *supra* note 36, Appendix J (noting “an electronic timing control system can significantly improve on the NO_x/particulate and NO_x/fuel economy trade-offs possible with static or mechanically variable injection timing”); IPCS, *CRITERIA* 171, *supra* note 57, at 92 (stating that “adjustment of the engine plays a major role” in determining exhaust emissions); Sawyer & Johnson, *supra* note 106, at 76 (“Electronic fuel system control is also necessary for minimizing trade-offs among hydrocarbons, NO_x, the solids or carbonaceous fraction, and fuel consumption as a function of speed, load, and ambient conditions.”); Motor Vehicle Nitrogen Oxides Standard Committee, *supra* note 64, at 24 (technical experts “reported improvements in [the 10 to 15%] range when the latest generation of mechanical controls were replaced by electronic systems”); WILEY, *ENGINEERING*, *supra* note 120, at 362 (“The modern critical needs for fuel economy and environmental compliance have led to increasing sophisticated governor systems being developed.”).

188. See *Detroit Finally Wakes Up to Electronics*, BUS. WK., Oct. 11, 1976, at 90 (quoting Chrysler engineer that “[n]o matter how we calculate the cost of various engine control schemes, the lowest-priced system uses a microprocessor”).

189. See *id.* at 91-92 (noting that it was cost that delayed introduction of microprocessors); *Detroit’s New Appetite for Electronic Controls*, BUS. WK., Aug. 29, 1977, at 65 (noting that microprocessor in 1977 was a “costly addition to a product where costs are calculated to fractions of a cent” and where microprocessors added up to \$400 to a car’s cost).

introduction of fully controlled electronic engines in 1983, the changes in engine control . . . have been revolutionary."¹⁹⁰ The EPA endorsed this view of electronic controls as critical to emissions control in a 1981 technical review: "In short, the field of electronic controls—which have already revolutionized the light-duty fleet and which will certainly be carried over into the heavy-duty gasoline engine fleet is a control strategy which the EPA believes will permit significant NO_x reductions to be realized at minimum [fuel economy] penalty."¹⁹¹ Similarly, two California air quality regulators concluded in 2001 that "[e]lectronic computer control has also improved emissions."¹⁹²

These controls, which developed in response to emissions controls,¹⁹³ allowed for the first time variations in a number of engine parameters to meet performance criteria, such as emissions standards or maximizing fuel economy.¹⁹⁴ Engine manufacturers tout these controls as allowing manufacturers to "tailor the performance of [their] engines to the individual needs of their customers"¹⁹⁵ and to prevent sacrificing fuel economy to meeting more stringent emissions standards.¹⁹⁶ Controllers can save

190. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 556.

191. EPA OFFICE OF MOBILE SOURCE AIR POLLUTION CONTROL, REGULATORY ANALYSIS, ENVIRONMENTAL IMPACT STATEMENT, AND NO_x POLLUTANT SPECIFIC STUDY FOR PROPOSED GASEOUS EMISSION REGULATIONS FOR 1985 AND LATER MODEL YEAR LIGHT-DUTY TRUCKS AND 1986 AND LATER MODEL YEAR HEAVY-DUTY ENGINES 76 (1981).

192. Lloyd & Cackette, *supra* note 26, at 827.

193. Jim Mele, *Integrating Vehicle Electronics: Plugging into the Network*, 92 FLEET OWNER 60, 62 (1997) ("Pushed by emissions requirements, engine makers were the first to develop sophisticated electronic controls for heavy trucks . . ."); *Detroit Finally Wakes Up to Electronics*, BUS. WK., Oct. 11, 1976, 91 (noting that electronic controls in cars developed in response to emissions regulations).

194. *See, e.g.*, Frank Najlepszy, *Dynamic Diesels*, MACHINE DESIGN, Oct. 22, 1998, at 1, 3 (describing Cummins' Signature 600 engine as "designed around and for electronic controls" that "monitors and controls the fuel, air and combustion subsystems for each individual cylinder . . ."); DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 555 (stating that engine manufacturers have met demand for fuel economy "mainly through the use of electronic controls, advanced materials, and innovative design approaches, coupled with more aerodynamic vehicles and matching the entire driveline for a given set of operating requirements"); Michael P. Walsh & Ron Bradow, *Diesel Particulate Control Around the World*, in SAE International Congress & Exposition, GLOBAL DEVELOPMENTS IN DIESEL PARTICULATE CONTROL 1, 10 (1991) ("The advent of computerized electronic engine control systems has greatly increased the potential flexibility and precision of fuel metering and injection timing controls. In addition, it has made possible whole new classes of control functions, such as road speed governing, alterations in control strategy during transients, synchronous idle speed control, and adaptive learning—including strategies to identify and compensate for the effects of wear and component to component variation in the fuel injection system.").

195. *See, e.g.*, CUMMINS 1997 ANNUAL REPORT: SHAREHOLDERS LETTER at 5 (copy on file with authors); *see also* George L. Snyder, *Engine Makers Push for More Efficiency*, FLEET OWNER, Sept. 1987, at 104, 108 (discussing that engine controllers allow manufacturers to optimize engine for power, fuel economy, or faster response).

196. *See, e.g.*, MICHAEL E. MONCELLE & G. CLARK FORTUNE, SAE TECHNICAL PAPER SERIES 850,173, CATERPILLAR 3406 PEEC (PROGRAMABLE ELECTRONIC ENGINE CONTROL) 10 (1985) (stating that a 4.7% decline in fuel economy happens under more stringent California standard with mechanical controller; fuel economy penalty "can be significantly

“thousands of dollars per truck in fuel costs a year.”¹⁹⁷ By allowing upgrades to in-use engines, existing engines can easily be made to run cleaner if new engine settings were found that improved emissions control.¹⁹⁸

Engine controls can now engage in adaptive learning to optimize performance, further complicating regulatory measures that rely on fixed performance criteria.¹⁹⁹ Electronic controls also complicate emissions predictions²⁰⁰ and make far greater demands on emissions testing²⁰¹ because they enable the engine to operate quite differently depending on conditions, leading to large differences in emissions under different operating conditions. With the evolution of electronic engine controls came the concern that the controls might be too sophisticated for existing emissions test cycles.²⁰² A 1993 Organisation for Economic Co-operation and Development (OECD) report, for example, noted that it was now possible

for a manufacturer to formally meet the legal requirements and at the same time circumvent these for engine conditions that are not prevalent in the cycle. Traditionally with gasoline and diesel vehicles this was of little concern, since the relatively crude means to adapt engine settings

reduced” by electronic controller).

197. See William B. Cassidy, *Electronic Engines Get High Marks*, FLEET OWNER, Aug. 1988, at 68.

198. See *Cat Tackles Emissions*, FLEET OWNER, August. 2001 (“Cat also announced new electronic calibrations that it said will cut NO_x levels by as much as 7% on most 1993-1998 Cat midrange and heavy-duty truck engines. ‘The new calibrations will greatly reduce NO_x emissions from in-service engines,’ said [Caterpillar marketing manager David] Semlow, ‘but will in no way affect performance, reliability or fuel economy.’ He said all that is required is a simple recalibration that can be performed at any Cat authorized dealer.”); Jim Mele, *The First Look at 1991 Engines*, FLEET OWNER, Nov. 1989, at 76, 79 (noting Detroit Diesel electronic controllers could be reprogrammed to meet MY 1991 emissions standards and drivers will be unable to tell the difference).

199. See Sawyer et al., *supra* note 26, at 2164 (explaining the adaptive learning process).

200. See Clark et al., *Factors Affecting*, *supra* note 62, at 94 (“Timing variations in electronically controlled diesel engines present the single greatest obstacle to present-day mobile source emissions inventory prediction.”).

201. See Bowman, *EPA Off*, *supra* note 36, at app. J (“A potential drawback of the increasing use of electronic controls is the demand that it places on the emissions test procedure [because it could be programmed to recognize test cycles] The earlier mechanical controls were incapable of such sophisticated control strategies.”).

202. Not surprisingly, given that the federal test procedures (FTPs) specified exact conditions under which engines would be tested, the EPA sometimes had to revise procedures to account for emissions from conditions not being tested. For example, in its 1995 support document for the revised test standard for light duty vehicles, the EPA noted that particular types of driving previously not tested had been discovered to be the source of higher emissions. “One possible explanation of these emission increases is that the engines were not calibrated for emission control during the higher engine loads associated with aggressive driving, as these loads are not encountered during current FTP testing.” EPA, OFFICE OF AIR & RADIATION, OFFICE OF MOBILE SOURCES, CERTIFICATION DIVISION, SUPPORT DOCUMENT TO THE PROPOSED REGULATIONS FOR REVISIONS TO THE FEDERAL TEST PROCEDURE: DETAILED DISCUSSION AND ANALYSIS app. J. (1995) (copy on file with authors).

(e.g. injection timing) to engine conditions (e.g. load) did not allow for this. With the advent of electronic engine controls, however, engine manufacturers can make their engine control strategies almost arbitrarily complex. A test procedure which measures only at a limited number of specific operating conditions, or which concentrates in selected areas of the operating range, makes it easy for a manufacturer to optimize for emissions only in the conditions being tested. For example, in a steady-state test, a manufacturer could optimize for emission in the speed/load plane around each test point, while in the remainder of the speed/load plane optimizing for fuel economy and performance instead.²⁰³

The diesel engine development story is thus quite straightforward: Emissions controls developed in response to technology-forcing mandates from the EPA. The natural avenue for diesel engine emissions regulation was increasing the efficiency of combustion rather than changing the post-combustion treatment of exhaust or the composition of diesel fuel. Developing sophisticated electronic engine controls was thus the natural outcome of the EPA's technology-forcing mobile source regulations.

Much as the space program also produced spin-off benefits like Tang,[®] a byproduct of the technology needed to meet emissions standards the engine controllers allowed engine manufacturers to also improve engine performance in customer-demanded characteristics such as fuel economy. Because of the structure of test procedures, engines could simultaneously satisfy the EPA's test requirements and customers' demands for fuel economy by minimizing emissions during test cycle conditions and maximizing mileage at other times. This result was the natural outcome of the structure of the EPA's regulations and market forces. Indeed, any engine manufacturer that had not adopted such a strategy would have suffered market share losses as customers would have chosen competitors' more desirable engines. Our analysis is thus not merely hindsight, and, as the 1993 OECD report quoted above indicates, it is consistent with contemporaneous analyses.

C. Tradeoffs in Controls

Because there are tradeoffs between control of different pollutants, increasing controls on one may increase emissions of another. For example, one early study found that earlier injection of fuel in the combustion cycle reduced smoke exhaust but increased NO_x emissions, while retarding injection timing reduced NO_x but increased unburned hydrocarbons.²⁰⁴ Similarly, exhaust gas recirculation (EGR) systems²⁰⁵ can

203. Bowman, *EPA Off*, *supra* note 36, at 5 app. J.

204. See Henein, *Combustion*, *supra* note 156, at 255-56; see also Reitze, *Mobile Source*, *supra* note 56, at 324 ("[T]he deliberate detuning of an engine, such as occurs when the spark timing is retarded, results in reduced NO_x, although HC and CO can rise . . . using

reduce NO_x emissions, but may increase soot and CO emissions.²⁰⁶ EGR systems can also potentially shorten engine life²⁰⁷—the catalysts needed to regenerate filters for nanoparticles oxidize SO₂ to form sulfates, often resulting in more soot in engine oil.²⁰⁸ The *Diesel Engine Reference Book* even refers to a “natural tradeoff between particulate emissions and NO_x” as “one of the critical challenges in the design of diesel combustion

engine modifications to control NO_x usually increases HC and CO emissions which are then subject to cleanup using post-combustion controls such as catalytic converters.”); DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 93 (noting that soot can be reduced by higher injection pressure but that it will produce more NO_x); MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 75 (“Hydrocarbons interact with sunlight and NO₂ to form oxidants, which in general produce the same kinds of lung damage as NO₂. Hence, a rise in hydrocarbon emissions tends to vitiate the health benefits of reduced NO_x emissions.”). Similarly, using super high pressure injection systems can reduce soot, but increase NO_x. See Hajime Fujimoto et al., *New Concept on Lower Exhaust Emission of Diesel Engine*, in DIESEL ENGINE COMBUSTION AND EMISSIONS FROM FUEL TO EXHAUST AFTERTREATMENT (SP-1113) 65, 65 (1995). Timing changes to reduce particulates can increase NO_x. See Clark, et al., *Factors Affecting*, *supra* note 62, at 92; Kashmir S. Virk & Donald R. Lachowicz, *Testing of Diesel Fuels for Their Effects on Exhaust Emissions and Engine Performance*, in EMISSION PROCESSES AND CONTROL TECHNOLOGIES IN DIESEL ENGINES (SP-1119) 169, 169 (1995) (“[I]n general, NO_x emissions increase and particulates decrease when injection timing is advanced.”); see also CARCINOGENIC AND MUTAGENIC EFFECTS OF DIESEL ENGINE EXHAUST 506 (Norburu Ishinishi et al, eds., 1986) (“[T]he countermeasures against NO_x and the countermeasures against HC and soot are in the relationship of a tradeoff, which makes it very difficult to simultaneously reduce the two different substances.”).

The EPA recognized these tradeoffs in settling the diesel litigation. See EPA, Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments 13, *United States v. Caterpillar, Inc.*, Civil Action 1:98CV02544 (Apr. 30, 1999) (“While it is feasible to program new engines with modified fuel injection timing that lowers NO_x emissions, doing so likely would have significant collateral consequences. These include increased engine overheating and decreased engine life due to sooting, excessive engine wear, decreased fuel economy, and the need for changes to the truck chassis to deal with these changes in engine operation.”).

205. See Sawyer, et al., *supra* note 26, at 2164 (noting that in EGR systems, “[t]he exhaust-gas recirculation (EGR) system directs a small fraction of the exhaust back into the engine to dilute the intake charge and reduce peak combustion temperature, hence reducing the engine-out NO_x”).

206. See Desantes et al., *supra* note 183, at 58 (“EGR increase reduces NO_x emissions in a linear fashion, but increases Soot emissions, CO emissions, and [brake specific fuel consumption].”); see also C. Arcoumanis and A. Nagwaney, *Effect of EGR on Spray Development, Combustion and Emissions in a 1.9L Direct-Injection Diesel Engine*, in EMISSION PROCESSES AND CONTROL TECHNOLOGIES IN DIESEL ENGINES (SP-1119) 99, 116 (1995) (discussing tradeoffs between NO_x and soot, CO, CO₂, and HC emissions).

207. See Zelenka et al., *Clean*, *supra* note 92, at 12 (“There is some concern about increased wear rate when introducing EGR on heavy-duty diesel engines.”); see also Arcoumanis and Nagwaney, *supra* note 206, at 99 (“There are limits to the amount of exhaust gas that can be reintroduced into the engine before power output and fuel economy are adversely affected. There are also questions about the wear implications of the recirculated soot particles.”).

208. See Johnson, *Review*, *supra* note 106, at 26; see also Mike Brezonick, *Centrifugal Filters Target Heavy-Duty Mobile Equipment Applications*, 64(6) DIESEL PROGRESS NORTH AMERICAN EDITION 18, 20 (1998) (quoting Dominic Jephcott of Federal-Mogul Oil Conditioning Systems, that “[w]ith the emissions regulations, there can be much more soot going into the [engine] oil”).

systems.”²⁰⁹ Another example is that the engine timings²¹⁰ and fuel characteristics²¹¹ necessary to minimize NO_x are different from those needed to minimize particulates. Regulators and manufacturers thus face important tradeoffs among pollutants and regulatory standards.²¹² Indeed, the 1977 Clean Air Act Amendments recognized these tradeoffs among pollutants, altering the requirements for California’s waiver of federal standards to allow the state to swap NO_x control for CO control.²¹³ Taking these tradeoffs into account is important, as “[m]ost trade-off curves are approximately hyperbolic in shape, so that the first increment of control produces only small degradation of performance while later increments cause accelerating degradation of performance.”²¹⁴ Progressive tightening of diesel emissions standards, as the EPA has done over the last 30 years with NO_x,²¹⁵ will eventually move tradeoffs onto the less favorable portion of the curve where large increases of other pollutants are the price to pay for small increases in NO_x control.

Emissions control also requires tradeoffs across different engine designs and operating modes. For example, quiescent combustion systems, used in marine diesel engines, are being investigated for use in heavy-duty trucks. These engines offer an attractive combination of fuel economy and low emissions under heavy loads and at high speed, but at lower speeds and partial loads they increase NO_x emissions and noise levels.²¹⁶ Similarly, some filter-based approaches require regular regeneration cycles that produce temporarily increased emissions.²¹⁷ Particular control measures may also affect other parts of the industry—some control technologies, for

209. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 93. See also Nauss et al., *supra* note 121, at 24 (“One of the problems with controlling diesel emissions is the tradeoff between emissions of particulate matter and emissions of oxides of nitrogen.”).

210. Virk and Lachowicz, *supra* note 204, at 170.

211. *Id.* at 177 (stating that higher cetane numbers lower NO_x but raise particulate emissions under high load conditions). “The cetane number determines the ignition performance of transport fuels” based on a relative scale. IPCS, CRITERIA 171, *supra* note 57, at 19.

212. Auto makers are considering expanding diesel use in light duty vehicles to meet the Corporate Average Fuel Economy (CAFE) standards imposed upon them by Congress. See Richard Truett, *Redoing the Diesel*, 75 AUTOMOTIVE NEWS 2i, 2i (2001) (“Because diesels typically deliver 25 percent to 35 percent greater fuel economy than a similar-sized gasoline engine, automakers view diesels as a way to boost their Corporate Average Fuel Economy figures.”).

213. ENVTL. LAW INST., 2 LAW OF ENVIRONMENTAL PROTECTION § 11.07[2] at 11-189 (2001).

214. MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 23.

215. See *infra* notes 311-365 and accompanying text (describing tightening of standards).

216. Kazutoshi Mori et al., *New Quiescent Combustion System for Heavy-Duty Diesel Engines to Overcome Exhaust Emissions and Fuel Consumption Trade-off*, in COMBUSTION IN DIESEL AND SI ENGINES (SP-1549) 39 (2000).

217. Verbeek et al., *supra* note 187, at 96.

example, depend on significantly reducing sulfur in diesel fuel²¹⁸ and many measures for reducing emissions require redesigning engine oils.²¹⁹ Indeed, engine makers cannot design their emissions control systems without knowing the sulfur content of the fuel to be burned.²²⁰

218. Zelenka et al., *Clean*, *supra* note 92, at 13 (“The oxidation catalyst concept is only feasible if low-sulfur fuel will be available in due time.”); Johnson, *Review*, *supra* note 106, at 26 (“Perhaps the best solution [to nanoparticles] is to reduce sulfur in the fuel and lubrication oils as much as feasible.”); *id.* at 33 (indicating that NO_x control systems require ultralow sulfur fuel or particulate emissions increase); IPCS, CRITERIA 171, *supra* note 57, at 93 (“Catalytic converters require fuels with low sulfur content, as sulfur poisons the active centres of the catalyst.”). The EPA has required significant reductions in diesel fuel sulfur content by 2006 and 2010. See Walsh, *Global Trends*, *supra* note 166, at 9. See 66 Fed.Reg. 5002 (Jan. 18, 2001) (“These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies. Because these devices are damaged by sulfur, we are also reducing the level of sulfur in highway diesel fuel significantly by mid-2006.”). These regulations are currently being challenged in court. *Major Mobile Source Issues of 2002*, BNA’S ENVIRONMENT REPORTER, Jan. 25, 2002. For an overview of fuel regulation and mobile sources, see generally Arnold W. Reitze, Jr., *The Regulation of Fuels and Fuel Additives Under Section 211 of the Clean Air Act*, 29 TULSA L.J. 485 (1994).

These regulations have been justified, in part, by the EPA’s prediction that the new technologies that will develop to meet the higher standards will require low sulfur diesel fuel to prevent sulfur from damaging the pollution control equipment. REGULATORY STUDIES PROGRAM, MERCATUS CENTER, GEORGE MASON UNIVERSITY, PUBLIC INTEREST COMMENTS EPA HEAVY-DUTY ENGINE AND DIESEL RULE SUBMITTED TO ENVIRONMENTAL PROTECTION AGENCY 4 (2000) [hereinafter RSP, HEAVY-DUTY]. Fuel changes are, however, particularly costly means of improving diesel emissions control. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 93 (indicating that because the cost of the fuel burned by a typical diesel engine significantly exceeds the cost of the engine, it is more cost effective to invest in engine technology than in all but the most inexpensive fuel changes). *Diesel Technology for the 21st Century*, Hearing Before the Subcomm. on Energy and Environment of the Committee on Science, 105th Congress 23,24 (Testimony of Ronald J. Robinson, Texaco) (stating that improvements in emissions controls directly from fuel changes are unlikely). Moreover, the impact of fuel changes may be dependent on the test procedure used to measure them. One study found that reducing sulfur content hardly affects emissions in a light-duty engine under the European test procedure but does affect it under the US procedure. See R.H. Hammerle et al., *Emissions from Diesel Vehicles with and without Lean NO_x and Oxidation Catalysts and Particulate Traps*, in EMISSION PROCESSES AND CONTROL TECHNOLOGIES IN DIESEL ENGINES (SP- 1119) 197, 199-201 (1995).

219. Engine oil is a good example of the complexity of changes required by increased emissions control. Consider the following description from Lubrizol, an engine oil manufacturer, of the consequences of other changes in heavy-duty engines to reduce emissions:

While design changes are helping to reduce emissions, the lubricants—which must protect the engine first and foremost—are subjected to even greater stresses. These include a more hostile combustion environment and higher operating temperatures and pressures. Greatly reduced oil consumption will mean that the lubricant must reside in the ring zone longer with consequent greater thermal exposure. Reduced engine oil top-up will mean less additive replenishment via the new-fill oil compared to engines in the past. The changes made for combustion management to reduce NO_x (nitrogen oxide) emissions are reported to increase the amount of soot and combustion byproducts introduced into the lubricant, which will affect lubricant performance demands.

P.M. Lewinsky, *Exhaust Emissions Challenge Heavy Duty Engine Oil Formulators*, THE OIL DAILY, Jan. 28, 1991 at B6; see also *Emissions Will Stress Lubes*, 96 FLEET OWNER 44, 44 (2001).

220. See John Wislocki, *Bush Team Reopens Diesel Sulfur Rule*, TRANSPORT TOPICS,

Changes in one aspect of emissions controls can have far-reaching impacts on other pollution problems. For example, significantly lowering sulfur content in diesel fuel has implications for the pipeline system used to transport various fuels, since low sulfur fuel could be contaminated through contact with higher-sulfur fuels or residues left in the pipeline.²²¹ Moreover, requiring equipment that demands extremely low sulfur fuel has national implications, even if only some regions are not in attainment for the pollutant to be controlled by the equipment,²²² since the low sulfur fuel will have to be sold exclusively nationally to avoid fouling equipment needed inside the nonattainment areas when it is refueled outside the nonattainment areas.

There are also tradeoffs between engine types, with diesel engines offering some environmental advantages over gasoline engines because of their greater fuel efficiency.²²³ Had the United States ratified the Kyoto Treaty, for example, increased use of diesel engines to reduce CO₂ emissions would likely have resulted.²²⁴ Improving fuel efficiency can also adversely affect pollution control measures.²²⁵ For existing heavy-duty trucking diesels there is a general tradeoff between fuel economy and emissions, with greater emissions control reducing fuel economy.²²⁶ Of

Jan. 29, 2001, at 1, 33.

221. RSP, HEAVY-DUTY, *supra* note 218, at 17-18.

222. *Id.* at 5. The comment notes that 44 of 50 states have no areas failing to meet the particulate standard, making particulates “a regional, rather than a national problem” and that AEPAs’s “modeling predicts that more than half of the total population [Band most Americans living west of the Mississippi River B] will live in ozone attainment areas for the foreseeable future under existing programs,” making NO_x control a regional issue as well. *Id.* at 8-9. The EPA does not necessarily consider reducing emissions in attainment areas an unnecessary cost. For example, in comparing a regulatory strategy of requiring “Stage II” refueling emissions controls on gasoline pumps in nonattainment areas with one of requiring such controls on all automobiles, the EPA considered their impact in attainment areas to be a benefit rather than an unnecessary cost. GEN. ACCT. OFF., EPA’S EFFORTS TO CONTROL VEHICLE REFUELING AND EVAPORATIVE EMISSIONS 21 (1987).

223. Zelenka et al., *Clean*, *supra* note 92, at 11 (“[T]he diesel principle is by far the best choice to minimize CO₂-emissions.”); Nauss et al., *supra* note 121, at 14 (“[D]iesel engines emit approximately 10% to 25% less carbon dioxide than gasoline engines, an important factor when considering global warming trends.”). *But see* Walsh, *Global Trends*, *supra* note 166, at 1-2 (“Even the potential global warming benefits of diesel vehicles, due to their substantial fuel economy benefits relative to gasoline fueled vehicles, have been undercut by recent studies, which indicate that diesel particles may by reducing cloud cover and rainfall, more than offset any CO₂ advantage.”).

224. *See* RHEIN, 5TH EDITION, *supra* note 185, at 26.

225. *See* Johnson, *Review*, *supra* note 106, at 27 (stating that “heavy-duty diesel exhaust temperatures usually are hot enough in normal driving conditions to oxidize the soot without active regeneration in modern filters. However, heavy-duty diesel exhaust temperatures are decreasing as the engine efficiency increases, so active regeneration strategies” may be needed in the future).

226. *See, e.g.*, DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 91 (discussing that “[t]he two principal driving forces behind modern diesel engine design are the desire for lower exhaust emissions and improved fuel economy. These goals, often conflicting”); *see also* Mori et al., *supra* note 216, at 39 (discussing fuel economy-emissions tradeoff); *see also* Moser et al., *Impact*, *supra* note 182, at 53 (stating that “[w]ithout a technological

course, some improvements may not require tradeoffs,²²⁷ the point is merely that heavy-duty diesel trucks are complex systems in which any change may have significant consequences for other parts of the system.

Finally, there are tradeoffs with unrelated regulatory measures. For example, prior to interstate trucking deregulation, there were more "empty backhaul" trips by trucks, increasing fuel used and thus emissions. Using 1987 data, empty backhaul trips accounted for 18-21 percent of fuel used; some estimates are that deregulation reduced this to 13-15 percent of fuel used by 1995.²²⁸

The existence of these tradeoffs is important for several reasons. First, it suggests that making the tradeoffs through a regulatory agency is likely to cause the choices to diverge from those that would result from the consumer-choice tradeoff. Thus, the EPA may opt for less fuel economy and more emissions control, more NO_x control and less CO control,²²⁹ or a more maintenance-intensive form of emissions control than engine consumers would in the absence of regulatory controls.²³⁰ Indeed, if the EPA does not expect its choice to be different from market outcomes, there is no reason for the EPA, rather than consumers, to make the choice at all. This tradeoff has occurred. In a review of diesel emission issues, two California regulators concluded that "some fuel combustion efficiency has been traded for lower emissions to attain standards."²³¹ Justifying shifting the choice from consumers to the EPA therefore requires identification of a

breakthrough the required drastic NO_x reduction will deteriorate fuel economy and increase engine cost considerably"); see also IPCS, CRITERIA 171, *supra* note 57, at 19 (finding that there is also a tradeoff in fuel design, with higher density fuels providing more engine power output but also increasing particulate emissions).

227. See, e.g., Sturgess, *supra* note 186, at 27 ("Past emissions strategies found that improved fuel control to manage particulates and NO_x resulted in better combustion—and an overall increase in economy.").

228. See Duleep, *supra* note 30, at 190.

229. The EPA's choices differ significantly from those of regulators in other countries. For example, in the 1990s Japan required 50% more stringent CO controls but allowed more than 100% more hydrocarbon emissions and seven times as much particulate emissions. See IPCS, CRITERIA 171, *supra* note 57, at 134, tbl. 30.

230. See WILEY, ENGINEERING, *supra* note 120, at 364 (John G. Webster ed., 1999) discussing that maintenance is critical to operation of emissions controls:

Although great efforts are being made to produce more environmentally friendly diesel fuels and lubricants, better engine designs and emissions control equipment, these measures by themselves will not ensure perpetual environmental compliance throughout the operational life of an engine. Operational vigilance is most important, including planned maintenance, inspection and emission monitoring, and the enforcement of good working practices.

Maintenance of both the emissions control systems and the engine can have a significant impact on emissions. *Id.* See also IPCS, CRITERIA 171, *supra* note 57, at 127 (finding that "up to twofold increases in emissions of carbon monoxide, hydrocarbons, and particulate matter have been measured even in the absence of a significant effect on power or fuel consumption . . . Malfunction of the fuel injection system may contribute markedly to higher emissions").

231. See Lloyd & Cackette, *supra* note 26, at 827.

market failure.²³²

Second, the market failure cannot be identified solely by noting the difference between the EPA's and the customers' choices²³³ since each tradeoff presents its own advantages in terms of emissions control. Consumer preferences for fuel economy, and hence lower CO emissions, control CO at the expense of NO_x, for example.²³⁴ A preference for CO control over NO_x control reflects a different balance in emissions control, not a simplistic choice between "clean" and "dirty" engines. An individual primarily concerned about global warming would likely prefer higher NO_x emissions to higher CO emissions in many instances, for example, while an individual concerned most with urban human health issues would prefer the reverse.²³⁵

Third, to the extent possible, engine manufacturers "move last" in the design of engines, i.e., they make choices about engine design after the EPA has announced regulatory requirements. Because customers demand choices the EPA attempts to prohibit, market pressures will lead engine manufacturers to emphasize the features customers desire at the expense of those that the EPA desires.²³⁶ For example, "[o]ne of the most commonly

232. See RSP, NONROAD, *supra* note 52, at 7 (discussing issue, in the context of other regulations: "Without market failure, competition would ensure that over the long term all energy/maintenance savings—that do not require customers to sacrifice an equal or greater reduction in the value of other desired attributes (e.g., reliability, safety, acceleration, comfort, durability, and so forth) would flow through to customers").

233. See *id.* at 7 (discussing issue, in context of other regulations, noting: "energy/maintenance savings [flowing from mandated technology] estimated by the EPA may actually represent money that consumers want to pay to obtain other desirable vehicle attributes such as safety, acceleration, durability, and so forth"); see also DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 555 (finding that "[m]arket demands for heavy-duty diesel engines used in trucks and buses include: size, weight, cost, durability, reliability, performance and fuel economy, gaseous and noise emissions, and amenities such as electronic controls and features").

234. See Bruce R. Judd, *Decision Analysis of Auto Emissions Control*, 11 SOC. ECON. PLAN. SCI. 123 (1977) (noting that consumers never selected the EPA's emission control strategy regardless of cost and always preferred an alternative approach).

235. See Lloyd & Cackette, *supra* note 26, at 839 ("In the United States, increased diesel penetration has been proposed as one way to reduce CO₂ emissions and associated global climate change impacts from the transportation sector."). However, particulate emissions may offset this benefit, as diesel particulates may modify cloud cover and increase rainfall, and thus alter the earth's albedo and offset at least some of the improvement in CO emissions. See *id.* at 823.

236. See *Diesel Technology for the 21st Century: Hearing Before the Subcomm. on Energy and Env't of the House Comm. on Science*, 105th Cong. 45 (1998) (explaining that customers do not yet buy diesel "for low emissions yet; they buy it for better fuel economy, they buy it because of better durability, better performance"). There are other tradeoffs to be made in designing engines:

In designing a heavy-duty diesel, the picture becomes complicated by the question of—what customer does one design the engine/truck package for? An owner-operator may be willing to compromise on fuel economy in return for higher performance and better passing and hill-climbing ability, while the owner of a fleet of 50 or 100 trucks, with an annual fuel bill in the hundreds of thousands of dollars, is likely to be much less concerned with saving a few minutes of trip time than with

used approaches for setting injection timing for a diesel engine is to optimize it for a given speed to obtain optimum fuel consumption, power output and emissions."²³⁷ However, because engines typically "exhibit minimum specific fuel consumption and particulate and NO_x emissions at different injection timings,"²³⁸ engine designers must tradeoff the three criteria against each other. Engine manufacturers are likely to come as close as possible to the fuel-economy optimum for timing at highway speeds, consistent with meeting the EPA's announced emissions tests. Even if greater NO_x reduction were possible, customer pressure would prevent engine makers from optimizing engines at the expense of fuel economy.

Given the limits of the EPA's ability to specify all the parameters involved in engine design, it is likely that engines will diverge from the regulators' preferred design if consumer preferences differ from regulators' preferences. Market pressures will push engine design towards consumer preferences and the increasing complexity of engine design and enhanced control over engine operation offered by the sophisticated controllers necessary for emissions reduction will produce numerous opportunities for satisfying consumer preferences at the expense of regulators' preferences.

Fourth, these tradeoffs will influence how manufacturers implement regulations. A European engine manufacturers' association paper noted this effect:

The final choice always results from a compromise between environmental targets (low exhaust emissions) and users' requirements (power availability, fuel consumption). The tool available to development engineers for the definition of this compromise is the test cycle. The test cycle identifies the engine operating conditions during which emission aspects must take the predominant role in selecting the technological solutions. Different test cycles often result in different technological solutions and as a consequence different engine performance.²³⁹

As a result of the differences in tradeoffs made by regulators and consumers, manufacturers will be driven by market pressures to match their choices to regulators' preferences only at the points specified in test

squeezing the maximum number of miles out of a tank of fuel. The fleet driver, on the other hand, is inclined to favor (and perhaps take better care of) trucks with higher-powered engines which can reduce his gear-shifting effort, get him home to his wife and children earlier, and generally provide better driveability.

Larry Givens, *The Diesel Engine: Today and Tomorrow*, 84(6) AUTOMOTIVE ENGINEERING 30, 31 (1976).

237. Virk & Lachowicz, *supra* note 204, at 169.

238. *Id.*

239. ASSOCIATION DES CONSTRUCTEURS EUROPÉENS D'AUTOMOBILES G.I.E., TEST CYCLE TO MEASURE EMISSION LEVELS OF CV DIESEL ENGINES: AN INDUSTRY NOTE 2 (1994) (copy on file with authors) [hereinafter ASSOCIATION, TEST CYCLE].

procedures, or at points necessary to reach such performance. Elsewhere, they will match the choices among tradeoffs to consumer choices. As a 1972 EPA memorandum concluded,

[T]he standard Federal test cycle and procedure are exactly that—the standard. They are the yardstick by which all vehicles are measured. They serve as design criteria for vehicle manufacturers. If the test cycle and procedure do not evaluate what the EPA desires them to, the manufacturers can hardly be blamed.²⁴⁰

Thus the test cycles selected by the regulator will have consequences for off-cycle emissions as well as on-cycle emissions, making the former higher than if they had been included in the test cycle.²⁴¹

Finally, the widespread existence of tradeoffs among pollutants requires that a rational regulatory policy consider the relative costs of reducing particular pollutants from different classes of sources.²⁴²

D. Industry Characteristics' Influence on Regulation

The structure of the industry also has an important influence on how heavy duty diesel engines are regulated. There are only a few heavy-duty diesel engine manufacturers in the United States market. World markets are fragmented, with “every major industrialized country” having “its own range of diesel engines,”²⁴³ although this may be changing and the international market may increase.²⁴⁴ The major manufacturers of diesel

240. Memorandum from the EPA Office of Air Programs, Characterization and Use of Emission Control Systems that Operate Only Under Specific Ambient Conditions or Vehicle Operational Modes 7 (July 7, 1972).

241. See ASSOCIATION, TEST CYCLE, *supra* note 239, at 4 (stating “[e]ngine technologies are to be selected on the basis of the emission standards and the test procedure legally adopted to measure engine exhaust emissions. This choice will have an influence on the emission performance of the engine when it is operated under conditions that substantially differ from those of the legal test cycle”).

242. See MOTOR VEHICLE NITROGEN OXIDES STANDARDS COMM., *supra* note 64, at 18 (stating that regulators should “consider the cost of reducing a given amount of NO_x emissions from heavy-duty vehicles compared to the cost of the same reduction of NO_x emissions from other sources”).

243. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 5. U.S. heavy-duty engines differ significantly from European and Japanese heavy-duty engines, for example. See Lee et al., *Fuel Quality*, *supra* note 163, at 13 (explaining that U.S. engines “tend to have large displacements and have a high degree of electronic control whilst in Europe, where mechanical control still dominates, they tend to be more highly rated and have smaller displacements”). U.S. and European engines are turbocharged and aftercooled, whereas “the Japanese market is dominated by large displacement, naturally aspirated HD diesel engines” and the cetane quality of U.S. diesel fuel is “significantly lower than in other parts of the world.” *Id.* See also David L. Sparkman, *Focus on Finding a Fleet*, 42(5) TRANSP. & DISTRIBUTION 41, 44 (May 2001) [hereinafter Sparkman, *Focus*] (noting difficulty of selling used U.S. trucks outside the U.S. because of different configurations and equipment). U.S. diesel fuel is also different from European fuel. IPCS, CRITERIA 171, *supra* note 57, at 1 (“The specifications of commercial diesel fuel differ considerably from in different countries.”).

244. See RHEIN, 5TH EDITION, *supra* note 185, at 38 (predicting a “steady increase” in

engines for use in trucks in the United States today include Caterpillar, Cummins, Navistar, Detroit Diesel, and Volvo.²⁴⁵ While a few decades ago there were over fourteen manufacturers and importers,²⁴⁶ today these five companies produce virtually all of the heavy-duty and medium-duty market.²⁴⁷ The trend is toward fewer firms due to regulatory and competitive pressures to cut costs,²⁴⁸ including the increasing demands on engine manufacturers to develop products with improved efficiency and environmental standards.²⁴⁹ One industry observer predicts that either Caterpillar or Cummins, the remaining independent engine manufacturers, will exit the market before 2007.²⁵⁰ As Cummins continues to lose market share,²⁵¹ its future in the heavy duty market seems most in doubt.

Diesel truck manufacturing has not traditionally been a fully vertically integrated industry. Some firms manufacture only heavy-duty diesel engines (e.g., Caterpillar, Cummins, and Detroit Diesel), some manufacture only truck bodies (e.g., Ford, GM, PACCAR, and Western Star Trucks), and others manufacture both (e.g., Volvo). Some firms offer truck lines with a choice of engines from different manufacturers (e.g., Navistar).²⁵²

import share of market); RHEIN, 7TH EDITION, *supra* note 185, at 24-25 (discussing globalization of diesel market).

245. See RHEIN, 5TH EDITION, *supra* note 185, at 11-15 (explaining that in 2001, Volvo merged with two other firms in the U.S. market, Mack and Renault, reducing the number of firms that manufacture diesel engines from six to five); see generally ITS AMERICA, *Volvo to Join Forces with Renault VI and Mack* (April, 26, 2000), available at <http://www.itsa.org/ITSNEWS.NSF/0/feec7fff21c42cd3852568cd005e5a62?OpenDocument> (last visited Apr. 19, 2004) [hereinafter *Volvo to Join*].

246. See *A Buyer's Market*, HEAVY DUTY TRUCKING, Sept. 2000, at 78.

247. See RHEIN, 5TH EDITION, *supra* note 185, at 32, 39 (identifying Mercedes, Perkins, Daewoo, Isuzu and Hyundai as other important international players).

248. See generally *Volvo to Join*, *supra* note 245.

249. See *id.* It became necessary for companies attempting to take advantage of economies of scale to spread investments over larger volumes of production. For example, Volvo merged with RenaultVI/Mack on January 2, 2001. The merger nearly doubled the volume of Volvo's truck business and strengthened its global presence. Its market share in North America doubled to 24%. *Id.* As Volvo's Chief Executive Officer at the time, Leif Johansson stated:

The transaction . . . increases Volvo's competitiveness in the medium heavy truck segment and in heavy diesel engines. Mack is an ideal partner for continuing expansion of our North America truck operations. Mack is one of the world's strongest brands in the industry and it has its own production of engines, which was a very important factor for us. We intend to achieve further critical mass in the engine sector that will permit us to make aggressive investments that will better enable us to meet demands from our customers and from society.

Id. Other companies in the industry also formed alliances and compacts to help survive the increasing competition. Caterpillar formed a global alliance with DaimlerChrysler Engines in 2000, Cummins was chosen by DaimlerChrysler in 2001 to be their diesel engine supplier for Dodge Ram pickup trucks, and Navistar in 2001 joined forces with Ford Motor Company to create a subsidiary, the Blue Diamond Truck Company. Also in 2000 DaimlerChrysler bought out Detroit Diesel, in the process delisting the company's stock on the New York Stock Exchange.

250. RHEIN, 5TH EDITION, *supra* note 185, at 38.

251. *Id.* at 100.

252. Navistar sells trucks with both its engines and engines made by some other

The lack of vertical integration complicates truck manufacture because truck and engine designers often do not work for the same firm. Placing an engine into a truck is not simply a matter of tightening a few bolts, as new engines often require extensive redesign of the existing truck body—a process that can take years.²⁵³ Redesign is necessary to accommodate the shape of the truck body to the engine and other components—especially the cooling system, and to accommodate the location of the other engine compartment components to the engine (moving wires away from particularly hot areas, for example).²⁵⁴ Truck customers often insist on extensive testing opportunities for new models before committing to purchases.²⁵⁵ For example, when Detroit Diesel introduced one of the first

companies.

253. See Gail Kachadourian, *Truckmakers Seek Delay on Diesel Engine Rule*, AUTOMOTIVE NEWS, Mar. 26, 2001, at 17 (explaining that “[o]nce the truckmakers receive prototypes, they still have to modify the trucks. One likely modification will involve changing the cooling system, because the engines are expected to run at higher temperatures. The trade group says truckmakers need at least two years to modify and validate their vehicles. Only 18 months remain until the October 2002 deadline”); see also *Detroit Diesel Corporation Confirms 2002 Series 60 Program*, PR NEWSWIRE, Apr. 5, 2002, (quoting Detroit Diesel officials):

At the time we signed the consent decree in 1998, DDC was concerned that the time allowed to meet the new standards was minimal in comparison to normal development and testing. But consistent with our initial commitment, we have met our objectives. Having said that, we still believe the industry would be well-served by a longer period of time for customers to test our new engines and prove to themselves that the 2002 Series 60 continues the engine’s long tradition of excellent performance, fuel efficiency and low cost of operation. Unfortunately, given the compressed development schedule, it is apparent that our industry will face another up and down cycle due to pre-buying and delayed buying.

Id. See also Max Heine, *Emissions Rules Affect Truck and Sales Says Volvo Chief*, OVERDRIVE 14 (June 2002) (“Truck manufacturers may have to limit their designs to one truck, one engine for the federally mandated round of emissions reductions in 2007.”); Declaration of Steven Matsill, *United States v. Caterpillar, Inc.*, Civil Action Nos. 98-2544, 98-2546, and 98-2546 (Nov. 27, 2002):

The design of the engine and truck are closely related. The engine affects the overall truck performance including important attributes such as fuel economy, gross vehicle weight rating, transmission selection, rear axle ratio definition, physical profile, maintenance schedule, noise level, and speed . . . Likewise, the truck design affects the engine designs that are acceptable candidates for use in a given vehicle. The truck design must have enough room to accommodate an engine, must have adequate heat removal capability, and must not generate excessive noise.

Id. at 6-7; Declaration of Michael von Mayenburg, *United States v. Caterpillar, Inc.*, Civil Action Nos. 98-2544, 98-2546, and 98-2546 (Nov. 27, 2002), at 6 (“The designs of the engine and truck are closely related.”).

It is worth noting that the EPA underestimated the redesign of engines in other areas as well. See, e.g., RSP, *NONROAD*, *supra* note 52, at 8 (noting the EPA’s claim that higher standards for off-road engines could be met by “converting existing engines to accept known emission control technologies (such as those used on automobiles)” while simultaneously predicting that substantial R&D expenditures will be needed to comply).

254. See, e.g., *Domino Effect*, 94(11) FLEET OWNER 69, 69-74 (1999).

255. See Ball, *Buying Binge*, *supra* note 115, at A12 (noting fleet plans to purchase only a few new trucks with MY 2003 emissions controls for testing purposes); see also *Detroit Diesel Corporation Confirms 2002 Series 60 Program*, PR NEWSWIRE (April 5, 2002);

electronically controlled engines in 1985, it had done more than nineteen million miles of dynamometer testing and more than 4.5 million miles of fleet service on the new engine.²⁵⁶ Before adopting electronic engine controllers in the 1980s, fleets did extensive testing with small numbers of vehicles.²⁵⁷ Design changes thus require lengthy lead times before they can appear in production models.²⁵⁸ Indeed, one reason emissions regulations are driving a trend toward vertical integration is because of the increased difficulty in integrating new engines into trucks.²⁵⁹ The lack of vertical integration has consequences for emissions control, as testing in a non-vertically-integrated-manufactured vehicle is more complex. Engines and trucks are not designed together; as a result, testing actual vehicles would require significantly more testing than simply testing engines alone²⁶⁰ since an engine may be used in multiple trucks and a truck model may be available with several different engine types. As a result, the EPA chose to certify engines rather than trucks.²⁶¹ The lack of vertical integration also complicates modeling, as engine emissions must be measured in lab tests and vehicle emissions estimated from test results.²⁶² Because such testing is more costly than measuring emissions with the engine installed in a truck, “no effort has been made to monitor the change in emissions from

Declaration of Steven D. Duley, *United States v. Caterpillar, Inc.*, Civil Action Nos. 98-2544, 98-2546, and 98-2546 (Nov. 27, 2002), at 3 (large trucking company purchasing executive noting that field tests for MY1991 engines, which introduced new emissions controls, took up to 30 months and 200,00 miles of testing); Declaration of Steven Matsill, *United States v. Caterpillar, Inc.*, Civil Action Nos. 98-2544, 98-2546, and 98-2546 (Nov. 27, 2002), at 10 (noting that GM typically takes 3.5 years to integrate a new engine into its fleet); Declaration of Michael von Mayenburg, *United States v. Caterpillar, Inc.*, Civil Action Nos. 98-2544, 98-2546, and 98-2546 (Nov. 27, 2002), at 10 (noting that Freightliner typically needs two years to complete validation and testing work after an engine design is finished).

256. Hamilton & Henjum, *Electronics: The Wait is Over*, *supra* note 101, at 58.

257. *Truck Electronics: Fleets Give New Engines High Marks*, FLEET OWNER, June 1985, at 65.

258. Jim Mele, *Integrating Vehicle Electronics: Plugging into the network*, 92 FLEET OWNER 60, 64 (1997) (“Faced with new heavy-duty diesel emissions standards in 2004, ‘we’re going to need new ECMs by 2003, and it takes about three years for a development program’ . . .”).

259. See Sparkman, *Focus*, *supra* note 243, at 42 (quoting a former president of Volvo Trucks that “[w]e are no longer dealing in a plug-and-play environment, where you can just drop any engine into any vehicle. It takes a very close match of components and new technology, such as new cooling systems, to meet those tough [emissions] regulations”); RHEIN, 7TH EDITION; *supra* note 185, at 17 (“As we approach the 2004 and 2007/10 regulations and beyond, it is becoming apparent that the need for an overall vehicle or equipment approach to emissions is required (European model) . . . A captive or exclusive engine will be preferred or required.”).

260. DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 473 (“To avoid the problem of having to test every possible engine, transmission, chassis, and body combination the engines themselves are tested on a test bench.”); see also Clerc, *Catalytic*, *supra* note 126, at 99-100 (noting that heavy-duty vehicles vary in design more than passenger cars, producing a “wide range of engine types and transmission types for a particular vehicle”).

261. See Reitze, *Mobile Source*, *supra* note 56, at 401.

262. See COMMITTEE TO REVIEW, *supra* note 58, at 25.

engines as they age, using the FTP. Consequently, estimations of older heavy-duty vehicle contributions to the emissions inventory remain suspect, and the degradation of PM (particulate matter) and NO_x emissions performance over time remains poorly documented.”²⁶³

The industry is changing, however, in part due to the costs of the research and development (R&D) necessary to meet new standards.²⁶⁴ Vertically integrated truck companies are growing and independent engine makers are increasingly under pressure. For example, DaimlerChrysler now owns the Dodge, Freightliner, Sterling, and Western Star truck and engine brands; General Motors owns the Chevrolet and GMC truck brands; 49 percent of Isuzu International, an engine manufacturer, owns its own engine maker, but has offered Caterpillar and Cummins engines in the past; and Volvo owns the Volvo and Mack truck brands and engine brands, but has also offered Cummins engines in the past.²⁶⁵ Although these many brands have offered Cummins and Caterpillar engines in the past, the continued willingness of DaimlerChrysler to continue to do so is questionable since Cummins and Caterpillar sales come at the expense of its own engine brands. Moreover, as engine technology grows more complex, the independent engine makers’ sharing of engine technology with competitors to facilitate truck construction will grow more difficult. A market forecast suggests that “[m]ost truck manufacturers would like to have only two engine choices at the most for medium and heavy duty trucks.”²⁶⁶ As a result, truck manufacturers are paring their engine offerings, with, for example, the DaimlerChrysler brands recently dropping Cummins for heavy duty trucks.²⁶⁷ This consolidation made the two independent engine makers particularly vulnerable to EPA pressure in the months leading up to the October deadline. If truck manufacturers intended to reduce the number of engines they offered, losing market share due to a failure to gain a certificate or to large noncompliance penalties (NCPs) could lead to permanent loss of a market.

Most importantly, heavy-duty diesel engines are used in the market in a different way from other types of engines. Heavy-duty trucks using diesel

263. Clark & McKain, *supra* note 62, at 432.

264. RHEIN, 7TH EDITION, *supra* note 185, at 10:

The advent of emissions regulations that started with the Clean Air Act of 1990 has led to a flurry of R&D activity that requires cash. Without sufficient volume to write-off these expenses, many companies would be going out-of-business and some have. As a result, major worldwide manufacturing companies are increasing their captive and committed volume by mergers, acquisitions and joint ventures.

Id.

265. RHEIN, 5TH EDITION, *supra* note 185, at 12-13.

266. *Id.* at 12.

267. *Id.* at 13.

engines are expensive, often costing substantially more than \$50,000.²⁶⁸ Their durability gives them exceptionally long useful lives,²⁶⁹ much longer than the Clean Air Act models and regulations assumed.²⁷⁰ Many smaller trucking companies primarily purchase used trucks,²⁷¹ extending truck lives even further. The market thus follows the life-cycle of trucks. New trucks are typically purchased by long distance shipping companies, including the large national fleets. Large fleets typically operate the trucks through the engine warranty period.²⁷² This relieves the large fleets from having to maintain the trucks, since most work is done under warranty.²⁷³ Trucks are then sold to regional trucking companies and other shorter-haul users.²⁷⁴ Eventually used trucks sometimes find their way to small companies that need occasional transport.²⁷⁵ The important thing is that heavy-duty trucks have long lives and gradually migrate into the short-haul market, precisely where NO_x emissions are of greatest health concern.

E. Summary

Diesel technology influenced the regulatory options available to the EPA in four key ways. First, because diesel combustion was poorly understood relative to spark ignition engines, tightening emissions standards required a

268. See *Diesel Technology for the 21st Century 1: Hearing Before the Subcomm. on Energy & Env't of the House Comm. on Science*, U.S. House of Representatives, 105th Cong. 31 (1998) (testimony of Robert J. Crites, Condor Freight Lines) (asserting that truck cabs cost over \$67,000 for "our largest line haul over-the-road tractors" before taxes).

269. See DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 555 (noting current engine life goal is 1,000,000 miles, up four times from the 1970s); *Diesel Technology for the 21st Century 1: Hearing Before the Subcomm. on Energy & Env't of the House Comm. on Science*, 105th Cong., 47 (1998) (explaining that diesels today have more than a million miles before a significant rebuild and that "[h]eavy duty engines stay around for a long time"). However, most of the mileage is accumulated in the early part of a truck engine's life. *Id.* (stating that most mileage occurs before an engine is five years old).

270. Reitze, *Mobile Source*, *supra* note 56, at 407 ("Heavy-duty diesel engines are regularly rebuilt so that the actual mileage accumulated normally exceeds their statutory useful life, while light-duty diesel engines and gasoline engines are rarely rebuilt.").

271. See *Diesel Technology for the 21st Century 1: Hearing Before the Subcomm. on Energy & Env't of the House Comm. on Science*, 105th Cong., at 32 (1998) (testimony of Robert J. Crites, Condor Freight Lines) ("[M]any small companies and independent owner-operators in particular tend to purchase their vehicles from used fleet equipment."); see also *The 2000 Used Truck Market: It's For Buyers*, 40 OVERDRIVE 1-S (July 2000) ("Any driver running local deliveries, hauling cross-country or state-to-state loads buys used trucks.").

272. Ed Thomas & Greg Berg, *Equipment Maintenance: How to Run It Longer*, HEAVY DUTY TRUCKING 48 (May 2001).

273. See Sparkman, *Focus*, *supra* note 243, at 44 (explaining that "[o]ver the last two decades, many fleets fell into the habit of trading in their trucks every three years, eliminating the need for heavy maintenance and expensive shops staffed with trained diesel mechanics. If any heavy maintenance was needed, they could have it performed by OEM dealers under warranty").

274. Sean Kilcarr, *Going Once . . . Going Twice . . . Sold!*, TRANSPORT TOPICS 18 (Feb. 21, 2000) (describing the secondary market for trucks).

275. *The 2000 Used Truck Market: It's for the Buyers*, 40 OVERDRIVE 1 (2000) (describing secondary market for trucks).

greater degree of technology-forcing than for other mobile sources. As a result, manufacturers had to invest in developing technology to which their customers were indifferent or hostile.

Second, regulatory choices for diesel engines involve important tradeoffs across pollutants controlled. Increasing control of one may “cost” regulators increased emissions of another. Such tradeoffs are generally not linear. Regulations specified in terms of satisfying specific test standards provide an incentive to design engines to the standards.

Third, heavy-duty diesel engines’ cost advantages, independent of pollution control considerations, led to a significant increase in their market share from the early days of clean air regulation to the present. As a result, diesel emissions’ relative importance to regulators increased, making it increasingly likely that the EPA would seek to reduce emissions from them in the 1990s.

Finally, diesel engines are relatively worse than other engines with respect to NO_x emissions. The growth of diesel’s market share and in fuel use generally thus increased NO_x emissions during the 1990s, the time when the EPA began to feel pressure to find new ways to reduce NO_x emissions. Heavy duty engines’ greater cost means that fleet turnover slows the impact of new emissions controls on real world conditions.

III. EXPLAINING THE EPA’S REGULATION OF HEAVY-DUTY DIESEL ENGINES

Regulation of heavy-duty diesel engines has had five phases, involving non-regulation and all the forms of federal regulation: regulation-by-rulemaking, regulation-by-negotiation, and regulation-by-litigation. The first phase was the pre-Air Quality Act of 1967 period, during which diesel emissions were left unregulated. The second was the period of regulation-by-rulemaking from the Air Quality Act of 1967 through the 1990 Clean Air Act Amendments. The third phase was a brief flurry of formal and informal regulation-by-negotiation after the 1990 Amendments. The fourth, involving regulation-by-litigation, began with the EPA’s suit against the heavy-duty engine manufacturers in 1998. The fifth is the post-1998-consent decree period, a return to regulation-by-rulemaking. In this section we describe the substance and history of the regulations produced by each of these forms, subdividing several of the broader periods according to the various major amendments to the Clean Air Act. Having provided this historical summary, we then attempt to explain why the EPA selects one form over the other.

Over the course of the last four decades, regulation of heavy-duty diesel emissions has gone from virtually nonexistent, to an initial opacity test for “smoke,” and then through a series of increasingly stringent standards for

NO_x, hydrocarbons, and particulates. NO_x emissions standards have fallen, for example, from a combined 16 grams per brake horsepower hour (g/bhp-hr) for NO_x and hydrocarbons in MY 1974²⁷⁶ to separate limits of 0.20 g/bhp-hr for NO_x and 0.14 g/bhp-hr for nonmethane hydrocarbons.²⁷⁷ Particulate standards have fallen from 0.6 g/bhp-hr in 1988²⁷⁸ to 0.01 g/bhp-hr for MY 2007.²⁷⁹ Regulations have also tightened in other ways: new test procedures required greater emissions controls²⁸⁰ and the regulatory-defined "useful life" of heavy-duty diesel engines—during which emissions must meet standards—grew from five years, 100,000 miles, or 3,000 hours to ten years, 435,000 miles, or 22,000 hours.²⁸¹

Just as important as the level of emissions is the method of determining that level. Test standards are extremely important for understanding emissions generally, since they specify the means of measurement. They are particularly important for heavy-duty diesel engines, as it is the engine rather than the vehicle that is tested. "Any test procedure for mobile source emissions represents a compromise between the need for accurate representation of on-the-road emissions (which might dictate a long and complicated test procedure) and the need for a test procedure that can be easily and inexpensively performed by manufacturers and control agencies."²⁸² The specification of the test standard can have a significant influence on the outcome.²⁸³ For example, when the EPA switched from the steady state to transient testing in MY 1984, engines that had been in compliance with hydrocarbon regulations could not pass the new test.²⁸⁴

A. Early Air Pollution Regulatory Efforts

Until the 1970 Clean Air Act Amendments, federal air pollution efforts were primarily directed at providing information to support state pollution

276. 40 C.F.R. § 85.974-1 (1974). As the EPA explained, "the unit, 'g/bhp-hr,' is a unit of emissions per unit of work performed by an engine." Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments 9, n.4 (Apr. 30, 1999) (copy on file with authors). According to the EPA, a 4.0 g/bhp-hr standard "translates to about 2 lbs. of NO_x per hour for a loaded 18-wheeler operating at highway speeds." *Id.*

277. 40 C.F.R. § 86.007-11(a)(1)(A)(i), (ii) (2001).

278. 40 C.F.R. § 86.088-11 (1988).

279. 40 C.F.R. § 86.007-11(a)(1)(iv)(A) (2001).

280. See *infra* note 374.

281. 40 C.F.R. § 86.004-2(1)(4)(v) (2001).

282. MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 89.

283. See, e.g., R.H. Hammerle et al., *Emissions from Diesel Vehicles with and without Lean NO_x and Oxidation Catalysts and Particulate Traps*, in EMISSION PROCESSES AND CONTROL TECHNOLOGIES IN DIESEL ENGINES (SP-1119) 197, 199-212 (1995) (describing different results of various tests under European and U.S. test protocols on light duty diesel engines); IPCS, CRITERIA 171, *supra* note 57, at 91 ("It is difficult to obtain artefact-free samples, as exhaust constituents can undergo chemical reactions, adsorption and desorption processes, and condensation and diffusion.")

284. EPA, SUMMARY AND ANALYSIS, *supra* note 92, at 14.

control efforts.²⁸⁵ For example, the Air Pollution Control Act of 1955 authorized the Surgeon General "to prepare or recommend research programs for devising and developing methods for eliminating or reducing air pollution."²⁸⁶ As the Senate Public Works Committee stated in its report:

The committee recognizes that it is the primary responsibility of State and local governments to prevent air pollution. The bill does not propose any exercise of police power by the Federal Government and no provision in it invades the sovereignty of States, counties, or cities. There is no attempt to impose standards of purity.²⁸⁷

The 1955 act was extended twice through 1964, while Congress studied and then negotiated over more comprehensive federal approaches.²⁸⁸ The auto makers took steps to avoid imposition of control technology, at one point in the 1950s creating a cross-licensing agreement for emissions technology that deterred innovation.²⁸⁹ California lost patience with the automobile industry before the federal government did, enacting a requirement for control of "blowby" emissions in the early 1960s.²⁹⁰

These early efforts at support through providing information identified heavy-duty diesel engines as a source of concern. At a conference held in December 1961 to present "current research findings on quantities and type of air pollutants from motor vehicles and the effects of these pollutants on the health of man, plants, and laboratory animals,"²⁹¹ for example, one study identified diesel exhaust odorants and eye irritants and relating their concentrations to engine operations. "Concentrations were presented for particulate, low-molecular-weight hydrocarbons, formaldehyde, acrolein, carbon monoxide, carbon dioxide, nitrogen dioxide, and nitric oxide."²⁹²

Heavy-duty diesel engines were still comparatively rare, however, and despite their visible smoke and odor would not have been likely to be seen as a major source of air pollution.

Mobile sources generally were an early issue of concern.²⁹³ The focus,

285. See Morriss, *Politics*, *supra* note 15, at 276-77.

286. Air Pollution Control—Research and Technical Assistance Act, Pub. L. No. 84-159, §2, 69 Stat. 322 (1955), *reprinted in* 15 U.S.C.C.A.N. 351.

287. S. REP. NO. 389 (1955), *reprinted in* 1955 U.S.C.C.A.N. 2457, 2459.

288. Morriss, *Politics*, *supra* note 15, at 277.

289. See WHITE, *supra* note 43, at 12-13 (recounting how patent pool worked to discourage research).

290. See *id.* at 12 (describing history of California regulators' efforts).

291. Larsen, Motor Vehicle Emissions and Their Effects: Conference Report, 77 PUB. HEALTH REP 963 (1962).

292. *Id.*

293. The 1963 Clean Air Act, for example, required the Secretary of HEW to encourage the continued efforts . . . to develop devices and fuels to prevent pollutants from being discharged from the exhaust of automotive vehicles . . . the Secretary shall report to Congress on measures being taken toward the resolution of the vehicle exhaust pollution problem . . . [and] his recommendations for additional

however, remained on federal assistance to state efforts. As a result, there was relatively little interest group activity at the federal level other than a general opposition to federal enforcement authority by industry groups. As one author summarized this period, the interest groups "did not coalesce strongly" in the lobbying over the 1963 act.²⁹⁴

Throughout the 1960s concern over mobile source emissions, including diesel emissions,²⁹⁵ continued to grow, eventually prompting the 1965 Motor Vehicle Air Pollution Control Act, which granted authority to the Secretary of Health, Education, and Welfare (HEW) to issue regulations "as soon as possible" that would, "giving appropriate consideration to technological feasibility and economic costs," regulate "the emission of any kind of substance, from any class or classes of motor vehicles or new motor engines, which in his judgment cause or contribute to, or are likely to cause or contribute to air pollution which endangers the health or welfare of any person"²⁹⁶ The first national regulation of mobile sources went into effect with 1966 regulations for MY 1968 vehicles. Despite the broad mandate, however, the first set of regulations covered only cars.²⁹⁷

Like the dog who did not bark in the Sherlock Holmes mystery, this first round of federal involvement in mobile source air pollution regulation is notable largely because the federal government did not act. Although this appears strange today, in the pre-1970 world the absence of federal regulatory action was the norm, not the exception. States regarded air pollution as their responsibility and, although they welcomed federal dollars and accepted federal research, they did not see a need for a federal regulatory role. Indeed, in the late 1960s and early 1970s the primary advocate of environmental legislation was former governor Senator Edmund Muskie (D-Me.), whose initial efforts focused on channeling aid to state governments.²⁹⁸ The lack of national regulation of heavy-duty diesels in this period was thus less a conscious decision than simply the status quo and a reflection of the comparatively small market share of the

legislation, if necessary, to regulate the discharge of pollutants from automotive exhausts.

Clean Air Act, P.L. 88-206, § 6, 77 Stat. 392 (1963), *reprinted in* 1963 U.S.C.C.A.N. 433, 440.

294. Robert G. Dyck, *Evolution of Federal Air Pollution Control Policy 1948-1967*, at 58 (1971) (Ph.D. dissertation, University of Pittsburgh, Graduate School of Public and International Affairs).

295. House Report No. 899 indicates the bill (S. 306) would "amend the Clean Air Act to require standards for controlling the emission of pollutants from gasoline-powered or diesel-powered vehicles" H.R. REP. NO. 899 (1965), *reprinted in* 1965 U.S.C.C.A.N. 3608.

296. Motor Vehicle Air Pollution Control Act, P.L. 89-272, § 202(a), 79 Stat. 992, *reprinted in* 1965 U.S.C.C.A.N. 983, 984.

297. Reitze, *Mobile Source*, *supra* note 56, at 328.

298. Morriss, *Politics*, *supra* note 15, at 279-80.

heavy-duty diesel engines.

B. Regulation-by-Rulemaking: 1967 to the 1990s

The first federal regulatory efforts covering diesel engines were a series of regulation-by-rulemaking restrictions on heavy-duty diesel engine emissions under the Air Quality Act of 1967 (AQA) and the Clean Air Act Amendments of 1970, 1977, and 1990.

1. The Air Quality Act of 1967

The first major national regulatory effort on air pollution was the Air Quality Act of 1967, which established a complex approach based on national ambient air quality criteria and state ambient standards.²⁹⁹ The most important set of regulations, for our purposes, is the AQA, which addressed a major concern of mobile source manufacturers: the threat of inconsistent state standards that could lead to having to outfit vehicles differently for sale in different states. California had adopted auto tailpipe emissions standards for hydrocarbons and carbon monoxide in 1966 and begun regulating mobile source emissions in 1961,³⁰⁰ spurred by Los Angeles' smog problems. With the growing interest in air quality, the auto industry feared other states would begin to do so as well.³⁰¹ The AQA preempted all state regulatory efforts to regulate motor vehicle emissions, except for California's,³⁰² which presented a special case by virtue of its

299. *Id.* at 280-82.

300. See CAL. AIR RES. BD., CALIFORNIA'S AIR QUALITY HISTORY KEY EVENTS, at <http://arbis.arb.ca.gov/html/brochure/history.htm> (accessed June 30, 2002) ("The first automotive emissions control technology in the nation, Positive Crankcase Ventilation (PCV), is mandated by the California Motor Vehicle State Bureau of Air Sanitation to control hydrocarbon crankcase emissions. PC withdraws blowby gases from the crank.").

301. C. Stewart Gill, *Comment: California or Bust!: Federal Preemption of State Authority to Regulate Nonroad Engines and Vehicles Under the 1980 Amendments to the Clean Air Act—Engine Manufacturers Association v. EPA*, 6 DICK. J. ENV. L. & POL'Y. 189, 193 n. 22 (1997) ("the original bill did not contain the federal preemption provision for motor vehicles. Once the topic was brought up, however, intense debate developed between the states, which were adamant that they retain primary control over the regulation of motor vehicles, and the manufacturers, which insisted that a patchwork of state regulations would place a tremendous strain on auto-makers").

302. Air Quality Act of 1967, P.L. 90-148, § 208(a), 81 Stat. 485, 501 (1967):

Section 208 (a) No State or any political subdivision thereof shall adopt or attempt to enforce any standard relating to the control of emissions from new motor vehicles or new motor vehicle engines subject to this title . . . (b) The Secretary shall, after notice and opportunity for public hearing, waive application of this section to any State which has adopted standards (other than crankcase emission standards) for the control of emissions from new motor vehicles or new motor vehicle engines prior to March 30, 1966, unless he finds that such State does not require standards more stringent than applicable Federal standards to meet compelling and extraordinary conditions or that such State standards and accompanying enforcement procedures are not consistent with section 202(a) of this title.

Id.

existing regulatory structure and particular environmental conditions.³⁰³ The price of preemption for the mobile source manufacturers was agreement to national regulatory efforts. Mobile source emissions standards would in the future be created only at the national level and this time regulation included diesel emissions.

The initial concern with diesels was “smoke”—the heavy, black exhaust visible from some diesel exhausts.³⁰⁴ Smoke standards for diesel engines began with standards applicable to MY 1970.³⁰⁵ To measure “smoke” required HEW to specify the conditions under which measurements of exhaust would be made. The measurements could then be compared to the standard and the engine evaluated. HEW’s proposal, issued January 4, 1968,³⁰⁶ required that heavy-duty diesel engines

shall not reduce the transmission of a beam of light by more than 20% except that reduction of light transmission of not more than 40% for a total of not more than 5 seconds shall be permitted during the running of the two dynamometer tests described in section 85.122(a) (2) and (3).³⁰⁷

The final regulations took the same approach,³⁰⁸ but specified separate measurements for “engine acceleration mode” and “engine lugging mode.”³⁰⁹ An initial standard was set for MY 1970- MY 1973, and a stricter level for MY 1974 and forwards. These standards for diesel exhaust smoke would remain the same through model year 1973, even after the passage of the next major piece of air pollution legislation, the Clean

303. Since the 1977 amendments other states may also adopt the more stringent California standards. 42 U.S.C. § 7507 (2001).

304. “Smoke” was defined by the regulations as “the solid or liquid matter in exhaust emissions which obscure the transmission of light.” 33 Fed. Reg. 8304, 8305 (June 4, 1968). Diesels in the 1960s, at least in our recollections, almost uniformly emitted such smoke. It is much rarer today.

305. Regulation of other pollutants from diesel engines would not start until MY 1974, when standards were set for emissions of hydrocarbons (HC) and oxides of nitrogen (NO_x) combined, as well as individual emissions of carbon monoxide (CO).

306. Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines: Proposed 1970 Standards for Exhaust Emissions, Fuel Evaporative Emissions, and Smoke Emissions. 33 Fed. Reg. 110 (Jan. 4, 1968).

307. *Id.* at 112. The proposed standards also included defined terms such as exhaust emissions, model year, smoke, and heavy-duty vehicle (a commercial vehicle of more than 6,000 lbs. gross vehicle weight). *Id.* at 111.

308. The final rule included Subpart J: Test Procedures for Engine Exhaust Emissions (Diesel Engines for Use in Heavy Duty Vehicles). 33 Fed. Reg. 8304, 8319-24 (June 4, 1968). Technical amendments and corrections to the testing procedure were published on July 1, 1969. 34 Fed. Reg. 11,096-98 (July 1, 1969). The current smoke emission standards are at Subpart I, 40 C.F.R. §§ 86.884-1 to 86.884-14 (2001).

309. “The opacity of smoke emissions from new diesel engines subject to this subpart shall not exceed: (1) 40% during the engine acceleration mode. (2) 20 % during the engine lugging mode.” Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines: Standards for Exhaust Emissions, Fuel Evaporation Emissions, and Smoke Emissions, Applicable to 1970 and Later Vehicles and Engines, 33 Fed. Reg. 8304, 8306 (June 4, 1968).

Air Act Amendments of 1970.³¹⁰

The 1967 Air Quality Act thus created the format that diesel engine regulation follows to this day: specific standards for specific pollutants, standard lab tests to measure the emissions, and standard sets of conditions under which the tests were to be conducted. Given what regulators were attempting to do, this format represented a reasonable set of choices: standardization of procedures and consistency in test conditions was necessary to prevent manipulation of engine operations and to provide fairness to engine manufacturers. The focus on "smoke," which today seems remarkably vague, addressed what was then seen as the most important pollutant—the highly visible emissions from tailpipes. Smoke emissions were largely solved through introducing turbochargers by the mid-1970s,³¹¹ rendering the smoke rules less relevant.³¹²

2. Regulation-by-Rulemaking Under the 1970 Clean Air Act & the EPA

Major changes to air pollution regulation came about in 1970. The Nixon Administration created the EPA and transferred air pollution control to it from HEW.³¹³ The Clean Air Act Amendments of 1970 established the basic approach to mobile sources that continues today. The statute mandated reductions of 90 percent of hydrocarbon, carbon monoxide, and NO_x, with an initial target of 1975; mobile source air pollution was to be primarily controlled through federally mandated technology standards on new vehicles.³¹⁴ States were left with the regulation of in-use vehicles, a politically difficult issue and authority they were not eager to exercise.³¹⁵

310. See, e.g., 36 Fed. Reg. 22,452 (Nov. 25, 1971); 37 Fed. Reg. 24,295 (Nov. 15, 1972).

311. JOHNSON, *supra* note 168, at 88 ("The problem of diesel smoke has been overcome to a great degree by turbocharging.").

312. Despite smoke's status as the first diesel pollutant regulated, no standard in-use test for smoke emissions existed until 1996. Mike Osenga, *Going After Gross Emitters of Diesel Smoke*, 62(2) DIESEL PROGRESS ENGINES & DRIVES 18, 18 (Feb. 1996).

313. Reorganization Plan No. 3 of 1970 established the EPA, and transferred the functions of The National Air Pollution Control Administration to it from Secretary and Department of Health, Education, and Welfare. 35 Fed. Reg. 15,623-24 (Oct. 6, 1970).

314. The Clean Air Act Amendments of 1970 added new controls on carbon monoxide and hydrocarbons from "light duty vehicles and engines manufactured during or after model year 1975" and emissions of oxides of nitrogen from "engines manufactured during or after 1976." Clean Air Act Amendments of 1970, Pub. L. No. 91-604, 84 Stat. 1676, 1690-92, reprinted in 1972 U.S.C.C.A.N. 1954 (codified as amended at 42 U.S.C. § 7521 (1994)). The statute also allowed for a "suspension for one year only of the effective date of any emission standard required . . ." The standards would also prove to be subject to future modification by legislation. The oxides of nitrogen requirement for automobiles would ultimately be changed to a reduction of "at least 75 percent." See DAVID P. CURRIE, AIR POLLUTION: FEDERAL LAW AND ANALYSIS 2-51 (1981). The Amendments also provided the definition of "model year," as well as a semblance of a definition of "light duty vehicle." Pub. L. No. 91-604, 84 Stat. 1676, 1691. The term "light duty vehicles and engines" means new light duty vehicles and new light duty motor vehicle engines, as determined under regulations of the Administrator, i.e. automobile and light truck.

315. Reitze, *Mobile Source*, *supra* note 56, at 329-30.

Even under the new statute, heavy-duty diesel engines continued to receive less stringent treatment than gasoline passenger cars through the early 1970s,³¹⁶ with only smoke regulated until the 1974 model year engines, when hydrocarbon, NO_x, and CO emissions would begin to be regulated.³¹⁷ The lack of attention to diesel emissions is not surprising, given their small contribution to U.S. air pollution at the time: only 1.75 percent of total particulates, 0.02 percent of CO, 1.9 percent of hydrocarbons, 4.8 percent of NO_x, and 0.4 percent of SO_x in the early 1970s.³¹⁸ Unlike today, when diesel engines power 91 percent of the heavy-heavy-duty transportation sector,³¹⁹ in 1967 they comprised only a small fraction of trucks in use.³²⁰ The EPA's limited concern with diesels can be seen from the fact that the agency ordered diesel emissions from heavy-duty trucks reduced by much less than the equivalent reductions in passenger car emissions.³²¹

After the 1970 Amendments, the smoke exhaust emission standard was tightened for model year 1974 and later engines.³²² The new regulations continued the format of specifying emissions levels for specific "modes" of operation both for smoke and for the newly regulated substances.³²³ This

316. EPA, 230/3-74-013, PROGRESS IN THE IMPLEMENTATION OF MOTOR VEHICLE EMISSION STANDARDS THROUGH JUNE 1974, at IV-8 (1974) ("Separate emission control regulations have been in effect since 1970 for new heavy-duty gasoline and diesel truck engines manufactured for use in over-the-highway trucks and buses of over 6,000 lb. gross vehicle weight (GVW).").

317. See *id.* at IV-10 to IV-12 (finding that "through 1970-1973, federal standards for heavy-duty diesel truck engines covered smoke emissions only. In 1974, the standards were revised to include HC, NO_x and CO, emissions as well as more stringent smoke emissions. The permissible gaseous- emissions levels are the same as for heavy-duty gasoline engines for 1974, but the test procedure is different").

318. See Henein, *Combustion*, *supra* note 156, at 211 (providing a table comparing the contributions of transportation diesel engines to air pollution in the United States).

319. See CHARLES RIVER ASSOCIATES, *supra* note 131, at 10 (noting that the larger the truck is, the more likely it will have a diesel engine).

320. See U.S. DEP'T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERVICE, ENVTL. HEALTH SERVICE, NAT'L AIR POLLUTION CONTROL ADMIN., CONTROL TECHNIQUES FOR CARBON MONOXIDE, NITROGEN OXIDE, AND HYDROCARBON EMISSIONS FROM MOBILE SOURCES 2-4, Table 2-1 (1970) (noting diesel trucks made up only 416,454 out of 16,998,546 trucks in use). Finding comparable numbers on diesel usage across time has proven challenging and we were not able to locate a more precise figure.

321. See Gale M. Reed, Note, 1976 *Congressional Action on the Clean Air Act: Automobile and Truck Emission Standards*, 8 TRANSP. L.J. 353, 361 (1976) (noting that NO_x and hydrocarbon reduction of 15% and CO reduction of 57% compared to 80% reduction for cars of both).

322. See 40 C.F.R. § 85.874-1 (1974) (stating that the opacity of smoke emissions from new diesel engines shall not exceed: (i) 20% during the acceleration mode. (ii) 15% during the engine lugging mode. (iii) 50% during the peaks in either mode); see also Control of Air Pollution From New Motor Vehicles and Engines, 40 Fed. Reg. 27,574, 27,579 (June 30, 1975) (discussing the current, 2002, smoke emissions standards). See also EPA VOLUNTARY DIESEL RETROFIT PROGRAM 1974 STANDARDS, at <http://www.epa.gov/otaq/retrofit/1974.htm> (accessed March 9, 2002) (showing a Diesel Timeline that tracks heavy duty diesel regulation).

323. See Protection of Environment, 40 C.F.R. § 85.974-1 (1974) (stating that "exhaust

first set of emission standards issued by the EPA would be in effect through MY 1978.³²⁴ By this time the academic community had recognized that more realistic test standards were needed³²⁵ and emissions standards for automobiles were being specified in terms of a driving cycle, by California since 1960 and by the federal government since 1968.³²⁶ The new test standards thus evolved from the original opacity test with the creation of a steady-state test, thereby simulating highway driving conditions.³²⁷

Already, however, the EPA was concerned with the potential inconsistencies between test-cycle performance and off-cycle performance for other engines—concerned enough to issue an advisory circular warning light-duty vehicle and light-duty truck manufacturers that “the rapid advance in the introduction of more sophisticated emission control systems, especially those that offer new flexibility in control capability,” a development that the EPA thought would be incorporated into “most, if not all, motor vehicles and engines” by the early 1980s, could be considered illegal “defeat devices.”³²⁸ Controllars were not illegal, the EPA concluded, if NO_x emissions under the Highway Fuel Economy Test were within a specified range of test protocol emissions or could otherwise prove to the EPA’s satisfaction that the equipment was not a defeat device.³²⁹ The EPA was thus concerned, as early as December 1978, about the

gaseous emission from new heavy duty diesel engines shall not exceed: (i) Hydrocarbons plus oxides of nitrogen (NO₂). 16 grams per brake horsepower hour. (ii) Carbon Monoxide. 40 grams per brake horsepower hour. (2) The standards set forth in paragraph (a) of this section refer to exhaust gaseous emissions generated under the conditions set forth in § 85.974-9 through § 85.974-18 and measured and calculated in accordance with those procedures”); see also Control of Air Pollution From New Motor Vehicles and Engines, 40 Fed. Reg. 27,574, 27,588 (June 30, 1975).

324. See, e.g., Control of Air Pollution From New Motor Vehicles and Engines, 40 Fed. Reg. 27,574, 27, 598 (discussing the 1977 standards); see also 40 C.F.R. § 86.078-11 (1981) (discussing the 1978 standards); see also Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 42 Fed. Reg. 32,906, 32,907 (June 28, 1977). A later technical amendment in the *Federal Register* was necessary to confirm that these standards “also apply to later model year engines.” Control of Air Pollution From New Motor Vehicles and Engines, 40 Fed. Reg. 27,574 (June 30, 1975) (referring to § 85.801). This highlights the problem of careful drafting.

325. See Myers et al., *Engine Exhaust*, *supra* note 157, at 27 (stating that “[i]deally the driving cycle or cycles employed in vehicle emissions tests should represent an average or composite of vehicle operation typical of the driving of a large segment of the driver population . . . Not only does typical vehicle operation vary inter-regionally, or even intra-regionally, but in addition the relative importance of each of the several types of pollutants may vary geographically”).

326. See *id.* at 27-28.

327. See Bowman, *EPA Off*, *supra* note 36, at A1 (reporting the lack of attention the EPA has paid to the large amount of NO_x pollution when diesel rigs cruise steadily down the highway).

328. EPA, OFFICE OF AIR AND WASTE MGMT., OMSAPC ADVISORY CIRCULAR 24-2, at 1 (1978), *reprinted in* ASLEEP AT THE WHEEL, *supra* note 36, app. A; see also EPA, SUMMARY AND ANALYSIS, *supra* note 92, at 6-7 (noting development of transient test began in 1972).

329. EPA, OFFICE OF AIR AND WASTE MGMT., OMSAPC ADVISORY CIRCULAR 24-2, at 3 (1978), *reprinted in* ASLEEP AT THE WHEEL, *supra* note 36, app. A.

potential for controllers to create excess emissions in off-test-cycle conditions.

The Clean Air Act as recreated by the 1970 Amendments was largely the result of a game of political one-upmanship between Republican President Richard Nixon and Democratic Senator Edmund Muskie (D-Me.), who anticipated being rivals in the upcoming 1972 presidential election.³³⁰ Although the Amendments imposed emissions standards on mobile sources, they were not a serious blow to the auto industry. The automobile makers prevailed on a number of key conference committee issues, including deleting the requirement of testing each new vehicle in favor of prototype testing and preventing public disclosure of emissions control testing results and equipment costs.³³¹ Most importantly, the 1970 Amendments left open the possibility of delays in the new standards—delays the auto industry lost little time in seeking.³³² Particularly given the anti-car attitudes in 1970 (one Congressman called the internal combustion engine the “most serious and dangerous source of air pollution in the [n]ation today”),³³³ the degree of regulation of mobile sources that resulted was comparatively mild. Moreover, the constant battles over automobile emissions that resulted as the industry sought repeated extensions of deadlines likely helped distract the EPA from the comparatively small heavy-duty diesel engine sector. Heavy-duty diesel engine regulation under the 1970 Clean Air Act Amendments thus seems mostly an afterthought, with most of the regulatory energy going into the bruising battles over automobile emissions. Nonetheless, the 1970 Clean Air Act Amendments established several of the crucial features that set the stage for the later conflicts over heavy-duty diesel emissions.

3. *Regulation-by-Rulemaking Under the 1977 Clean Air Act Amendments*

Dissatisfaction with the 1970 version of the Clean Air Act prompted a major effort at reform in 1976. Although the proposed 1976 Amendments were blocked from final passage by Western senators unhappy about the impact on western development during a midnight marathon session at the close of the 1976 session of Congress, the measures were reintroduced and a revised version was enacted in 1977.³³⁴ Relaxing mobile source regulations on automobiles was an important purpose behind the 1977 Amendments.³³⁵

330. See Morriss, *Politics*, *supra* note 15, at 282-83.

331. See *id.* at 286.

332. See *id.* at 286-87.

333. *Id.* at 289.

334. See *id.* at 295-96.

335. See Currie, *Mobile-Source*, *supra* note 18, at 819 (“One of the principal motive forces behind the 1977 amendments to the Clean Air Act was the auto industry’s urgent cry

For our purposes, the important parts of the 1977 Amendments were those that delayed the unmet mobile source reductions mandated in 1970 until the 1980s, required inspection and maintenance programs, and added an explicit requirement for regulations requiring “the greatest degree of emission reduction achievable” consistent with cost, technical feasibility, noise, energy, and safety factors for heavy-duty diesel engines.³³⁶ The lack of the EPA’s regulatory activity in the heavy-duty diesel sector in particular prompted Congress to directly specify reductions.³³⁷ The Amendments called for significant reductions from heavy-duty diesel engines of hydrocarbons and carbon monoxide (during and after model year 1983 of at least 90 percent), oxides of nitrogen (during and after model year 1985 of at least 75 percent), and particulate matter (during and after model year 1981 or earlier, if practicable).³³⁸ Despite the tightening of the standards, the EPA’s proposals for 1980 did not require new technology to meet the new standards.³³⁹

that further postponement of the light-duty-vehicle- emission standards was necessary to avoid a disastrous shutdown.”)

336. The Clean Air Act Amendments of 1977 (Pub. L. No. 95-95), 91 Stat. 685, 765 (codified as amended in 42 U.S.C. § 7521 (1994)). Section 224 amended § 202(a) of the Clean Air Act by adding the following:

(3)(A)(i) The Administrator shall prescribe regulations under paragraph (1) of this subsection applicable to emissions of carbon monoxide, hydrocarbons, and oxides of nitrogen from classes or categories of heavy-duty vehicles or engines manufactured during and after model year 1979. Such regulations . . . shall contain standards which reflect the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the model year to which such standards apply, giving appropriate consideration to the cost of applying such technology within the period of time available to manufacturers and to noise, energy, and safety factors associated with the application of the technology.

Id. See also Reitze, *Mobile Source*, *supra* note 56, at 330-31.

337. See Currie, *Mobile-Source*, *supra* note 18, at 848 (“Congress in 1977 was dissatisfied with the emission standards for trucks and buses set by [the] EPA under the general authority of section 202(a).”). The 1977 Amendments’ congressional findings included that:

[H]eavy-duty truck and bus emissions have not been adequately reduced. Although standards applicable to new heavy-duty engines have been promulgated, their requirements are much more lenient (even in terms of per cent reduction from uncontrolled levels) than the statutory requirements for light-duty vehicles . . . The 1977 Federal standards require no reduction of HC, NO_x, or CO from uncontrolled diesel- powered engines.

H.R. REP. NO. 95-294, at 271-72 (1977), *reprinted in* 1977 U.S.C.A.N. 1077, 1350-51. See also Reitze, *Mobile Source*, *supra* note 56, at 402 (“[L]ittle regulation occurred even after the passage of the CAA, which led Congress to more specifically require HDEs to be regulated in the 1977 CAA Amendments.”).

338. See Clean Air Act Amendments of 1977, Pub. L. No. 95-95, § 224, 91 Stat. 685, 765.

339. See 45 Fed. Reg. 4144 (Jan. 21, 1980):

EPA projects that 36 percent of the diesel engine families will emit at or below target emission levels . . . The approaches that EPA anticipates for achieving the targets are not new: such things as injector spray pattern and sac volume, after-cooling of turbocharged intake flows, and turbocharging of naturally-aspirated

The Amendments allowed the new standards to be revised starting in 1979 and again every subsequent three years.³⁴⁰ Although the statute imposed more stringent standards, two “escape valves”³⁴¹ were also included in the statute, allowing the EPA to temporarily or permanently revise the statutory standards for several reasons, including for reasons of cost.³⁴² The EPA “liberally” used the former but did not use the latter.³⁴³ Congress also imposed extensive reporting and other requirements relating to fuel efficiency costs.³⁴⁴ Importantly, Congress also created the requirement of a four-year lead time requirement for changed standards.³⁴⁵

When the EPA set out to implement its new mandate to further reduce diesel emissions, part of its approach was to propose extensive changes in test procedures and instrumentation requirements to make the tests more closely resemble engine use conditions.³⁴⁶ Test procedures are important not only because of the role they play in establishing whether a particular engine receives certification, but because the EPA continued to rely on its test procedures to check compliance as well as to formulate the standards themselves.³⁴⁷ Using its models, the EPA translated the new standards into changes in air quality, predicting substantial reductions in emissions.³⁴⁸

engines are available paths to compliance.

Id. The same was true for automobile standards through the 1990s. *See also* Reitze, *Mobile Source*, *supra* note 56, at 327 (explaining that new pollution control technology did not achieve this reduction, rather, the motor vehicles used current engine technology to work around and achieve the emission limits).

340. *See* 91 Stat. 685, 766 (1977) (as amended 42 U.S.C. § 7521(a)(6) (2000)) (stating the reason an Administrator may use to warrant revising the current standard).

341. ENVTL. L. INST., 2 LAW OF ENVIRONMENTAL PROTECTION §11.07[2] at 11-186 (2001).

342. *See* 42 U.S.C. § 7521(a)(3)(B) (temporary revisions) (1976); 42 U.S.C. § 7521(a)(B)(i) (permanent revisions).

343. ENVTL. L. INST., *supra* note 341, at 11-187.

344. *See, e.g.*, 42 U.S.C. § 7521(b)(3)(C) (2000) (fuel economy); 42 U.S.C. § 7521(c)(3) (reporting to Congress); *see also* 42 U.S.C. § 7521(c)(1)-(3) (requiring that the National Academy of Sciences has not issued report to contrary relating to costs and fuel economy).

345. *See* 42 U.S.C. § 7521(a)(3)(C) (“Any standard promulgated or revised under this paragraph and applicable to classes or categories of heavy-duty vehicles or engines shall apply for a period of no less than 3 model years beginning no earlier than the model year commencing 4 years after such revised standard is promulgated.”).

346. *See* U.S. EPA Final Rule, *Certification and Test Procedures for Heavy Duty Engines for 1979 and Later Model Years*, 42 Fed. Reg. 45,132 (Sept. 8, 1977).

347. *See* 45 Fed. Reg. 4137 (Jan. 21, 1980):

The HC and CO standards were derived from a ‘baseline’ test program. Twenty-three 1969 model year gasoline heavy-duty engines, chosen in numbers proportional to their sales fractions in the 1969 market, made up the sample; engines representing 81.5 percent of the sales were tested. Once these uncontrolled emissions had been measured on the transient test procedure, it was a straightforward matter to reduce the HC and CO numbers by 90 percent and arrive at the final standards.

Id.

348. 45 Fed. Reg. 4136 (Jan. 21, 1980):

We estimate that the implementation of these regulations will reduce the lifelong HC emissions from the average heavy-duty gasoline fueled engine by one ton and

Industry comments on the EPA's proposal were highly critical. One of the most important comments "claimed that there is insufficient lead time to comply with the regulations as proposed for the 1979 model year."³⁴⁹ After consideration, the EPA concluded that the industry was correct³⁵⁰ and allowed "the continued use of the existing test procedures and instrumentation to demonstrate compliance for 1979. All subsequent demonstrations of compliance (1980 and later) will be only by the new test procedures (with the exception of small volume manufacturers)."³⁵¹ The EPA also made extensive changes to the testing procedures in response to industry comments.³⁵² Nonetheless, the industry remained critical of the new test procedures.³⁵³

The most important development was the EPA's creation of the transient engine test standard in 1979, designed to simulate urban driving conditions.³⁵⁴ Under steady-state operation, temperatures of engine components and the fuel have reached an equilibrium value that varies only slightly and randomly from one cycle to the next. However, under transient conditions, fuel pressures and temperatures and engine component

CO emissions by 29 tons. Similarly, the average heavy-duty diesel engine will experience a reduction of 0.8 tons [sic] in HC. These gains translate into average urban mobile source HC and CO reductions of 17% and 30%, respectively, by the late 1990s [sic]. As a result, the average urban ambient air quality will improve some 2% in ozone and 7% in carbon monoxide.

Id.

349. Final Rule, 42 Fed. Reg. 45,132 (Sept. 8, 1977).

350. *See id.* ("EPA's analysis supports the manufacturers' claim that lead time . . . is tight.")

351. *Id.* at 45,132-33. *See also id.* at 45,133 ("[C]ompliance may be demonstrated to the originally proposed standards (1.5 HC, 25 CO, 10 HC+NO_x or the more stringent levels 5.0 HC+NO_x, 25 CO) at the option of the manufacturer.")

352. "The commentators questioned the need for the extensive test procedure and instrumentation changes proposed . . . EPA has made the following major revisions to the heavy-duty NPRM:

(a) The requirement for use of a specified analysis system designed without deviation in accordance with EPA's schematic diagram has been deleted. Instead, minimum requirements and performance specifications are substituted . . . (c) A chemiluminescence analyzer or high performance NDIR analyzer with an NO₂ to NO converter is specified for NO_x measurement. An option to allow the use of current NDIR analyzers with an NO₂ to NO converter is also included . . . (d) The CO₂ measurement is made optional for Diesel engines.

42 Fed. Reg. 45,133 (Sept. 8, 1977). For MY 1980, only low volume manufacturers, as defined in 40 C.F.R. § 86.080-11(a)(2) (1981), had the option of using either testing procedure. 40 C.F.R. § 86.080-11 (1981).

353. *See* MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 88 ("The committee has received many criticisms of the cycle from engine manufacturers who disagree sharply with the conclusions of EPA [regarding the appropriateness of the test cycle].")

354. *See* Bowman, *EPA Off*, *supra* note 36, at A1 (reporting the EPA's fear that, due to inadequate testing procedures, it had grossly underestimated the amount of pollution caused by diesel rigs); *see also* U.S. EPA Proposed Rulemaking, Control of Air Pollution from New Motor Vehicles and Motor Vehicle Engines, 44 Fed. Reg. 9464-65 (Feb. 13, 1979) (discussing the need for urban air improvements and actual on road improvements).

temperatures vary “progressively rather than randomly from cycle to cycle.”³⁵⁵ Since diesel emissions are sensitive to temperature, pressure, and the like,³⁵⁶ transient and steady-state testing have different results for the same engine.

The new test was introduced because of the EPA's concern that “[t]he mandated 75 percent reduction will be difficult for the manufacturers of diesels, and the incentive to design around the test will be great.”³⁵⁷ Under a steady-state test protocol, an engine manufacturer could optimize the engine's emissions performance for precisely the specification. An overly-simplified example can clarify the engineering problem for the EPA: with mechanical engine controllers, an engine manufacturer could optimize the engine's emissions control performance for operation at 45 miles per hour.³⁵⁸ Emissions at other speeds would be higher. Since engines operate at multiple speeds, overall emissions would thus be higher than the test predicted. “Transient testing will be needed to assure that the reductions mandated by Congress [will] actually [be] achieved”³⁵⁹ The transient test would, again oversimplifying the variables, test the engine at several speeds.

[The] EPA's theory at the time was that urban emissions likely would be greater and, by controlling those emissions, one would also control emissions under highway, or steady-state conditions³⁶⁰

A theory that even the highly critical House Commerce Committee Report *Asleep at the Wheel* later termed “plausible given that, in the 1970s, heavy-duty diesel engines were controlled by unsophisticated mechanical carburetors such that emission levels when the engine was *not* performing on the designated test cycle were not likely to vary much from emission levels experienced when the engine was operating *on* the test cycle.”³⁶¹

The culmination of five years' development by [the] EPA (and, in part, by the heavy-duty manufacturing industry), the transient test exercises the engine through a continually changing series of speed/torque conditions as emissions are sampled. The new testing and sampling

355. Myers et al., *Engine Exhaust*, *supra* note 157, at 23.

356. See Marr & Harley, *Spectral Analysis*, *supra* note 80.

357. 45 Fed. Reg. 4138 (Jan. 21, 1980)

358. Actual optimization would be more complex and depend on multiple factors such as load.

359. 45 Fed. Reg. 4138 (Jan. 21, 1980).

360. ASLEEP AT THE WHEEL, *supra* note 36, at 5. See also OECD, Control of Emissions from Heavy-Duty Vehicles 44 (1993), reprinted in ASLEEP AT THE WHEEL, *supra* note 36, app. J (“Control of heavy-duty emissions over the specific U.S. transient cycle is considered to provide proportional control also of emissions under driving conditions not explicitly represented by the transient cycle itself.”). Urban exposure levels to diesel exhaust are significantly higher in both the United States (1-2 ug/ m³ vs. less than 0.6-1 ug/ m³) and Germany (5-10 ug/m³ vs. less than 1.5 ug/ m³). IPCS, CRITERIA 171, *supra* note 57, at 94.

361. ASLEEP AT THE WHEEL, *supra* note 36, at 5-6.

requirements differ so greatly from those currently in place that the development of an entirely new set of regulations has been necessary.³⁶²

The transient system was designed to make the tests more representative of in-use conditions.³⁶³ The EPA selected the specific test conditions after a survey of 44 trucks and 7 buses driven in New York City and Los Angeles.³⁶⁴ These 2 cities were selected as representing "the extremes of urban traffic flow."³⁶⁵ Performing well on the test meant that an engine met the EPA standards for driving conditions likely to be encountered in urban conditions.

The transient test also required new test equipment³⁶⁶ and the delays in obtaining the equipment prompted the EPA to delay introduction of the new test.³⁶⁷ As the EPA described the procedure:

Transient engine tests are performed in the laboratory using a dynamometer, a computer-based controller, and an emissions sampling apparatus. The dynamometer is simply an electric motor which is linked to the drive shaft of the engine (with the transmission removed) to either absorb the engine's energy or to drive the engine By properly controlling the dynamometer, the engine can be subjected to conditions which simulate the operation of an engine in a vehicle on the road It is the transient-control computer that "drives" the dynamometer through the cycle in a repeatable manner The exhaust flow of an engine is conducted through a machine called a constant-volume sampler (CVS), from which a small proportional sample is withdrawn. This method of sampling is dictated by the varying exhaust flow which accompanies transient operation To compute mass emissions during transient testing, the total volume of sample, diluted in the CVS, must be measured Hydrocarbon emissions are measured using a flame ionization detector (FID); CO and CO₂ using a non-dispersive infrared analyzer; and NO_x using a chemiluminescence analyzer. The resulting pollutant concentrations found in the sample are applied to the total diluted flow to yield, after conversion, the mass emissions during the test.

362. 45 Fed. Reg. 4137 (Jan. 21, 1980).

363. See Michael P. Walsh, *Worldwide Developments in Motor Vehicle Diesel Particulate Control*, in DEVELOPMENTS IN DIESEL PARTICULATE CONTROL SYSTEMS (SP-775) 1, 3 (1989) [hereinafter Walsh, *Worldwide*].

364. See TAD WYSOR & CHESTER FRANCE, EPA TECHNICAL REPORT HDV-78-02, SELECTION OF TRANSIENT CYCLES FOR HEAVY-DUTY VEHICLES, 1 (1978) (copy on file with authors).

365. *Id.*

366. See 45 Fed. Reg. 4138 (Jan. 21, 1980) ("Unlike the gasoline engine manufacturers . . . diesel manufacturers may have to completely replace their present equipment . . .").

367. See EPA, SUMMARY AND ANALYSIS, *supra* note 92, at 179-85 (determining that although some certification could occur for the 1983 MY, it would involve too much risk for missing the deadline to be practical).

The gasoline and diesel test cycles (Appendix I) are composed of second-by-second sequences of engine speed/torque pairs, with values given in normalized (percent of maximum) form. These cycles were computer-generated from a large data base of urban heavy-duty engine operation.³⁶⁸

The resulting test "consists of a second-by-second listing of prorated speeds and torques, through which the engine must be exercised within statistically acceptable limits."³⁶⁹ Despite the EPA's argument that the transient test was needed to make testing reflect real world conditions, the EPA not only did not attempt to validate its new test but denied that validation was desirable:

Heavy-duty truck operation, and therefore heavy-duty emissions, are application-specific. The objective of CAPE-21 was to arrive at an "average" duty cycle for an "average" urban truck. Any given application wouldn't necessarily correlate with emissions measured on the average cycle. To choose an on-road application identical in duty cycle to the test procedure itself would prove nothing.³⁷⁰

Engine manufacturers were critical of the EPA's proposal for transient testing.³⁷¹ Their comments during rulemaking "centered around the justification for the tests, their representation of real life operation, their validation, their repeatability, and the lack of current knowledge upon which to base comments."³⁷² They also regularly expressed concerns about the lead time necessary to implement new standards and procedures.³⁷³

368. 45 Fed. Reg. 4138 (Jan. 21, 1980) (providing a complete summary of the testing procedure).

369. Clark & McKain, *supra* note 62, at 433.

370. EPA, SUMMARY AND ANALYSIS, *supra* note 92, at 31.

371. See 45 Fed. Reg. 4147 (Jan. 21, 1980) ("Transient testing requirements were roundly criticized by both gasoline and diesel engine manufacturers (and others)."); EPA, SUMMARY AND ANALYSIS, *supra* note 92 (summarizing the industry desire to retain the steady-state procedures).

372. 45 Fed. Reg. 4147 (Jan. 21, 1980). See also EPA, SUMMARY AND ANALYSIS, *supra* note 92, at 2-6 (listing the complaints of the manufacturers for each category).

373. See 48 Fed. Reg. 1408 (Jan. 12, 1983):

Manufacturers of HDDEs expressed the need for timely decisions on potential relaxation of the optional steady-state standards and possible revisions of other key regulatory provisions in order to keep their 1984 model year development and certification programs on track . . . both LDT and HDE manufacturers requested expeditious action on EPA's proposal to revise the AQL applicable during SEA testing and on the useful-life requirements. Also due to leadtime constraints, the Motor Vehicle Manufacturers Association (MVMA) requested a 1-year postponement of the full-life useful-life regulations. The majority of the manufacturers strongly urged that EPA announce its 1984 model year requirements as soon as possible after the close of the comment period.

Id. at 1406. The manufacturers' concerns included the amount of leadtime for 1987 MY standard, the environmental need for revising the HD NO_x standard, and the technological feasibility of a 4.0 g/BHP-hr standard for HDDEs. See also 50 Fed. Reg. 10,622-23 (Mar. 15, 1985) (listing other comments made about fuel economies penalties associated with the proposed standards, particularly for diesel engines, the costs of standards, and statutory leadtime provisions).

The transient test introduction made a major change in engine emissions testing. Testing engines under both the old and new standards found “[t]here is no general correlation between emissions measured on the two cycles; correlations are different for different emission species, for different engine types, and even for different manufacturers.”³⁷⁴ Initially there were also large differences in emissions test results under the new procedure between laboratories.³⁷⁵ The transient test procedure did appear to produce approximately 10 percent lower NO_x levels than did the steady-state test.³⁷⁶ This difference suggests the critical importance of designing engines to the test procedures for engine manufacturers, since sales of their engines depend on receiving the EPA certification that their engines met the standards. Later analysis in Europe determined that the transient test cycle, while more realistic of U.S. driving conditions, was also more vulnerable to engine controller strategies aimed at test passage rather than emission reductions.³⁷⁷

Over the next decade, the EPA continued to tighten heavy-duty diesel emission standards under the transient test. From HEW’s regulation of only “smoke” in 1970, the diesel emission regulations evolved into a complex and stringent list of regulations covering hydrocarbons, CO, NO_x, and particulates. Leadtime to meet new standards continued to be an important issue. After the EPA promulgated the 6.0 g/bhp-hr NO_x heavy-duty diesel engine standard on March 15, 1985,³⁷⁸ the Engine Manufacturers Association sued the EPA for not providing four years leadtime as required by the Clean Air Act. The EMA prevailed in the D.C. Circuit, which ruled that the NO_x standard for all heavy-duty engines could not go into effect until the 1990 model year.³⁷⁹ Not all the EPA proposals

374. MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 8; *see also* JOHN DEERE & CO., 2 EPA AIR DOCKET A-91-24, DEERE & COMPANY COMMENTS ON ENVIRONMENTAL PROTECTION AGENCY NOTICE OF PROPOSED RULEMAKING “CONTROL OF AIR POLLUTION: EMISSIONS OF OXIDES OF NITROGEN AND SMOKE FROM NEW NONROAD COMPRESSION-IGNITION ENGINES AT OR ABOVE 50 HORSEPOWER,” (1993) (copy on file with authors) (noting that steady state and transient test cycles “could cause the EPA to reach entirely different decisions during the [engine] certification process”).

375. *See* MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 29 (stating that NO_x differed 15%; particulates and hydrocarbon results by “as much as a factor of two”).

376. *See* MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 29.

377. *See* ASSOCIATION, TEST CYCLE, *supra* note 239, at 8 (“The test cycle configuration should be such as to bring about results in terms of low engine emissions that are as far as possible independent of the patterns of use of the engine. This objective is better fulfilled by a test cycle based on a set of steady state modes than by a transient cycle.”).

378. Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 50 Fed.Reg. 10,606 (Mar. 15, 1985).

379. *Natural Res. Defense Council v. Thomas*, 805 F.2d 410, 436-37 (D.C. Cir. 1986); *see also* 52 Fed. Reg. 47,858 (Dec. 16, 1987) (“In response to the Court’s remand, this technical amendment package changes the 1988 effective date of the NO_x standards to the 1990 model year. This delay in the effective date applies to heavy duty engines and heavy

for regulations resulted in action; neither a proposed particulate standard nor revision of the NO_x standard in January 1981 were adopted.³⁸⁰ Table 1 lists the major regulations. MY 1988 brought the first particulate standards for heavy-duty diesels,³⁸¹ five years after the EPA imposed the first diesel particulate standards in the world on cars and light duty trucks.³⁸² "In 1984, with no HDE standards yet promulgated, the NRDC successfully sued to obtain a court order to compel [the] EPA to publish final NO_x and PM standards by March 15, 1985."³⁸³

MY 1991 standards tightened the NO_x standard to 5.0 g/bhp-hr, and introduced an innovation: allowing the averaging and trading of emission credits, with "not to exceed" levels for engine families (FELs).³⁸⁴ These "innovative, voluntary programs" allowed engine manufacturers "who reduce emissions below regulatory requirements for a particular model year for a particular engine to offset these reductions against emissions in a later model year or to trade credits for these reductions to other manufacturers of similar engines."³⁸⁵ Limited banking was allowed starting in 1990. The value of the programs was reduced by the requirement of a 20 percent discount required by the EPA "as an added assurance that the incentives created by the program will not only have no adverse environmental effect but also provide an environmental benefit."³⁸⁶

One reason the EPA continued to tighten the standards was the increasing importance of diesel engines in the heavy-duty truck market. As the EPA noted in 1981:

As diesel engines continue over time to power an even greater portion of the nation's heavy-duty vehicles (on-the-road trucks and buses whose gross vehicle weight rating exceeds 8,500 pounds), their contribution to ambient levels of total suspended particulate (TSP) will increase over levels that are already significant. Current heavy-duty diesels emit more than twice the particulate per mile emitted by heavy-duty gasoline engines operated on leaded gasoline.³⁸⁷

Gasoline burning engines were being heavily regulated by the EPA and

light-duty trucks having a gross vehicle weight exceeding 6,000 lbs."))

380. See Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 46 Fed. Reg. 5838 (proposed Jan. 19, 1981); see also Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 46 Fed. Reg. 1910 (proposed Jan. 7, 1981).

381. See Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 50 Fed. Reg. 10,607 (Mar. 15, 1985).

382. See Walsh, *Worldwide*, *supra* note 363, at 3.

383. Reitze, *Mobile Source*, *supra* note 56, at 403.

384. 55 Fed. Reg. 30,622 (July 26, 1990).

385. 55 Fed. Reg. 30,584 (July 26, 1990).

386. *Id.*

387. Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 46 Fed. Reg. 1910 (proposed Jan. 7, 1981).

their emissions were being reduced. The increasing use of diesel engines, however, threatened to wipe out these gains.³⁸⁸ Even without the changes in market share, as gasoline engines' emissions declined, diesel engines' relative share of total emissions increased.³⁸⁹

If current trends continue, EPA expects the use of diesel engines in heavy-duty vehicles to increase dramatically over the next 15 years. While diesel engines currently power about one-third of all new heavy-duty vehicles sold in the U.S., EPA expects this percentage to increase to 57-69 percent by 1995. This move toward more diesels will increase nationwide particulate emissions from heavy-duty diesels to an estimated 218,000-266,000 metric tons per year by 1995. Urban areas would be the most heavily affected by these emissions.³⁹⁰

Truck manufacturers managed to meet the increasing standards through the 1980s through improvements in combustion without adding post-combustion treatment of exhaust.³⁹¹ Indeed, the first particulate standards, effective in 1988 "required little reduction from the emission levels of uncontrolled engines for most vehicles."³⁹²

One important result of the tougher clean air standards was the increasing reliance on electronic controls in mobile source engines to meet standards³⁹³ and improve performance.³⁹⁴ While the first electronic

388. *See id.*

Beginning with the 1984 model year, heavy-duty gasoline engines will for the most part be equipped with catalysts in order to comply with stringent standards for hydrocarbons and carbon monoxide. These engines will then be operating on cleaner burning unleaded gasoline and their particulate emissions will decrease by 95-98 percent. Thus, without regulation, heavy-duty diesels will emit 40-100 times the particulate emitted by these 1984 and later model year gasoline engines.

Id.; *see also* John H. Cushman, Jr., *Record Penalty Likely Against Diesel Makers*, N.Y. TIMES, Oct. 22, 1998, at A1 ("Environmentalists and [g]overnment officials say diesel engines were passed over in emission standards until the 1990s because they caused much less smog than did cars and smokestack industries. But since car emissions of hydrocarbons and nitrogen oxide began to be regulated in 1970, diesel engines have increasingly emerged as a greater problem."). Diesel engines emit similar levels of particulates to comparable gasoline engines, but the introduction of emissions controls on the latter created a disparity. C.A. Amann et al., *Some Rudiments of Diesel Particulate Emissions*, in THE MEASUREMENT AND CONTROL OF DIESEL PARTICULATE EMISSIONS, PART 2, at 3 (1981). NO_x emissions, however, are greater from uncontrolled heavy-duty diesel engines than from uncontrolled heavy-duty gasoline engines. MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at x.

389. *See* White, *supra* note 43, at 13 (discussing the lack of incentive for a firm to partake in its own independent research in emissions control technology preventing it from significantly competing with rivals).

390. Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines, 46 Fed. Reg. 1910-11 (Jan. 7, 1981).

391. *See, e.g.*, Stephen E. Plumb & Stewart Siegel, *They May Growl, But Bulldogs Can Be Friendly*, 28(3) WARD'S AUTO WORLD 111, 111 (1992) (describing new Mack engine and noting that Mack, Cummins, Caterpillar, and Detroit Diesel all had developed engines that reduce emissions "without an after-treatment device or significant price increase").

392. Sawyer and Johnson, *supra* note 106, at 69.

393. *See supra* notes 101-02; *see also* Reitze, *Mobile Source*, *supra* note 56, at 363 ("Manufacturers of automobiles began to use onboard computer[s]" for emissions control).

controls were simply add-ons to existing engines, by the late mid-1980s engine manufacturers began to introduce fully electronic control systems.³⁹⁵ Electronic engine controls also allowed manufacturers to price discriminate among customers, since engines were programmed differently for conditions that would result in higher warranty claims.³⁹⁶

The pattern of regulation through the 1980s reflected the institutional structure of clean air regulation outlined earlier. Initial regulatory efforts in mobile sources focused on the largest contributor—automobiles. As further reductions in automobile emissions became increasingly costly as regulation moved up the marginal cost curve, regulators also turned to the cheaper gains in air quality possible in the heavy-duty diesel sector. Indeed, we would not be surprised if one of the reasons for the growth in heavy-duty diesel engines' market share in transportation was their comparatively light regulatory burden into the early 1980s. As diesel's relative importance in emissions grew, however, so did regulatory attention.

The EPA's choice of regulatory means is also easy to explain. Into the 1980s the EPA used only regulation-by-rulemaking and had no need for an alternative method. The fights in mobile source regulation in the 1970s were primarily political disputes over allocation of emissions between stationary and mobile sources, fought out in the halls of Congress, with the EPA having little discretion in how it implemented congressional directives to reduce mobile source emissions by specific percentages. The EPA's alternative in the 1980s, the new, informal forms of negotiated rulemaking being experimented with, were not desirable for highly politicized disputes over the levels of reduction in mobile source pollutants, particularly given the intense congressional interest in the EPA's activities in the area. Since

Bob Deierlein, *The Show Must Go On*, 112 BEVERAGE WORLD 106 (1993) (describing the Detroit Diesel electronic system as "evolved as a result of a unique set of events [including] . . . the need to meet increasingly stringent air quality standards . . .").

394. See ROBERT N. BRADY, HEAVY-DUTY TRUCKS: POWERTRAINS, SYSTEMS, AND SERVICE 818 (1997) ("Electronic systems optimize control of critical engine functions that affect fuel economy, exhaust smoke, and emissions. These electronic systems provide the capability to protect the engine from serious damage resulting from conditions such as high engine coolant temperatures, high oil temperature, and low engine oil pressure conditions.") [hereinafter Robert N. Brady].

395. See *id.* at 817-18.

396. See *id.* at 835:

If an engine horsepower setting is altered, or if major alterations to the engine parameters are required while the engine is still under warranty, the OEM needs to know what changes are being made. This reprogramming can cost the engine user from several hundred to several thousand dollars, particularly if a higher horsepower setting is desired, because experience proves that higher horsepower engines tend to cost more because of service failures than do lower power-rated engines. The user pays extra dollars to cover the anticipated possible failure costs charged back to the OEM while the engine is under an extended warranty period.

Id. at 835.

negotiated rulemaking was not formally recognized until 1990, it is not surprising that the EPA opted not to use it for the major mobile source rules in the 1980s.³⁹⁷ This period is thus primarily about creating the circumstances that would later shape the EPA's choices among regulatory instruments once the EPA had such a choice.

4. Regulation-by-Negotiation

As it tightened standards during the 1980s, the EPA modified its approach to accommodate the need for greater flexibility in engine and truck manufacture. Initially, the EPA had simply required manufacturers to meet regulatory deadlines and then fought over pushing deadlines back. The EPA introduced delays in implementation to accommodate economic conditions in the industry³⁹⁸ and to accommodate manufacturers' need for lead time.³⁹⁹ The EPA also introduced "noncompliance penalties" that allowed engines that exceeded the standards (but which did not pollute beyond an "upper limit" of acceptable pollution)⁴⁰⁰ to be sold despite their failure to meet the standards.⁴⁰¹ The NCPs were intended to ameliorate problems with developing technology to meet the "technology-forcing" regulations.⁴⁰² This innovation was the result of the EPA's first "negotiated

397. See The Negotiated Rulemaking Act of 1990, 5 U.S.C. §§ 561-570; Administrative Dispute Resolution Act of 1996, 110 Stat. 3870, 3873-74 (codified at 5 U.S.C. § 561).

398. See Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 48 Fed. Reg. 1406 (Jan. 12, 1983):

At the time the initial final rules were being prepared, the industry had just finished a year of record sales (1978) and sales continued strong into 1979. However, in late 1979 and early 1980 a general economic downturn occurred . . . Engine and truck sales have dropped dramatically and most manufacturers have reported operating losses for 1980 and 1981.

Id. In response to this economic crisis, the Administration announced a number of regulatory relief initiatives aimed at reducing the cost of government regulations.

399. See 48 Fed. Reg. 1408 (Jan. 12, 1983):

[T]he remaining leadtime is inadequate for HDDE manufacturers to comply with 1984 HDDE emission standards and regulatory provisions . . . [the] EPA has therefore decided to revise the 1984 HDDE standards and other related regulatory provisions to 1983 levels for a period of one year. As in the case of HDGEs, the current 1984 emission standards and regulatory provisions remain optional.

Id.

400. See Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 50 Fed. Reg. 35,374 (Aug. 30, 1985) ("An 'upper limit' is an emission level, established by regulation and appropriate to a specific pollutant, above which an HDE or HDV cannot be certified.")

401. On Aug. 30, 1985, the EPA promulgated the generic aspects of a nonconformance penalty (NCP) rule to:

[A]llow a manufacturer of heavy-duty engines (HDEs) or heavy-duty vehicles (HDVs) whose engines or vehicles fail to conform with certain applicable emissions standards, but which do not exceed a designated upper limit, to be issued a certificate of conformity upon payment of a monetary penalty.

50 Fed. Reg. 35,374 (Aug. 30, 1985).

402. Control of Pollution From New Motor Vehicles and New Motor Vehicle Engines, 50 Fed. Reg. 35,374 (Aug. 30, 1985) ("In placing section 206(g) in the Clean Air Act, amendments of 1997 Congress intended NCPs as a response to perceived problems with

rulemaking" exercise.⁴⁰³ Agreement on the rule was reached in four months.⁴⁰⁴

The NCPs were conditioned on three findings by the EPA:

[A]n emission standard must become more difficult to meet, either because the standard itself has become more stringent or because compliance with it has been made more difficult because of another standard which has become more stringent; EPA must find that substantial work is necessary to meet the standard; and EPA must determine that there is likely to be a technological laggard.⁴⁰⁵

Why did the EPA choose regulation-by-negotiation for these rules? One factor was surely the promotion of regulation-by-negotiation itself within the agency. The push for regulatory negotiation in the 1980s meant there were advantages within the agency to adopting a strategy favored by agency administrators. With hostile forces within the Reagan Administration and Congress, the Agency had little political capital to lose in giving more control to the industry in the NCP negotiations. The cost of regulation-by-negotiation was thus low. Moreover, these issues fit our profile of the type of circumstances under which regulation-by-negotiation is desirable for agencies. The NCP rule was merely a negotiation over how much the industry would have to pay to exceed the standards – akin to a purely financial settlement of a lawsuit. Regulation-by-negotiation's structure was perfectly suited to this issue. The EPA had to satisfy the environmental pressure groups by showing that it was not letting the engine makers buy their way out of stricter pollution controls (or at least not doing so too cheaply). The structure of regulation-by-negotiation created the circumstances under which a dialogue between the pressure groups and the industry could take place, one more conducive to credible commitments than a sequential filing of public comments.

technology-forcing heavy-duty emissions standards. (Footnote omitted) Following *International Harvester v. Ruckelshaus*, 478 F.2d 615 (D.C. Cir. 1973), Congress realized the dilemma that technology-forcing standards were likely to cause . . . NCPs were intended to remedy this potential problem . . .").

403. See 50 Fed. Reg. 35,374 (Aug. 30, 1985):

This rule is the result of an innovative rulemaking process called Regulatory Negotiation, the concept of which is to allow the parties interested in or affected by the outcome of the rule an opportunity to participate in its development through face-to-face negotiations. This rule, which was proposed in 50 [Fed. Reg.] 9204 (March 6, 1985), is based upon the consensus that was reached during the Regulatory Negotiation process. This is [the] EPA's first completed rulemaking under this new regulatory process.

Id.

404. See GARY C. BRYNER, *BLUE SKIES, GREEN POLITICS: THE CLEAN AIR ACT OF 1990 AND ITS IMPLEMENTATION* 213 (1995).

405. Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines, 50 Fed. Reg. 35,375 (Aug. 30, 1985).

5. Regulation-by-Rulemaking Under the 1990 Clean Air Act Amendments

The next set of major amendments to the Clean Air Act came in 1990, after more than a decade of political stalemate due in part to Michigan Congressman John Dingell's attempts to weaken mobile source regulation and stall tighter rules⁴⁰⁶ and regional divisions over acid rain.⁴⁰⁷ When the stalemate finally broke, the result was a large, complex bill that addressed multiple major programs:⁴⁰⁸ "an eight-inch pile of approximately 1,500 pages of typescript."⁴⁰⁹ As part of that rewrite, the 1990 Clean Air Act Amendments added a number of new programs to mobile source regulation.⁴¹⁰ Most of these were not relevant to the heavy-duty diesel engine industry, but new fuel mandates did come into being⁴¹¹ and standards were tightened again.⁴¹² Many of the mobile source provisions affected consumers rather than manufacturers and helped stationary sources shift burdens onto mobile sources.⁴¹³ The 1990 Amendments shifted heavy-duty diesel regulation to § 202 generally, except for NO_x, which removed the requirement for specific reductions in emissions.⁴¹⁴ The effect of the 1990 amendments was "to freeze the newly established provisions for 14 years."⁴¹⁵

Section 201 of the Clean Air Act Amendments of 1990 revised the standards applicable to emissions of HC, CO, NO_x, and particulate matter from heavy-duty vehicles or engines manufactured during or after model year 1983 to ones "which reflect the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the model year to which such standards apply, giving appropriate consideration to cost, energy, and safety

406. BRYNER, *supra* note 404, at 110; *see also* Morriss, *Politics*, *supra* note 15, at 303.

407. *Id.* at 111.

408. Morriss, *Politics*, *supra* note 15, at 305-06; GEN. ACCT. OFF., GAO/RCED-00-72, STATUS OF IMPLEMENTATION AND ISSUES OF THE CLEAN AIR ACT AMENDMENTS OF 1990, at 5 (2000) ("In large part, the 1990 amendments to the Clean Air Act were intended to meet unaddressed or insufficiently addressed problems.").

409. Timothy E. Wirth, *Energy and Politics in the Clean Air Bill*, 5 TUL. ENVTL. L.J. 209, 209 (1991).

410. *See* Reitze, *Mobile Source*, *supra* note 56, at 333-38 (describing 1990 amendments mobile source provisions); *see also* Wirth, *supra* note 410, at 210 ("[T]he regulation of pollution from cars and trucks was one of the issues that dominated the politics of the [1990 amendments].").

411. *See* 104 Stat. 2399, 2490 (as codified at 42 U.S.C. § 7545(i)(1) (1995)) (describing that § 217 of the 1990 amendments prohibits diesel fuel which contains a concentration of sulfur in excess of .05 percent (by weight)).

412. The 1990 Clean Air Act Amendments and subsequent regulations tightened the standards by decreasing the permissible NO_x level for MY 1998 and the particulate standards starting in MY 1994. (See Table 1 for details). The regulations also applied the standards to engines' "useful life," making them more stringent.

413. *See* Morriss, *Politics*, *supra* note 15, at 309.

414. *See* ENVTL. L. INST., 2 LAW OF ENVIRONMENTAL PROTECTION § 11.07[2], at 11-211 (2001).

415. *See* FRANK P. GRAD, 1 TREATISE ON ENVIRONMENTAL LAW 2.06[D] (2001).

factors.”⁴¹⁶ The Administrator was also given the authority to revise heavy-duty vehicle or engine standards “promulgated under, or before the date of, the enactment of the Clean Air Act Amendments of 1990 (or previously revised under this subparagraph).” The Amendments also set stability of at least three model years and a lead time of no earlier than the model year commencing four years after promulgation of a revised standards.⁴¹⁷ After the 1990 Amendments, the EPA added regulations forbidding the use of “defeat devices” that would interfere with emissions controls in automobiles and light trucks.⁴¹⁸ Similar regulations were added for MY2000 heavy-duty diesel engines.⁴¹⁹

There were two important developments that changed the EPA's attitude toward diesel emissions in the 1990s. First, by 1997 the EPA was reporting that heavy-duty diesels were the largest sources of particulates and NO_x among mobile sources,⁴²⁰ and additionally that the disparity in regulations between gasoline and diesel vehicles was becoming an issue.⁴²¹ Second, by the early 1990s, scientists' views about the carcinogenicity of diesel emissions had changed significantly. Diesel exhaust particulates had been thought to be a carrier of chemical carcinogens. Now, however, based on the results of rat studies it was thought that the respirable particulate matter in diesel exhaust was itself a carcinogen.⁴²²

Although the EPA had used regulation-by-negotiation for the NCP rule in the 1980s and continued to use it for other rulemaking in the 1990s, it reverted to regulation-by-rulemaking for the standards under the 1990 Clean Air Act Amendments. This choice was not surprising given what was at stake: heavy-duty diesel engines were now one of the major sources of NO_x. The combination of the gap between the EPA's model and reality on NO_x, and the problems with nonattainment of the ozone standard led to increasing pressure to find new sources of NO_x reduction. Reductions of heavy-duty diesel NO_x would benefit other categories of mobile sources as well as stationary sources, and even a negotiation limited to NO_x sources was unlikely to produce agreement on who was going to pay for further NO_x reductions. Moreover, technology-forcing regulations are built around not believing industry's predictions about what can and cannot be

416. See Section 201, Clean Air Act Amendments of 1990, P.L. 101-549, 104 Stat. 2399, 2472 (codified at 42 U.S.C. § 7521(a)(3)(A)(i) (1995)).

417. See Section 201, Clean Air Act Amendments of 1990, P.L. 101-549, 104 Stat. 2399, 2472 (codified at 42 U.S.C. § 7521(a)(3)(C) (1995)).

418. See 40 C.F.R. § 86.094-16(a) (2001) (light duty vehicles and trucks).

419. See 40 C.F.R. §§ 86.000-16(a), 86.004-16(a) (2001) (new vehicles including heavy-duty engines).

420. *Diesel Engines Pollute Most*, 112(4) IMPLEMENT & TRACTOR 9 (1997) (finding that engines in industries such as construction and farming are to blame for about half of all mobile emissions of particulate matter and NO_x).

421. See Reitze, *Mobile Source*, *supra* note 56, at 341.

422. Nauss et al., *supra* note 121, at 7.

done – the opposite of the credible commitment function of regulation-by-negotiation.

6. *Negotiations over Principles*

Although not formally regulation-by-negotiation under the Statute, the EPA did engage in further cooperative efforts with the engine manufacturers and California regulators. In 1995, the engine manufacturers, the EPA, and the California Air Resources Board (CARB) negotiated a “Statement of Principles” (SOP) for future regulation of heavy-duty diesel emissions. The SOP intended to provide the manufacturers with greater stability in the regulatory environment.⁴²³ At the time, the EPA termed the SOP “an historic agreement” and “an example of the type of private/public and federal/state partnership approach to environmental regulation that EPA is pursuing.”⁴²⁴ The Statement of Principles included a commitment to a 50 percent reduction in NO_x and non-methane hydrocarbons by MY 2004, an averaging, banking and trading system for emissions credits, and improvements in fuel quality.⁴²⁵ In return for agreeing to the reductions in NO_x, the engine manufacturers secured agreements from the EPA not to reduce particulate standards and from California to delay a reduction in NO_x standards.⁴²⁶ Most importantly, the SOP gave the manufacturers more stability.⁴²⁷ These features were critical to the engine manufacturers’ support for the SOP, as well as the EPA’s use of a “dual” standard that gave manufacturers the choice between two standards for MY 2004 engines.⁴²⁸ When the EPA later proposed additional regulations, however, the engine makers had “a sense of betrayal” and called on the EPA to honor its “gentleman’s

423. See Control of Air Pollution from Heavy-Duty Engines, Appendix: Statement of Principles, 60 Fed.Reg. 45,580, 45,602-04 (proposed Aug. 31, 1995) (to be codified at 40 C.F.R. pts. 80, 86, and 89). The EPA signed a similar agreement with manufacturers of small spark-ignition engines used in lawn, garden, and utility applications. See also Mike Brezonick, *Engine Manufacturers Sign Statement of Principles Covering Small Engines*, 63 DIESEL PROGRESS—NORTH AMERICAN EDITION 60 (Feb. 1997).

424. See EPA Air and Radiation Office of Mobile Sources, *EPA, California Air Resources Board, and Manufacturers of Heavy-Duty Engines Sign “Statement of Principles”*, (July 1995) EPA420-F-95-010a, available at <http://www.epa.gov/otaq/regs/hd-hwy/noxsop2.txt> (providing the environmental fact sheet of the SOP between the EPA, CARB and the manufacturers of heavy-duty engines).

425. Statement of the Engine Mfrs. Ass’n, EPA Doct A-95-27, *Control of Emissions of Air Pollution from Highway Heavy-Duty Engines* 2-3 (1996).

426. See *Breakthrough Agreement Reached in Limiting Bus, Truck Emissions*, ENERGY REPORT, July 17, 1995, available at 1995 WL 8063311.

427. *Id.* (“The rules won’t change on us part-way through the game,” said Daniel Ustian with Navistar International Corp. of Chicago.”)

428. Statement of the Engine Manufacturers Association, EPA Doct A-95-27, *Control of Emissions of Air Pollution from Highway Heavy-Duty Engines* 8-9 (Sept. 12, 1996) (“The flexibility provided by the option [between standards] is critical Indeed, consensus was reached on the standards proposal only after the option was created.”)

agreement."⁴²⁹

As in the earlier NCP negotiations, the EPA had little bargaining power to lose by cooperating with CARB and the industry on the SOP, since CARB could act on its own. The potential gains from coordinating efforts were large, since the total cost of regulation for the industry could be reduced by adopting rules that were consistent across jurisdictions. Moreover, the potential gains from cooperation increased after the 1990 Clean Air Act Amendments freed the EPA from the straightjacket of Congressionally mandated specific reductions in emissions, since both pressure groups and the industry could stall the EPA's efforts through litigation over new rules.⁴³⁰

7. Regulation-by-Litigation & Engine Controllers

The EPA's regulatory efforts failed to reduce diesel emissions enough to solve the ongoing NO_x regulatory problem. The EPA acknowledged this when the EPA's engine programs director told a California group of pollution specialists that diesel emissions were not declining, as the EPA had predicted, but increasing.⁴³¹ Although some of the EPA staff's initial approach to the issue of reducing NO_x emissions had been conciliatory, identifying "to more actively engage industry" as a necessary step,⁴³² the EPA soon took an aggressive position that the use of electronic controllers to increase fuel economy during non-urban driving conditions amounted to illegal "defeat devices" under the Clean Air Act.⁴³³ Abandoning both the consensus-based approach of regulation-by-negotiation and traditional rulemaking, the EPA sued the seven U.S. engine manufacturers then operating, which together were makers of over 95 percent of U.S. heavy-duty diesel engines.⁴³⁴ Since the EPA's test simulates only urban driving conditions, the EPA contended the controllers were able to allow the engines to pass the EPA's test without impairing long-haul fuel economy

429. Ralph Kisiel, *Cloud Hovers Over Proposed Diesel Rules*, AUTOMOTIVE NEWS, Jan. 27, 1997, at 34.

430. The EPA, the CARB, and the engine manufacturers recently negotiated an agreement over the development of a new set of "in use" test protocols. Although space precludes an extended discussion of this negotiation, it is exactly the type of topic our theory predicts would be suited to regulation by negotiation, given its primarily technical nature. See *Engine Manufacturers Reach Innovative Accord with EPA and California to Help Assure Cleaner Air*, BUSINESS WIRE, June 11, 2003 (explaining that the EPA, the CARB, and the engine manufacturers recently negotiated an agreement over the development of a new set of "in use" test protocols).

431. See Bowman, *EPA Off*, *supra* note 36.

432. CHET FRANCE, ENGINE PROGRAMS AND COMPLIANCE DIVISION, EPA OFFICE OF MOBILE SOURCES, ACCOUNTING FOR OFF-CYCLE NO_x EMISSIONS FROM HEAVY-DUTY DIESELS 19 (copy on file with authors).

433. See James Kennedy, *\$1 Billion Settlement with Engine Makers Includes Largest Civil Penalty Under Air Act*, 29 BNA'S ENVIRONMENT REPORTER 1285-86 (Oct. 30, 1998).

434. See RHEIN, 5TH EDITION, *supra* note 185.

by reducing emissions only under test conditions.⁴³⁵ EPA Administrator Carol Browner claimed that the engine manufacturers “programmed the engine so that it knew when it was being tested and when it was on the road.”⁴³⁶ The EPA estimated that the practice improved fuel economy by 4-8 percent.⁴³⁷ Although the engine manufacturers denied the EPA’s claim that the controller use was illegal,⁴³⁸ on October 22, 1998, seven U.S. heavy-duty engine manufacturers settled the enforcement actions by agreeing to substantial fines⁴³⁹ and to retrofit the vehicles when they were rebuilt.⁴⁴⁰ They also agreed to a parallel settlement with California.⁴⁴¹

Understanding the EPA’s approach to diesel NO_x emissions requires a consideration of the engine controller issue that formed the basis of the EPA’s lawsuits, one that is far more complex than the EPA’s public comments on the issue suggests. We next outline the terms of the settlement of the litigation and then take up the question of why the engine makers agreed to settle, a crucial part of assessing the EPA’s strategy of regulating through litigation. Next, we assess the consequences of the settlement for air pollution and the engine industry. Finally, we look at the implementation of the consent decree and its impact on the industry.

435. See Kennedy, *supra* note 433, at 1285.

436. Jeff Johnson, *EPA Fines Engine Makers*, TRANSPORT TOPICS, Oct. 26, 1998, at 1.

437. See Kennedy, *supra* note 433, at 1285. Astonishingly, the EPA then claimed that removing the programing from the electronic controllers would not affect fuel economy, since it would be done when the engine was rebuilt and rebuilding engines improves fuel economy. *Id.* Since the rebuilding is independent of the controller changes, the correct measure would be whether or not a rebuilt engine without the controller change would have superior fuel economy to a rebuilt engine with a controller change, not a comparison of a rebuilt engine with the controller change and an unrebuilt engine with the original controller. The American Trucking Association claimed a loss of 10% fuel economy would result. See Johnson, *supra* note 436, at 1.

438. See Kennedy, *supra* note 433, at 1285 (noting that Caterpillar “agreed that it has employed electronic controls to improve fuel economy during ‘over the road’ driving conditions, but added that this was ‘an area where we believed the regulations did not apply,” and that Cummins stated that the company “has been in full compliance with both the spirit and the letter of the Clean Air Act and EPA emissions regulations” but chose to settle because it was cost effective to do so); see also Johnson, *supra* note 436, at 1 (quoting truck companies on the same point). Supporting the engine manufacturers’ claim was a comment from the chief deputy executive officer of the California Air Resources Board in 1997: “I would like to have seen them minimize emissions no matter how the engines operate, but they weren’t required to do that.” Bowman, *EPA Off*, *supra* note 36.

439. The fines were based on sales of engines alleged to violate the rule and totaled:

Caterpillar \$60,000,000, Cummins \$60,000,000, Mack Trucks \$31,000,000, Detroit Diesel \$24,500,000, Volvo \$14,000,000, and Navistar International \$2,900,000.

Johnson, *supra* note 436 at 1.

440. See *id.* at 1.

441. See *Diesel Makers to Pay \$37 Million in Parallel Settlement with California*, 29 BNA’s ENVIRONMENT REPORTER 1285 (1998) (describing the agreement the same six diesel engine makers made with California, including \$37 million in fines and agreement to introduce cleaner engines on an expediated schedule).

a. *The Engine-Controller Issue*

There is much that is disputed concerning the engine litigation, with the EPA and the engine manufacturers holding divergent views on the merits and their respective likelihoods of success on the merits. However, the basic facts of how the electronic engine controllers operated are relatively uncontested. When engines were operating under the FTP test cycle conditions, all agree that they met the relevant the EPA emissions standards. When the engines were operating under non-FTP conditions, particularly highway driving conditions, the engines produced higher emissions levels than under FTP-conditions. The EPA alleged that this constituted a violation of the Clean Air Act's requirements; the engine makers argued that it did not.⁴⁴²

The engine manufacturers alleged that the EPA knew about their use of electronic controllers from the beginning and had at least tacitly approved it.⁴⁴³ For example, Volvo officials pointed to the existence of test results from Europe, using the quite different European test protocol, showing different results from the U.S. tests to demonstrate that the EPA was aware of controllers' impact by at least 1994 because the results were presented at a meeting attended by EPA officials.⁴⁴⁴ A presentation by an EPA staff member had identified control strategies "based on the transient test cycle" as "the regulatory requirement,"⁴⁴⁵ again suggesting the EPA was both aware of and approved of building emissions control strategies around the test protocols. Environmental organizations concurred, claiming they had

442. The engine manufacturers' defense, briefly, was that

the numeric standards apply when the engines are operating under conditions represented by [the] EPA's FTP, but that these limits do not apply when an engine is in other modes of operation. Under those circumstances, they say, emissions are unregulated, or at most, regulated only through the prohibition against defeat devices, and they argue that their engines do not employ defeat devices.

EPA, Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments, at 84, *United States v. Caterpillar, Inc.*, Civil Action 1:98CV02544 (Apr. 30, 1999).

443. See Jim Galligan, 'EPA Betrayed Us,' *Engine Makers Say Agency Knew About Designs, Test*, TRANSPORT TOPICS, Nov. 2, 1998, at 30.

444. Parker, *Engine Tests*, *supra* note 35, at 1; John Parker & Jeff Johnson, *Evidence Grows that EPA Knew About Test Flaws*, TRANSPORT TOPICS, Dec. 21, 1998, at 47 ("Documents from the [1991] Geneva meeting, attended by EPA, state that the agency's 'transient cycle' test was already known to grossly underestimate emissions of NO_x at highway speeds."). This was confirmed in ASLEEP AT THE WHEEL, *supra* note 36, at 14-15, which also noted that *Inside EPA's Mobile Source Report* had included information on the software in a 1994 article. *Id.* at 14. (The article is reprinted in ASLEEP AT THE WHEEL, *supra* note 36, app. K.) A January 27, 1994 memo from Thomas M. Baines, senior technical advisor in the Office of Mobile Sources to the office director confirms that the EPA knew of the results presented at the Geneva meeting. The memo is reprinted in ASLEEP AT THE WHEEL, *supra* note 36, app. H.

445. Chet France, Engine Programs and Compliance Division, EPA Office of Mobile Sources, *Accounting for Off-Cycle NO_x Emissions from Heavy-duty Diesels* at 12 (n.d.) (copy on file with authors).

identified the problem in 1995 to the EPA.⁴⁴⁶ CARB also initially identified the problem as the EPA's test procedures⁴⁴⁷ and northeastern states raised the issue with the EPA in 1996.⁴⁴⁸

A highly critical House Commerce Committee staff report, *Asleep at the Wheel*, also concluded that the EPA was aware of the engine manufacturers' use of electronic controllers as early as 1991.⁴⁴⁹ Among the additional instances recounted in *Asleep at the Wheel*:

- Representatives from Mercedes-Benz met with EPA officials in June 1991, presenting test data that showed that "engine timing on a competitor's engine increased after a certain amount of time had elapsed beyond the length of the FTP cycle."⁴⁵⁰
- In the course of reviewing the Mercedes' data, an EPA employee wrote a report concluding that "electronic controls are being used to tailor an engine's performance to the transient test."⁴⁵¹
- In July 1991 an independent computer programmer approached the EPA, alleging he had been hired to write defeat device code for Detroit Diesel.⁴⁵²
- John Deere & Co. submitted comments to an EPA rulemaking on

446. Parker & Johnson, *supra* note 444, at 47 (quoting an NRDC senior attorney that "[a]nybody involved in the regulation of diesel emissions—whether—in government, industry, an environmental group, or a state organization—knew that there was a disconnect between certification emissions and in-use emissions, and frankly I've been raising that issue since 1995 with the agency"). See Natural Resources Defense Council et al, *Comments Concerning EPA's Advanced Notice of Proposed Rule-Making for the Control of Air Pollution from Heavy-Duty Engines*, at 14-15 (Oct. 23, 1995) (copy on file with authors) ("Existing test methods need to be modified in several important respects: . . . to improve the test's sophistication and sensitivity to electronic engine controls . . . Additionally, the tests' sophistication needs to be improved to prevent the certification of engines that perform only within the narrow range of driving conditions simulated in the test cycle. For example, the current protocol is unable to identify and account for engines that incorporate controls called 'transient sensing algorithms.' These controls can automatically adjust engine timing and interrupt key emissions control devices such as EGR during extended periods of steady-state driving.").

447. See *ARB Says Old Test May Explain National Heavy-Duty Emission Exceedances*, INSIDE CAL/EPA, Feb. 27, 1998, at 2.

448. Letter from Northeast States for Coordinated Air Use Management, to Mary Nichols, Assistant Administrator, Office of Air and Radiation 8 (Sept. 11, 1996) (copy on file with author) ("Since onboard computers can quickly and dramatically change an engine's operating and emissions characteristics, engines operating in 'off-cycle' modes can be optimized for fuel economy and power at the expense of emissions.").

449. ASLEEP AT THE WHEEL, *supra* note 36, at 6-7 ("[The] EPA was informed, as early as 1991, that certain heavy-duty diesel engine manufacturers were using an electronic fuel injection strategy that would retard engine timing to meet the FTP, but would advance engine timing under long-haul highway operation in order to improve performance and fuel economy . . .").

450. *Id.* at 7.

451. *Id.* at 8.

452. *Id.* at 9-12. See also John Deere & Co., EPA Air Docket A-91-24, *Deere & Company Comments on Environmental Protection Agency Notice of Proposed Rulemaking "Control of Air Pollution: Emissions of Oxides of Nitrogen and Smoke from New Nonroad Compression-Ignition Engines at or Above 50 Horsepower"* at 2-3 (June 25, 1993).

off-road diesel engines noting it had discovered software in on-road engines that distinguished steady-state and transient operation, and producing higher NO_x emissions under the transient conditions.⁴⁵³

- A 1993 OECD publication on emissions control noted that “a recent set of tests in the U.S. EPA Motor Vehicle Emission Laboratory” found evidence of a “defeat strategy.”⁴⁵⁴

EPA officials, however, denied knowledge before 1997, claiming they discovered the problem only when retesting an engine that had failed its initial test.⁴⁵⁵ Given the extensive evidence of multiple EPA employees' knowledge of the controller use and the agency's work on exactly the same issue during the 1970s in the automobile area, it is implausible that the agency was unaware of the problem well before the decision to litigate.

Regardless of the merits of this particular dispute over whether the EPA had known of the use of electronic controllers or not, there is clearly a gray zone involving controller use. Indeed, in a 1972 memo, the EPA's Office of Air Programs identified precisely this problem:

Where does the basic engine stop and the control system begin? In a strict sense, even basic components such as a carburetor and a distributor could be considered defeat devices. The carburetor varies the air-fuel ratio, depending on air flow, throttle position, throttle movement, manifold vacuum, and other parameters. The distributor advances the spark as engine speed increases or load decreases.⁴⁵⁶

Using such devices to protect engines or vehicles from damage “under extreme operating conditions” is clearly not illegal.⁴⁵⁷ Using them to “reduce control system effectiveness under ambient or operational conditions which are characteristically low emission modes in order to improve engine economy and/or performance” would not harm emissions goals and would improve engine performance.⁴⁵⁸ Rather, as the EPA concluded in 1972, the devices are illegal when they are “intended to ‘beat

453. ASLEEP AT THE WHEEL, *supra* note 36, at 12-14. This was apparently well-known, since the American Lung Association discussed it in its 1996 comments to the EPA on a notice of proposed rulemaking. See American Lung Association, *Comments on EPA NPRM on Control of Emissions of Air Pollution from Highway Heavy Duty Engines*, at 3-4 (Apr. 12, 1996).

454. OECD, *Control of Emissions from Heavy-Duty Vehicles*, 45 (1993) reprinted in ASLEEP AT THE WHEEL, *supra* note 36, app. J.

455. See Jeff Johnson, *EPA Denies It Knew of Engine Test Flaws*, TRANSPORT TOPICS, Dec. 28, 1998, at 1; see also Galligan, *supra* note 443, at 30; ASLEEP AT THE WHEEL, *supra* note 36, at 16; Letter from Richard D. Wilson, Acting Assistant Administrator for Air and Radiation, to Rep. Thomas Bliley, reprinted in ASLEEP AT THE WHEEL, *supra* note 36, app. B.

456. EPA, OFFICE OF AIR PROGRAMS, MEMO: CHARACTERIZATION AND USE OF EMISSION CONTROL SYSTEMS THAT OPERATE ONLY UNDER SPECIFIC AMBIENT CONDITIONS OR VEHICLE OPERATIONAL MODES 6 (1972).

457. *Id.* at 1.

458. *Id.*

the test.”⁴⁵⁹

In 1972 the EPA wrestled with exactly the same issue with respect to automobiles as it faced in 1997-1998 with the heavy-duty diesel engines. The EPA’s investigation then, for example, determined that prohibiting “all temperature actuated devices” would affect “substantially all of the production of 14 [automobile] manufacturers.”⁴⁶⁰ When considering how to treat these controls, the EPA’s staff position paper determined that rejecting a vehicle because of its emissions outside of the federal test procedure was inappropriate and that revision of the FTP was the more appropriate means to address such concerns.⁴⁶¹ The staff recommended putting the focus on whether or not a particular control was aimed at discovering the test cycle or at modifying operations to adapt to engine conditions.⁴⁶² A reader of this EPA paper could thus plausibly conclude that the EPA did not consider off-cycle emissions as a violation of the statute.

Early work identified that

[t]he major advantage of electronic controllers, in terms of emission control is that they permit control system components to be programmed based on instantaneous sensing of engine variables. This allows control devices to operate fully when they have the most beneficial effect on emissions and the least deleterious effect on other aspects of engine performance.⁴⁶³

A controller that varies engine operation during certain conditions to protect the engine may be hard to distinguish from one that does so merely to avoid performance penalties, particularly when emissions controls are not post-combustion “black boxes” like catalytic converters, but rather combinations of injection timing and other engine parameters.⁴⁶⁴ Moreover, even before the advent of electronic controllers, the optimization of emissions control during testing was a well recognized strategy of mobile source manufacturers.⁴⁶⁵ Indeed, as Caterpillar told the EPA in 1978,

459. *Id.* at 7, 8.

460. EPA, OFFICE OF AIR AND WATER PROGRAMS, MOBILE SOURCE POLLUTION CONTROL PROGRAM, ISSUE PAPER: THE DEFEAT DEVICE ISSUE 3, at 4-5 (1972). The agency reached similar conclusions about pressure activated devices. *Id.* at 5.

461. *Id.* at 7.

462. *Id.* at 16-18.

463. MOTOR VEHICLE NITROGEN OXIDES STANDARD COMMITTEE, *supra* note 64, at 24.

464. John Deere & Co. found, for example, that two engines it tested in the early 1990s advanced injection timing after a period of steady state operation, yielding a 16% increase in fuel economy. See American Lung Association, *Comments on EPA NPRM on Control of Emissions of Air Pollution from Highway Heavy Duty Engines*, at 3-4 (Apr. 12, 1996). Since steady state operation would indicate both highway driving and that the EPA transient test was not being performed, it is not obvious that anything illegal was being done.

465. See EPA, SUMMARY AND ANALYSIS, *supra* note 92, at 7 (stating that the EPA’s “early decision to push for a transient certification procedure was initially brought on by observations of light-duty emissions control. The manufacturer’s ability to selectively

“manufacturers have no choice but to design engines to meet whatever test is prescribed.”⁴⁶⁶ The EPA itself concluded in 1979 that “the attainment of emission standards entails designing to a given test procedure.”⁴⁶⁷ Such optimization need not be the result of bad motives—engines optimized to the US test cycle performed poorly on European tests and vice versa.⁴⁶⁸ Indeed, the most plausible explanation for the difference between test results and actual emissions was offered by *Fleet Owner* magazine, when it stated that the EPA “told engine makers to develop new technology to meet the law, but wrote enforcement procedures based on old technology.”⁴⁶⁹ The technology that developed was “far more sophisticated than [the] EPA anticipated.”⁴⁷⁰

One result of the combination of the form of the EPA's regulations and advances in engine controls was that it became possible for engine controllers to detect the EPA test cycle and manage engine performance to minimize emissions of regulated pollutants during the test cycle. Testing of pre-MY 1999 engines showed that controllers were programmed to do so.⁴⁷¹ As a result, diesel emissions were significantly more than predicted for NO_x and particulates.⁴⁷² Similar problems occurred with automobiles.⁴⁷³

There is much that we will never know about the heavy-duty diesel litigation, including the subjective state of mind of the EPA's and the DOJ's litigators at the time the lawsuit were filed. Interviews with a wide range of sources elicited numerous off-the-record hypotheses about the rationales for the EPA's behavior, including career advancement strategies for particular individuals, political pressure related to the Gore campaign for President, and an internal lack of communication that left litigators unaware of the earlier (at least) tacit approval of engine controllers' use to enhance fuel economy in off-test-cycle conditions. Whatever the reason, the record seems clear that personnel at the EPA were aware of the

optimize emission control systems to pass simplistic test procedures . . . was recognized early on . . .”).

466. *Id.* at 11.

467. *Id.* at 219.

468. See ASSOCIATION, TEST CYCLE, *supra* note 239, at 4, Table 2 (summarizing differences in emissions).

469. Jim Mele, *New Tech, Old Regs*, 93 FLEET OWNER, Aug. 1998, at TC3.

470. *Id.*

471. See Clark et al., *Factors Affecting*, *supra* note 62, at 92 (discussing injection timing variances).

472. A comparison of the EPA test cycle data with actual operating data on two engines found, for example, that test and operating conditions differed by large amounts. See *id.* at 94 (explaining that PM emissions differ by a factor of 15 and NO_x emissions by a factor of 3 in different test schedules; injection timing differences made NO_x emissions differ by a factor of 2).

473. See Reitze, *Mobile Source*, *supra* note 56, at 359-60 (describing dispute between the EPA and General Motors over “a computer chip that increased fuel flow when the air conditioning and heating was used” at a time when the test protocol did not call for use of either. GM ended up paying \$45 million in penalties).

controllers' use long before the litigation and had tacitly accepted, if not formally approved it. The EPA thus might not quite fit the Claude Raines's profile from *Casablanca*, but it misses only because it is an agency of millions of employees, not because it is plausible that some agency employees were unaware of how the controllers worked. The EPA's "shocked, shocked" reaction in 1997 may not have been a purely cynical move, but it did not accurately reflect the state of knowledge within the agency concerning controllers' interaction with the FTP. The EPA's litigation position may have simply been tactical or reflected genuine outrage by litigators and top policy makers at having failed to secure compliance with the "spirit" of their regulation, but the facts can hardly have been a surprise to anyone at the EPA who had spent time working with actually implementing regulations. Moreover, the EPA's willingness to settle and subsequent defense of the consent decrees against criticism by environmental pressure groups and state regulators who saw them as too weak supports the conclusion that, despite the EPA's press hype about the clear nature of the violations, winning the suits was not a foregone conclusion.⁴⁷⁴

b. Settling the litigation

The EPA and the engine manufacturers settled the litigation in October 1998, entering into a series of consent decrees that set out a lengthy series of actions each company was required to take and imposed substantial penalties on the companies. The consent decrees imposed four types of injunctive relief: "1) a schedule for compliance with currently-applicable requirements, including specified emissions limits for new engines; 2) supplemental testing requirements; 3) programs to address emissions from engines already on the road; and 4) other projects to reduce overall emissions of NO_x and other pollutants to the environment."⁴⁷⁵

The emissions standards applied under the settlement became stricter over a two-year period, requiring engines used primarily under urban driving conditions and manufactured after November 1, 1998 to meet both a 4.0 g/bhp-hr standard under the FTP and a 6.0 g/bhp-hr standard under

474. See, e.g., EPA, Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments, at 36-37, *United States v. Caterpillar, Inc.*, Civil Action 1:98CV02544 (Apr. 30, 1999) ("Certainly the risk of higher penalties after trial is something the engine manufacturers had to consider, just as the United States had to consider the risk of lower penalties or none at all."); see *id.* at 90 ("While it is possible that the United States may have obtained higher penalties if the cases were tried, it is also possible that the penalties assessed by the Court would have been lower than that attained in settlement.").

475. *Id.* at 14-15. We cite to this document for the details of the settlement terms, since it covers all the settlements, while citing to the actual individual consent decrees would require addressing each company's decree individually.

the “Euro III” test.⁴⁷⁶ After July 31, 1999, emissions had to fall to 4.0 g/bhp-hr on both tests, and by October 1, 2002 had to meet the standard the EPA had imposed through rulemaking for October 1, 2004, which was a 2.4/2.5 g/bhp-hr NOX plus NMHC on both the FTP and Euro III tests.⁴⁷⁷ For engines in vehicles used primarily on the highway, a longer phase-in was allowed, giving the engine manufacturers until the end of 1998 to meet the 6.0 g/bhp-hr Euro III test and October 1, 2002 to meet the 2.4/2.5 g/bhp-hr NOX plus NMHC test on both the FTP and Euro III.⁴⁷⁸ In sealed portions, the consent decrees also identified “those strategies that the United States [allowed] . . . each engine manufacturer to use in the interim period” until October 2002, to allow an orderly transition to the new engines required after that date.⁴⁷⁹ “Any strategy not listed and which does not independently satisfy [the] EPA’s screen for defeat devices, is not allowed.”⁴⁸⁰

Testing requirements changed as well. In addition to the FTP, the consent decrees added several supplemental tests, including the Euro III test, which examines “13 test points representing different steady state conditions . . . within the normal operating range of the engine” and covers conditions “more representative of extended highway driving.”⁴⁸¹ Another required test imposed a “not to exceed” limit over a specified range of operations, set at about 1.25 times the applicable FTP standard.⁴⁸² A “Transient Not-to-Exceed Limit” covered short bursts of emissions during conditions such as accelerating after traffic stops and went into effect after October 2002.⁴⁸³ Finally, the consent decrees imposed a “Smoke or Opacity Limit” on particulate and smoke emissions to prevent tradeoffs of NO_x and particulate emissions.⁴⁸⁴ In-use testing was also required to ensure engines “continue to meet the reduced emissions limits and other requirements throughout their useful lives.”⁴⁸⁵

In short, the consent decrees created an entirely new set of test protocols layered on top of the FTP that addressed the FTP’s shortcomings. The imposition of transient limits, testing over a wider range of operating

476. *Id.* at 14-16.

477. *Id.*

478. *Id.* at 15-16.

479. EPA, Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments, at 17, *United States v. Caterpillar, Inc.*, Civil Action 1:98CV02544 (Apr. 30, 1999).

480. *Id.*

481. *Id.* at 18

482. *Id.*

483. *Id.* at 18-19.

484. *Id.* at 19.

485. *Id.* at 19. The in-use testing program is quite complex, but we omit the details here as what matters most is that the EPA now sought to match in use testing to the prior engine only tests.

conditions, and the addition of in-use testing to the out-of-chassis testing transformed the FTP into a wholly new test protocol. Engines designed for sale after October 1, 2002 could not have used the prior strategy the EPA alleged constituted a defeat device. Of course, the EPA could have modified the FTP to adopt additional test procedures at any time without suing the engine manufacturers. Had it done so, however, the EPA would have been required by the notice-and-comment procedure to allow public comment on the modifications, including public discussion of the costs and benefits of the various changes. It is likely also that the changes in the FTP would have been found sufficiently major to involve the Clean Air Act's lead time provisions. To justify such changes, the EPA would also have had to explain why the earlier FTP was inadequate—conceding at least implicitly that the EPA had failed to adequately design the FTP to cover actual driving conditions. By adopting these changes through the consent decrees, the EPA avoided the embarrassment of such an admission of regulatory failure and avoided an extended public debate (and likely set of court challenges by affected parties and environmental pressure groups) over its testing methodology.⁴⁸⁶

To reduce emissions from the existing engines, the EPA and the engine manufacturers agreed to a “Low NO_x Rebuild Program” that would cover engines manufactured between 1993 and 1998.⁴⁸⁷ Under this program, the engine manufacturers must provide to those who rebuild engines (including independent firms) free rebuild kits that will “significantly reduce

486. General Motors' Chief Engineer, for example, a truck manufacturer but not an engine manufacturer for heavy-duty engines, noted in a filing in a consent decree proceeding that

The imposition of these arbitrary numerical limits over a wide range of engine operating conditions greatly restricts an engine's allowed operating characteristics. Traditionally, under the FTP test, emissions were permitted to vary in response to engine operating conditions so long as the emissions over a typical driving cycle (the FTP) did not exceed the emissions limits. Under EPA's interpretation of the new supplemental test procedures, these limits must be met under nearly all engine operating conditions. Thus, it makes no difference whether the engine is being operated up a steep hill, into the wind, at high altitude, with a full load, on a hot day. That engine must meet the same numerical emission limits as when it is operated with virtually no load, down hill, at sea level, on a cool day. No allowance is made for differing engine conditions. The imposition of the supplemental testing requirements results in the need to design engines that exhibit different emission profiles. Lower emissions are now required under a wide variety of engine operating conditions and cannot just be lowered proportionately to meet the FTP limits.

Declaration of Steven Matsill, *United States v. Caterpillar, Inc.*, Civil Action Nos. 98-2544, 98-2546, and 98-2546, at 5 (D.D.C. Nov. 27, 2002).

487. The settlement included a choice of rebuild programs, allowing engine manufacturers to include either 1993-1998 or 1994-1998 engines, with a slightly stricter standard applying to the shorter period. See EPA, Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments, at 21, *United States v. Caterpillar, Inc.*, Civil Action 1:98CV02544 (Apr. 30, 1999).

emissions from current actual levels.”⁴⁸⁸

Finally, the engine manufacturers agreed to an additional set of programs to offset the “excess” emissions caused by their controllers. One portion cancelled the emissions credits that manufacturers had previously earned for overcomplying engines, which under the settlement’s terms were no longer in compliance.⁴⁸⁹ The engine manufacturers also agreed to meet MY 2006 nonroad equipment standards by MY 2005.⁴⁹⁰ Finally, each company agreed to spend specified sums on projects that offset excess emissions.⁴⁹¹

The non-test protocol portions of the settlement helped the EPA with its ozone NAAQS problem by cutting actual NO_x emissions, which reduced ozone in the model although did not necessarily do so in reality. Almost none of these provisions were ones that the EPA could have imposed directly through regulation, although some were relatively straightforward mitigation measures. Every ton of NO_x removed from the atmosphere and captured by the EPA’s models, through these various programs, helped reduce the NO_x overload that was causing problems without imposing additional costly controls on either upwind or downwind regions. To gain such reductions without the litigation, the EPA would have had to offer something of value to the engine manufacturers and, other than relaxing other limits, the EPA had little to put on the table. Of course the EPA could have funded such projects directly, but that would have required convincing Congress to appropriate \$104 million for it. By using regulation-by-litigation, the EPA got that appropriation for free. The EPA paid Congress not to object by directing the fines into the federal treasury. As the state of New York, which objected to the consent decrees, noted, those fines could have been allocated for additional NO_x reductions, but the EPA chose not to do so.⁴⁹²

Regulation-by-litigation thus offered the EPA significant gains over rulemaking. None of the settlement provisions other than the test protocol changes could have been directly imposed through rulemaking, either

488. *Id.* Several manufacturers also committed to specific product recalls and retrofitting programs. *Id.* at 21-23. An important issue with the implementation of the settlement was the problem of the interdependence of engine operating parameters that made a simple change in the controller’s program insufficient. It is unclear whether customers accept the reprogramming of the controllers that this entailed, since the reprogrammed controller would certainly provide reduced mileage.

489. *Id.* at 23.

490. *Id.* at 23-24.

491. These sums were: Caterpillar, \$35 million; Cummins, \$35 million; Detroit Diesel, \$12 million; Mack/Renault, \$13 million; and Volvo, \$9 million. EPA, Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments, at 24, *United States v. Caterpillar, Inc.*, Civil Action 1:98CV02544 (Apr. 30, 1999).

492. *Id.* at 87.

because of the lead time provisions of the Clean Air Act or because the provisions were outside the EPA's authority to require in regulations. As the EPA stated in responding to objections about the consent decrees from nonparties, "there is nothing that bars the United States from obtaining relief that goes beyond present regulatory or statutory requirements."⁴⁹³ Imposing the test protocol changes through rulemaking would have generated a contentious and lengthy process, with the EPA in the difficult position of having to make the case that the existing protocol was inadequate to justify the changes. Moreover, any rulemaking would likely have yielded changes only after the process was completed, pushing the gains into the future. Since the EPA needed NO_x reductions sooner rather than later, this made rulemaking an unattractive option. The settlement process also eliminated the industry challenges to the measures and increased the agency's authority relative to the environmental pressure groups and others who might object, since the changes would be reviewed as part of the settlement process rather than in a challenge to a rulemaking proceeding.⁴⁹⁴ As the EPA noted in seeking approval of the settlements, the complaints of many of the commentators on the settlements was

that the government did not conduct this negotiation as it does a rulemaking, bringing all "stakeholders" to the table, and working out a solution in the same way that they participated in the development of the emission standards. But the fact is that this matter is far from a rulemaking. This is an enforcement action alleging longstanding violations of the law, for which prompt compliance is a necessary remedy. While the public has an opportunity to comment on a consent decree during the comment period, it is neither feasible necessary nor appropriate for the public to be present in negotiations of the United States' claims against individual defendants.⁴⁹⁵

The EPA was able to gain from choosing regulation-by-litigation. The EPA's gains included faster reductions in NO_x levels from heavy-duty engines, circumvention of the Clean Air Act's lead time provisions, limits on environmental pressure groups' participation, and a public relations coup. The EPA even gained an advantage in defending its MY 2004 rulemaking efforts; the consent decrees' pull-ahead of the MY 2004 standards defeated a trucking industry challenge to the MY 2004 rules

493. *Id.* at 38-39.

494. A comparison of the EPA's responses to the comments opposing portions of the settlements with the EPA's responses to comments in rulemaking proceedings shows the EPA's reduced concern over potential challenges. The responses in the former are shorter and less detailed than the EPA's responses to significant comments in rulemakings.

495. *Id.* at 38. *See also id.* at 97 (summarizing comments from the California Trucking Association, the American Trucking Association, and Freightliner that "the Consent Decrees are circumventing Congressional intent regarding stability and lead time, and the government should be required to brief the court fully on why this is permissible").

themselves by mooted the truckers' standing to challenge the regulations.⁴⁹⁶ All of these were valuable to the EPA.

c. Choice of Technology

Significant technological innovation was necessary to meet the MY 2004 standards that had been pulled ahead to October 1, 2002 by the consent decrees. The standards agreed to in the consent decrees were clearly technology forcing. As a Cummins' vice president summed it up: "This is the first time I've ever come before the EPA without a clear idea of exactly how we're going to get to [the standards.]"⁴⁹⁷ The engine makers ultimately took divergent strategies toward compliance with the EPA, producing what one news account headlined as "EPA Rules Spark Engine War."⁴⁹⁸ There were gains to be had by any firm that could break free from the pack through technological advantage.⁴⁹⁹ Indeed, the EPA may have created the conditions for foreign firms to enter the US market.⁵⁰⁰ Mercedes Benz was able to sell its MBE4000 and MBE900 engines through 2003 while meeting only the 1998 emissions standards, allowing it to undercut its U.S. competitors' prices.⁵⁰¹ Mercedes's sales of the MBE4000 went from 1,764 in 2002 to over 10,000 in the first eight months of 2003.⁵⁰²

All of the U.S. engine makers except Caterpillar announced plans to develop various forms of EGR systems⁵⁰³ that would enable their engines to meet the October 2002 deadline, but which would be insufficient to meet

496. See *Crete Carrier Corp. v. EPA*, 2004 WL 756039, at 3 (D.C. Cir. Apr. 9, 2004) (noting that establishing the connection between 2004 standards and the trucking company plaintiffs' higher cost "would be the work of a minute" but for the Consent Decrees and concluding that "[b]ecause of the Consent Decrees . . . the Trucking Companies have not established the necessary causal connection between the 2004 Standard and the increased costs they will incur").

497. Sean Kilcarr, *Will the Diesel Engine Survive?*, 96 FLEET OWNER, Nov. 2001 at S11.

498. Boris Ladwig, *EPA Rules Spark Engine War*, THE REPUBLIC, May 5, 2002, at A1.

499. See Kachadourian, *supra* note 253, at 17 (quoting "Mack Trucks Inc. of Allentown, Pa., says it has an advantage because it makes both trucks and engines. The company is developing a cleaner engine and expects it to be in production by this summer").

500. EPA, Memorandum of Law of the United States of America in Support of Motion to Enter Consent Decree and Response to Public Comments, at 99, *United States v. Caterpillar, Inc.*, Civil Action 1:98CV02544 (Apr. 30, 1999) ("These emission limits and test protocols [in the consent decrees] do not impose any additional requirements on non-signatories to the decrees.").

501. RHEIN, 7TH EDITION, *supra* note 185, at 21.

502. *Id.* at 26.

503. The five adopted different technological approaches to meeting the consent decree requirements: Detroit Diesel is using an EGR system. *Low Emissions Engines Dominate Mid-America Trucking Show*, 41 OVERDRIVE, May 2002, at 12. Volvo is using an EGR system that uses high pressure pulses created by the exhaust system; Mack is using a "cooled EGR" system; Cummins has a cooled EGR system with a proprietary "variable geometry turbocharger;" Caterpillar has a non-EGR system that "involves optimizing in-cylinder combustion and using exhaust after treatment along with an oxidizing catalyst chamber." Bob Deierlein, *Running Hot*, 27 FLEET EQUIPMENT, Oct. 2001, at 31, 32.

the MY 2007 standards already announced. The EGR systems had some significant drawbacks; for example, Mack's had a 3 percent fuel consumption increase and added 100 pounds to the engine weight.⁵⁰⁴ Similar decreases in fuel economy occurred for the other EGR manufacturers' engines.⁵⁰⁵ The EGR engines also increase soot, putting higher demands on the engine oil⁵⁰⁶ and significantly increased demands on the engine cooling system.⁵⁰⁷ The October 2002 engines increased in cost between \$3,000 and \$5,000 compared to the prior year's models.⁵⁰⁸ For this group, a new emissions technology would have to be developed for the MY 2007 engines and the EGR system would be sufficient for MY 2003-MY 2006 engines. Although the EGR engines turned out not to require major chassis redesigns, as truck makers had initially feared,⁵⁰⁹ they did require changes to the cooling system, controllers, and oil system.⁵¹⁰ Some manufacturers used incentives to lure customers to the new engines. International, for example, offered \$2,500 in incentives for buyers of the October 2002-compliant trucks.⁵¹¹

Caterpillar, on the other hand, abandoned its EGR research in March 2001⁵¹² and focused on a system it called ACERT (Advanced Combustion Emissions Reduction Technology).⁵¹³ Caterpillar's non-EGR strategy was a

504. See Jim Starling, *Engine Makers Display Low-Emission Models*, TRANSPORT TOPICS, Mar. 25, 2002, at 35 (basing these statistics on the findings of an SAE Type IV fuel test).

505. See *id.* (noting that Cummins ERG engines will drop 3-5% in fuel economy and climb in weight by up to 130 pounds, and that Volvo's new engines will increase fuel consumption by 3% to 5% as well).

506. Tom Kelly, *The Show Must Go On*, RPM, May 2003 (on file with authors).

507. See Carol Birkland, *EGR: Its Time Has Come*, EQUIPMENT TECH., Feb. 2002, at 16 (quoting the chair of a SAE panel on the challenges posed by EGR: "The recycling of exhaust gas through a heavy-duty diesel engine will add 100,000 to 150,000 BTUs per hour to the cooling system. It is estimated that 15 to 20 percent of the heat from the exhaust will radiate from the EGR system to its surroundings, and the remainder will be added to the cooling system. Potentially, the additional heat load could be 60 percent of the exhaust heat or 288,000 BTUs per hour"); see also *Low Emissions Engines Dominate Mid-America Trucking Show*, 41 OVERDRIVE, May 2002, at 12-13 ("One ongoing concern about EGR engines is the increased cooling capacity required, since the hot exhaust will be going back into the engine rather than out.").

508. John Wislocki, *Kenworth Says Price Will Drive Decisions on Engines*, TRANSPORT TOPICS, Mar. 25, 2002, at 35.

509. See, e.g., Rolf Lockwood, *Elegant Solutions?*, HIGHWAY STAR, May 2002, at 22, 23; Steve Sturgess, *The Power and the Glory*, HEAVY DUTY TRUCKING, May 21, 2002; Steve Sturgess, *Lifting the Veil on EGR*, HEAVY DUTY TRUCKING, April 2001, at 98 (stating that meeting new standards "won't be as bad as feared").

510. Steve Sturgess, *The Power and the Glory*, HEAVY DUTY TRUCKING, May 21, 2002.

511. RHEIN, 7TH EDITION, *supra* note 185, at 177.

512. See Memorandum from Steve Brown, to Caterpillar Field Force, Re: "Additional Information for Dealer and Customer Questions" 3 (May 23, 2002) [hereinafter Brown Memo].

513. "ACERT is a systems solution that combines breakthrough combustion technology with advanced fuel and air system technology, new integrated Cat electronics and an aftertreatment solution." *Id.*

“better fit for Caterpillar, because the technology can be used to meet future emissions standards for off-road vehicles, a significant portion of Caterpillar’s business.”⁵¹⁴ Because this system would not be ready for October 2002 engines, Caterpillar developed a “bridge” engine that used some components of the ACERT system and which reduced emissions to a 3.5 gram standard.⁵¹⁵ As a result, these “bridge” engines were subject to a NCP. Caterpillar ultimately paid over \$54 million in such penalties in 2002 and 2003.⁵¹⁶

Detroit Diesel and Caterpillar requested a delay in the pull-ahead requirement in the spring of 2001. Detroit Diesel, which ultimately did manage to introduce an October 2002-compliant engine before the deadline, nonetheless argued that a longer phase-in for the new standard was appropriate, given the need for product testing and higher than anticipated costs associated with the new engines.⁵¹⁷ Environmental pressure groups were critical of the requests.⁵¹⁸

The most aggressive member of the EGR group was Cummins, which, on April 17, 2001, was the first company to announce an engine certified by the EPA for sale after October 1, 2002.⁵¹⁹ As one editorial in a trade journal summarized: “On the truck engine side, Cummins has gotten into everyone’s face about exhaust emissions regulations and technology.”⁵²⁰ After Cummins received its certification in April, the EPA rejected the requests from Detroit Diesel, Caterpillar, and some customers to extend the deadline.⁵²¹ Cummins thus played a valuable role for the EPA, providing it with “proof” that the October deadline was achievable and vindicating the EPA’s arguments that greater emissions reductions were possible. In the face of Cummins’ cooperation, it was impossible to imagine a court granting the other companies relief from the deadlines on the grounds of technological feasibility or cost.

Manufacturers competed on the technology to meet the October 2002 standard. For example, Cummins advertised that its EGR technology was

514. Boris Ladwig, *2 Ways to Get the Job Done*, THE REPUBLIC, May 5, 2002, at B1.

515. See Brown Memo, *supra* note 512, at 1 (describing October 2002 engines as including “some of the ACERT technology” but featuring “minimum changes to the current heavy-duty engines”).

516. RHEIN, 7TH EDITION, *supra* note 185, at 18.

517. Engine Update, available at <http://www.etrucker.com/apps/news/article.asp?id=19598> (last visited May 14, 2004).

518. See Press Release, Clean Air Trust, *Clean Air Trust Assails Caterpillar Lobbying to Roll Back Clean-Air Controls*, (Apr. 9, 2002), available at <http://www.cleanairtrust.org/release.040902.htm>.

519. United States’ Statement of Position–Pull-Ahead Dispute, at 10, *United States v. Caterpillar, Inc.*, No. 98-2544 (HHK) (D.D.C. June 18, 2002).

520. Mike Osenga, *What’s In the Water in Columbus?*, DIESEL PROGRESS—N. AM. EDITION, May 2002, at 2.

521. United States’ Statement of Position–Pull-Ahead Dispute, at 11, *United States v. Caterpillar, Inc.*, No. 98-2544 (D.D.C. June 18, 2002).

better because it was simpler.⁵²²

Truckers expected Cummins' certified engine would enable it to take market share away from other companies after October 1, 2002.⁵²³ When the issue of using emissions credits rather than engine emissions reductions to satisfy the EPA arose, Cummins threatened to sue the EPA if Caterpillar succeeded in getting credits for cleaning up off-road diesels to reduce its on-road emissions requirements.⁵²⁴ As this shows, October 2002-compliant engines were less desirable for customers, since if a competitor could buy NO_x reductions and sell a non-compliant engine, Cummins obviously feared a competitive disadvantage.

The EPA's position had a significant impact on technology. In short, when the EPA certified a Cummins' engine as meeting the consent decree terms in April 2002,⁵²⁵ Cummins, which opted not to develop a new engine technology as a means of saving costs, thus met the deadline, while Caterpillar, which invested in new technology,⁵²⁶ did not,⁵²⁷ making EGR the only technology that could meet the deadline. Indeed, the EPA became heavily involved in the design of EGR engines.⁵²⁸ Two issues in particular stand out. First, while the EGR companies managed to solve some technical problems, such as cooling the exhaust gases⁵²⁹ and increasing their pressure to equal that of the inlet side of the engine,⁵³⁰ there were left several unresolved problems for EGR engines, including the presence,

522. Cummins Cooled EGR and VGT Technology Website, available at <http://www.cumminsnorthwest.com> (last visited May 14, 2004) ("Compare our Holset Variable Geometry Turbocharger to all the others, and you'll be convinced that its simpler design is your best choice.").

523. Boris Ladwig, *Analysts: 'Hard to say' which Engine has Upper Hand in Race for Compliance*, THE REPUBLIC, May 7, 2002, at A1.

524. See Mike Shaheen, *The High Road*, Roadking.com, available at <http://www.roadking.com/inside/story339.php> (describing how Caterpillar hopes to "coast" through the October 2002 deadlines by using credits for clean-burning engines, and if that is the case then Cummins will sue).

525. *Mobile Sources: EPA Certifies First Heavy-Duty Engine to Comply with New Emissions Limit*, 3 BNA'S ENVIRONMENT REPORTER 729 (2002).

526. See Paul Hartley and Sean Kelley, *Engine Makers Take Steps To Cut Emissions*, 41 OVERDRIVE, Apr. 2001, at 16 (describing Caterpillar's new technology as better than EGR because it does not put heat or impurities into the engine).

527. See *Cummins Welcomes Engine Deadline Confirmation*, 47 OVERDRIVE, July 2001, at 16.

528. In a sworn statement filed in connection with the AECD dispute between Caterpillar and the EPA, an EPA environmental engineer described how "[the] EPA met frequently with engine manufacturers to discuss research and development, troubleshoot problems encountered, and push industry to consider promising alternatives." Declaration of Richard L. Gezelle, Jr., June 18, 2002, at 3.

529. See Steve Sturgess, *The Power and the Glory*, HEAVY DUTY TRUCKING, May 21, 2002 (stating that "to reduce NO_x as far as possible, the temperature in the combustion chamber has to be minimized so the recycled exhaust must be cooled").

530. See *id.* (finding that "with a turbocharged engine, the inlet side downstream of the turbo is at a higher pressure than the exhaust, especially with today's high efficiency turbochargers").

under some conditions, of condensation, and excessive heat under some operating conditions. To resolve these, the EPA approved the use of "auxiliary electronic control devices" (AECs) to turn off the EGR systems under three conditions for engines produced between October 1, 2002 and January 1, 2004: (1) to protect the engine against condensation at temperatures above 25 degrees Fahrenheit and below 50 degrees Fahrenheit if sensors reported condensation was occurring;⁵³¹ (2) to protect against overheating when engine temperatures rose above a set limit;⁵³² and (3) to protect the air handling system at certain temperatures and altitudes.⁵³³

The EPA asserted that its goal in approving AECs was "to ensure that the technologies needed to comply with the pull-ahead requirements on the Federal Test Procedure and the supplemental tests—without the use of defeat devices—are developed, demonstrated and deployed." To accomplish this, the EPA evaluated proposed AEC use by looking to see if a "manufacturer has pursued diligent and continuous efforts to reduce the need for the problematic AECs and has achieved results in this regard consistent with the utilization of all reasonably available technology given the time between the January 19th letter and the date of the certificate application."⁵³⁴ However, Caterpillar charged that some of the other engine manufacturers using EGR technology were being unfairly allowed to use electronic controllers as defeat devices, turning off the EGR system up to 30 percent of the time.⁵³⁵ Depending on the amount of time the controllers shut down the EGR system, a Caterpillar engine that was not certified as compliant could emit less total NO_x than an engine certified compliant with the 2.5 g/bhp-hr standard.⁵³⁶ The EPA's motive, Caterpillar charged, was to "claim compliance with the Consent Decree by engine manufacturers who would otherwise not have compliant engines."⁵³⁷ Caterpillar argued that if 2 g/bhp-hr EGR engines turned off the EGR systems 8 percent of the time, they would produce more NO_x than a non-EGR engine that met only a 3.5 g/bhp-hr standard.⁵³⁸

Second, the EPA proposed NCPs that were dramatically different from those used in prior years. The original "default" consent decree NCPs were

531. See Letter from Steven A. Herman, Office of Enforcement and Compliance Assurance, EPA, to Douglas Grandstaff, General Counsel, Caterpillar, Inc. 4-5 (Jan. 19, 2001).

532. See *id.* at 5.

533. See *id.*

534. See *id.* at 2.

535. See Brown Memo, *supra* note 512, at 4; see also Caterpillar's Statement of Position—AEC Dispute, at 1, United States v. Caterpillar, Inc., No. 98-2544 (May 10, 2002).

536. See Brown Memo, *supra* note 512, at 4.

537. Caterpillar's Statement of Position—AEC Dispute, at 1, United States v. Caterpillar, Inc., No. 98-2544 (D.D.C. May 10, 2002).

538. See Boris Ladwig, *Diesels Fuel War on Words*, THE REPUBLIC, May 6, 2002, at A1.

set using “cost of compliance values and factors 1.5 times the existing NCP values and factors.”⁵³⁹ The EPA subsequently proposed setting the NCP at five times the “default” NCPs.⁵⁴⁰ The difference was striking: “[a] 3.3 gram NO_x + NMHC heavy heavy-duty diesel engine would be subject to an NCP of about \$2000 under the Decree but would rise to almost \$7500 under the EPA’s NCP proposal.”⁵⁴¹ A critical step by the EPA in the post-consent decree period was to propose a dramatic increase in NCPs for engines that did not meet the MY 2004 standard that was “pulled ahead” to October 2002 by the consent decrees. To do so, the EPA proposed using significantly higher costs of compliance to calculate the NCPs raising the life-cycle cost from \$879⁵⁴² to \$8940.⁵⁴³ The EPA’s final rule set the NCP at \$6810, which was still well above the original “default” value.⁵⁴⁴

The EPA’s approval seems inconsistent with its claims in the controller litigation. The EPA’s theory of the litigation centered on the alleged illegality of the engine manufacturers’ controller use to change engine operations in non-FTP conditions. When the EPA implemented the consent decrees, however, it eventually determined that controller use remarkably similar to use it had challenged in the lawsuits would continue to be permitted as an interim measure for some engines. Although the EPA had initially stated in a January 19, 2001 letter that AECD use would require modification of the consent decrees, it later reversed that position and approved AECD use by engine manufacturers using EGR technology.⁵⁴⁵

A law review article is not the place to resolve the merits of the technical questions behind the EPA’s disputes with Caterpillar.⁵⁴⁶ What is important here is the nature of the dispute, the incentive issues for the agency, and the

539. Caterpillar’s Statement of Position—NCP Dispute, at 2, *United States v. Caterpillar, Inc.*, No. 98-2544 (D.D.C. May 10, 2002).

540. *See id.*

541. *Id.* at 8.

542. *See* Control of Emissions of Air Pollution From Highway Heavy-Duty Engines, 62 Fed. Reg. 54,694, 54,711 (Oct. 21, 1997) (to be codified at 40 C.F.R. pts. 9 & 86).

543. *See* Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Proposed Non-Conformance Penalties for 2004 and Later Model Year Emission Standards for Heavy-Duty Diesel Engines and Heavy-Duty Diesel Vehicles, 67 Fed. Reg. 2,159, 2,166 (Jan. 16, 2002) (to be codified at 40 C.F.R. pt. 86) (listing proposed NCP calculation parameters for heavy-duty diesel engines).

544. *See* Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Non-Conformance Penalties for 2004 and later Model Year Emission Standards for Heavy-Duty Diesel Engines and Heavy-Duty Diesel Vehicles, 67 Fed. Reg. 51,464, 51,467 (Aug. 8, 2002).

545. *See* Caterpillar’s Statement of Position—AECD Dispute, at 5, *United States v. Caterpillar, Inc.*, No. 98-2544 (D.D.C. May 10, 2002).

546. *See id.*; *United States’ Statement of Position—AECD Dispute*, *United States v. Caterpillar, Inc.*, No. 98-2544 (D.D.C. June 18, 2002). The parties exchanged dueling affidavits from engineers on the question of the necessity of the AECDs for engine protection as exhibits to these statements.

institutional means available for resolving the dispute. With respect to both the NCPs and the AECD use, the EPA created conditions under which one technology was favored over others. In short, the EPA's AECD and NCP decisions (ratified by the court) granted to those following an EGR strategy a competitive advantage over those opting for different technologies. This result occurred due to the EPA's actions of imposing larger NCPs on the non-compliant engines than engine manufacturers had reason to predict when making technology decisions and allowing AECD use that mirrored the pre-litigation use of the controllers only for EGR engines.

We are certainly not competent to evaluate the technical merits of such a dispute, but it also seems clear that the courts are not capable of resolving such disputes on the engineering merits. There is no bright line for "necessity" that can be drawn by an expert. The problem with the consent decrees is that they create conflicts such as this. The EPA as an agency had an incentive to ensure that as many of the engine manufacturers were found to have complied with the terms of the agreement as possible. In particular, it was necessary to have at least one major engine manufacturer certify an engine as quickly as possible to head off the public campaigns to alter the consent decrees' deadlines mounted by Caterpillar and Detroit Diesel. It is thus plausible that the EPA would accept controller use by Cummins that is technically indistinguishable from the controller use that prompted the lawsuits used solely to counter the Caterpillar and Detroit Diesel campaigns. To counter such an appearance of self-interest is impossible for the agency, since it is not possible to prove that the net emissions from, for example, the Cummins 2002-compliant engine with the AECD would not exceed those from the Caterpillar non-compliant engine except by actually gaining data on road conditions. What could be, and was, disputed was how the various scenarios played out in the EPA's model of mobile source emissions.⁵⁴⁷

Most importantly, EGR was an inferior technology to at least some alternatives for two reasons. First, it could not satisfy the MY 2007 standards, requiring engines be redesigned again for those standards.⁵⁴⁸ Second, it was not practical for off-road heavy-duty diesels, a significant

547. See, e.g., Declaration of Lyle R. Chinkin, AECD Dispute, *United States v. Caterpillar, Inc.*, No. 98-2544 (D.D.C. June 18, 2002) (including affidavit of consultant describing use of MOBILE6 to make estimates in connection with the EPA and Caterpillar's dispute over AECD devices).

548. See RHEIN, 7TH EDITION, *supra* note 185, at 22 (noting that particulate filters and NO_x catalysts will be needed to comply with the 2007 rules and that Caterpillar's ACERT strategy "seems to have some advantages looking toward 2007"); see *id.* at 41 ("The Cat ACERT model appears to be in line with what will be needed with a few tweaks and a particulate filter . . . What doesn't seem to be needed is cooled EGR, although internal EGR is expected.").

category of diesel engines.⁵⁴⁹ For a manufacturer with a significant off-road business such as Caterpillar, developing an emissions technology that could not work in off-road engines was not an efficient business decision if there was an alternative technology that could work in both on and off-road engines. The EPA's EGR strategy thus unfairly penalized companies that produce both on and off-road engines while rewarding those who produce only on-road engines.

d. Impact on Air Quality

How did the choice of regulation by litigation affect air quality? A static analysis of the pull-ahead would suggest that the consent decrees unambiguously improved air quality starting October 1, 2002, when the new, cleaner engines came into use. A dynamic analysis, however, shows that the question is more complicated.

The October 2002 compliant engines were unpopular with engine buyers because they involved new technology and designs and because they were relatively untested.⁵⁵⁰ For example, the inability to get test engines in time to complete testing meant that Schneider, one of the larger trucking companies, decided to prebuy in advance of its needs and buy used trucks to avoid the October 1 engines until it could acquire sufficient experience.⁵⁵¹ An editorial in *Transport Topics* predicted that large fleets would buy a "few" new engines when they became available to test them for up to a year before integrating them into fleets.⁵⁵² This was not unusual: in April 2002, *Fleet Owner* reported that "few fleets have even seen an '02-compliant engine much less gotten to tear one down after real-world service or even just take one for a spin."⁵⁵³ *Fleet Owner* quoted an anonymous vice president for maintenance and equipment at "one of the nation's largest tank-truck carriers" in favor of avoiding the post-October 2002 engines:

The way we figure it . . . the '02 engines will add about \$4,000 to the

549. See *id.* at 18.

550. See GEN. ACCT. OFF., GAO-04-313, EPA COULD TAKE ADDITIONAL STEPS TO HELP MINIMIZE THE BENEFITS FROM THE 2007 DIESEL EMISSIONS STANDARDS 4 (2004) [hereinafter GAO, EPA COULD TAKE ADDITIONAL STEPS] ("However, [engine manufacturers] were not able to deliver prototype engines to trucking companies early enough for them to test the engines' reliability, according to representatives of all 10 companies [GAO] contacted.").

551. See Boris Ladwig, *Tumultuous Market Making Buyers Wary*, THE REPUBLIC, May 7, 2002, at A1. The EPA's consultant argued that such a prebuy occurs whenever emissions standards change. ICF Consulting, *Economic and Emissions Implications of the Pull-Ahead Requirements for Heavy-Duty Diesel Engines*, June 18, 2002, at 2 ("A similar disruption would occur without the consent decrees, but in 2003 and 2004 rather than 2002 and 2003 as at present."). Although the problem with the October 2002 engines was not that they were new but that there was insufficient time allowed for testing.

552. See *Clean Engines and Common Sense*, TRANSPORT TOPICS, June 3, 2002, at 8.

553. Cullen, *supra* note 184, at 20.

cost of the trucks. Then we'll lose another \$4,000 to \$5,000 on decreased fuel efficiency. That puts us \$10,000 in the hole. And that's without figuring in the uncertainty of engine performance. Yes, those engines will be under warranty. But any downtime they pile up won't.⁵⁵⁴

Trucking firms had three options for avoiding the new engines: keeping existing trucks longer, buying used equipment,⁵⁵⁵ and pre-buying.⁵⁵⁶ All three involved increased costs. While substitution of existing used trucks for new purchases was made possible by a glut of used trucks in 2001,⁵⁵⁷ adding used trucks or extending an existing fleet brought higher maintenance costs.⁵⁵⁸ The problems with pre-buying include obtaining sufficient capital to make the purchases⁵⁵⁹ and complying with specific truck requirements that could not be predicted in advance.⁵⁶⁰ Moreover, the overall size of the pre-buy was limited by production capacity. Pre-bought engines had to be manufactured by October 1, limiting the total number that could be prebought. Some industry observers predicted that assembly line slots would be booked by the end of April.⁵⁶¹ Given the short-term nature of any increase in demand, the engine makers were limited in their ability to expand production to accommodate increased demand.

The pre-buy began in earnest in early 2002 with sales of new trucks

554. *Id.* at 22. This article on the new engines in the April 2002 issue of *Fleet Owner* summarized the problem:

The negatives already associated with the '02 engines—even before they hit the market—are considerable. First, it's expected the new technology engine makers will deploy to get down to the requisite EPA emissions limits will add \$3,000 to \$5,000 to the cost of a new vehicle. What's more, engine makers concede fuel efficiency will likely be compromised and maintenance schedules may have to be modified. Bad as that news is, what is most disconcerting to new truck buyers is the simple fact they don't know how these new engines will perform, that is, how much they will break down.

Id. at 20-21.

555. Demand for three-to-five-year-old used trucks was also up. Heine, *supra* note 253, at 14. See also GAO, EPA COULD TAKE ADDITIONAL STEPS, *supra* note 550, at 5 (indicating that rather than buying October 2002 compliant engines, some firms "instead bought more used trucks . . . than planned before October 2002").

556. See Doug Condra, *Can You Pre-Buy? Don't Count on It*, HEAVY DUTY TRUCKING, Apr. 2002, at 6.

557. See Declaration of Steven D. Duley, at 5, *United States v. Caterpillar, Inc.*, Nos. 98-2544, 98-2546, 98-2546 (D.D.C. Nov. 27, 2002) (noting that a "glut" of used trucks existed because of manufacturers' prior incentive purchase programs, so substitution of 400,000-500,000 mile used trucks for new trucks was feasible). See also GAO, EPA COULD TAKE ADDITIONAL STEPS, *supra* note 550, at 5 (rather than buying October 2002 compliant engines, some firms "instead bought more . . . new trucks with older technology than planned before October 2002").

558. See Cullen, *supra* note 184, at 24 (quoting a consultant who claims that doing a major engine overhaul could cost twice the premium of a 2002 engine).

559. See *id.* at 22.

560. See *What Fleets Are Saying*, HEAVY DUTY TRUCKING, February 2002, at 32 (stating that some leasing companies also could not pre-buy as their customers have specific equipment requirements that must be manufactured to order).

561. See Jonathan S. Reiskin, *Truck Makers Foresee Dip After October*, TRANSPORT TOPICS, Apr. 22, 2002, at 1; see also Condra, *supra* note 556, at 6.

doubling in the first quarter and up 170 percent in March alone.⁵⁶² Based on overall market conditions, industry observers saw that as twice the expected demand.⁵⁶³ Looking back, we can see the dramatic change in the production of engines in 2002.⁵⁶⁴ Truck engine consumers expressed skepticism about the new engines with “pre-buying” taking place while MY 2001 engines were still available.⁵⁶⁵ Importantly, however, analysis with MOBILE6 did not show increased emissions as a result of the pre-buy.⁵⁶⁶

All of the strategies for postponing the acquisition of October 2002-compliant engines meant “dirty” trucks would be on the road that would not be otherwise. For example, buying a new truck on September 30, 2002 that would not have otherwise been bought until January 1, 2003 would put a pre-October 2002 engine on the road for ten years or more, emitting at the pre-October 2002 emission levels. If enough engines were added through pre-buys or older engines were continued past their useful lives in the absence of the consent decrees, the net effect on air pollution might be an increase rather than a decrease for a period of time.

The EPA was not unaware of the potential problems for air quality caused by a pre-buy as Caterpillar raised the issue in a request for a modification of the consent decree. Caterpillar argued in its dispute with the Agency that the cost of October 2002 engines was higher than initially predicted by the EPA and that this higher cost would both increase the incentive for pre-buying and harm the engine makers, who would have to absorb some of the costs. Moreover, Caterpillar argued that its bridge engines would have “actual emissions . . . in the same range as the actual emissions of engines the EPA approves with overheat, air handling and

562. See Reiskin, *supra* note 561, at 1 (referring specifically to orders for Class 8 tractors).

563. See *id.*

564. See GAO, EPA COULD TAKE ADDITIONAL STEPS, *supra* note 550, at 18 (stating that prebuy was “a widely used strategy”).

565. See Donald J. Schneider, *EPA's New Engine Standard: An Economic and Environmental Defeat Device*, TRANSPORT TOPICS, May 20, 2002, at 9 (“The lack of engine availability combined with serious price uncertainty has caused the market to become spooked as evidenced by the massive ‘pre-buy’ of truck engines underway. In March, new truck orders were up 170% over the previous year, and first quarter orders were in excess of 70,000 units as compared with 38,000 the previous year.”); see also Ball, *Buying Binge*, *supra* note 115, at A1, A2 (noting that the operator of a large fleet says it will not buy “until we as an industry can get convinced the new products are cost-effective and reliable” and so is buying the 2,000 trucks needed for 2002 in 2001 before the new regulations go into effect). The EPA’s response was to launch an investigation of whether or not the “pre-buy” violated the terms of the consent decree, under which engine manufacturers could not encourage such behavior, and expressed concern that the pre-buy would jeopardize air quality goals. Daniel L. Whitten, *EPA Probes Engine Makers Over Trucking’s ‘Pre-Buying’*, TRANSPORT TOPICS, May 20, 2002, at 1, 33.

566. See ICF Consulting, *supra* note 551, at 17.

condensation AECDS."⁵⁶⁷

The EPA rejected Caterpillar's arguments for four reasons. First, while the EPA admitted that the cost of October 2002 engines was greater than it had previously considered, it argued that the extra cost was due to the engine makers' prior violation of the law in not complying with the existing standards: "these additional costs, which the United States overlooked in its Motion to Enter, derive from Caterpillar's and the other settling engine manufacturers' obligation to comply with the Clean Air Act by eliminating their defeat-devices."⁵⁶⁸ Second, the EPA rejected Caterpillar's argument that the pull-ahead would disrupt the trucking industry, contesting Caterpillar's forecast of future market conditions.⁵⁶⁹ In particular, the EPA argued that the general recovery in trucking expected for the first quarter of 2003 would cause truck sales to rebound more quickly than Caterpillar predicted. Third, the EPA relied on news reports quoting several truck manufacturers that they expected to be able to integrate the new engines into their truck lines.⁵⁷⁰ Finally, the EPA contended that delaying the deadlines would prejudice the engine manufacturers who had "invested the resources necessary to comply" with the pull-ahead: "it would be clearly unfair to modify [the consent decree] obligations based on speculation or to insulate one company from the competitive effects of its business decision to not comply with the pull-ahead."⁵⁷¹

The result was a technical dispute submitted to the court as Caterpillar sought a delay in the October 2002 deadline under the consent decree's dispute resolution provisions. Whether the pull-ahead would result in more or less NO_x in the coming years was dependent on differing assumptions in the EPA and Caterpillar's economic and emissions modeling. Resolving that dispute is not the point of our analysis. Rather what is important is that the court was asked to resolve a complex, technical point based on a

567. Caterpillar's Statement of Position—NCP Dispute, at 2, *United States v. Caterpillar, Inc.*, No. 98-2544 (D.D.C. May 10, 2002).

568. United States' Statement of Position—Pull-Ahead, Dispute at 6, *United States v. Caterpillar, Inc.* No. 98-2544 (D.D.C. June 18, 2002).

569. *See id.* at 6. The EPA relied on a consulting report it commissioned by ICF Consulting, which in turn incorporated a consulting report ICF commissioned from Rhein Associates, a report that the EPA also cited. ICF gave the EPA a copy of the entire Rhein report, without securing permission from Rhein to do so. The EPA then included it in its filing, which it submitted to the other parties. One of these parties notified Rhein that the EPA was preparing to submit the report, making it a public document. Rhein then contacted the EPA, demanding payment for the additional copies of the report. The EPA then had to seek to file the report under seal to prevent its further distribution. Interview with Tom Rhein, [institutional affiliation] (August 21, 2002); Declaration of Thomas A. Rhein (June 28, 2002).

570. *See* United States' Statement of Position—Pull-Ahead Dispute, at 7, *United States v. Caterpillar, Inc.*, No. 98-2544 (D.D.C. 2002).

571. *Id.* at 7-8.

contentious record which the EPA could expect to win based on courts' deference to agencies on technical issues. For example, the EPA's response to Caterpillar generated a series of letters and affidavits from trucking industry entities contesting the EPA's interpretation of their reports, comments, and positions.⁵⁷² Resolving disputes over such technical details is not an institutional strength of courts. Moreover, the dispute highlights the importance of the EPA's model, rather than reality, in determining the impact of regulatory changes, as the dispute centered on the appropriate inputs to the model, not the appropriate measures of air quality. The court's resolution of the disputes, focusing on the contractual nature of the settlements, did not allow for review of the substance of the engine makers' arguments, since it focused on the question of whether the heightened legal standard for modification was met rather than the issue of whether the policies made sense.⁵⁷³

Did the EPA make the right choice in refusing to extend the deadline in the face of the pre-buy? No definitive answer is possible because calculating emissions in the absence of the October 2002 deadline is ultimately speculative.⁵⁷⁴ There are reasons to suspect that the EPA made the wrong decision and to be doubtful that the Agency's incentives would lead it to make the correct decision.⁵⁷⁵ First, the EPA made its analysis of the pre-buy's impact based on the MOBILE model, which did not accurately forecast heavy-duty truck emissions. The traditional warning of "garbage in, garbage out" thus applies. Second, the EPA had an enormous investment in the success of the consent decrees, biasing the Agency against altering the deadlines. Third, the EPA and its consultants did not appear to grasp the differences between the 2002 pre-buy and other pre-regulatory deadline pre-buys. The October 2002 engines were different from the other new engines introduced after regulatory changes because the

572. See Declaration of Thomas A. Rhein (June 28, 2002); Letter from Peter Vroom, Truck Renting and Leasing Association, to John Pemberton (June 27, 2002); Letter from Peter Vroom, Truck Renting and Leasing Association, to Christine Todd Whitman, EPA Administrator (June 27, 2002); Declaration of Glenn F. Brown, CEO of Contract Freighters, Inc. (June 8, 2002); Affidavit of Karel Znamenacek, Executive Vice President of Crete Carrier Corp. (June 27, 2002); Affidavit of Dwayne O. Haug, Vice President of Werner Enterprises, Inc. (June 27, 2002); Declaration of Steven D. Duley, Director of Equipment Purchasing and Disposal for Schneider National, Inc. (June 27, 2002); Affidavit of Patrick E. Quinn, Co-Chairman of the Board and President of U.S. Xpress Enterprises, Inc. (June 28, 2002).

573. See *Case Note—Clean Air Act*, ENVTL. COMPLIANCE AND LITIG. STRATEGY, Sept. 2002, at 6 (describing court ruling).

574. Unfortunately the General Accounting Office did not consider the full implications of the pre-buy on emissions, determining only that the pre-buy delayed the purchase of October 2002-compliant engines but not examining the question of whether the extended life of older engines increased emissions. See GAO, EPA COULD TAKE ADDITIONAL STEPS, *supra* note 550, at 4-6 (describing GAO's approach to prebuy and conclusions).

575. *Id.* at 15 ("[T]he consent decrees will not achieve the full emissions reductions in the time frames EPA anticipated.").

type of technology being used was significantly different from previous engine upgrades, adding EGR with its demands on cooling, oil, and turbochargers rather than tweaking combustion and completely changing the test protocols. Moreover, other new engines had been introduced with greater lead time. This gave engine customers a stronger than usual incentive to avoid the new engines.⁵⁷⁶ Fourth, customers opted against the new engines, with a foreign firm (Mercedes) and U.S. firms that chose to pay NCPs rather than deliver October 2002-compliant engines before the deadline gaining market share against those who met the pull-ahead regulations' emissions targets,⁵⁷⁷ and trucking companies delaying upgrading the controller software by running engines longer before overhauls.⁵⁷⁸ Finally, other upgraded engines brought with them improvements in fuel economy as side effects of the controller technology necessary to meet the EPA's earlier deadlines. The October 2002 engines brought with them worsened fuel economy as a side effect. None of the EPA's analysis of the pre-buy seems to have acknowledged these differences.

Looking back, the EPA's assumptions were clearly wrong. As one independent industry analyst summarized the impact of the consent decrees: "The emissions regulations of October 2002 have created one of the biggest boom and bust scenarios for the diesel engine manufacturer The pre-buy happened and devastated the diesel engine manufacturers during the last quarter of 2002 and the first quarter of 2003."⁵⁷⁹ Because of the pre-buy orders in mid-2002, the total number of engines built in 2003 was 38 percent more than in 2001.⁵⁸⁰ Production in 2003 was estimated to be "well below normal production levels."⁵⁸¹ Compare this to how the EPA might have handled the issue through rulemaking. To pull the MY 2004 standards ahead to October 2002, the EPA would have had to offer the engine makers incentives because the Clean Air Act's lead time provisions otherwise barred a pull ahead. Similarly, it seems likely that a radical change in test protocols would have required compliance with the lead time rules.⁵⁸² An incentive structure

576. *Id.* at 22 ("[T]hese engines had inherent disadvantages relative to existing engines that made them difficult to sell.").

577. *Id.* at 5 (stating that four of five engine manufacturers who met the deadline lost market share to engine manufacturers either exempt or who chose to pay penalties instead of complying).

578. *Id.* at 6 ("[T]ruck owners are now operating their trucks longer before overhauling the engines and adjusting the emissions computer controls.").

579. RHEIN, 7TH EDITION, *supra* note 185, at 39-40.

580. *See id.* at 40.

581. *Id.* at 41.

582. *See Engine Manufacturers Oppose California Arb Proposal to Pull-Ahead 2007 Requirements for Heavy-Duty Diesel Engines*, BUS. WIRE, Dec. 8, 2000 (describing Engine Manufacturers Association argument that new test procedures proposed by California were

would have compensated engine makers for reducing emissions toward the MY 2004 standards early, possibly by postponing the MY 2004 standards through emissions credits.⁵⁸³ Such an approach would have encouraged engine makers to adopt technologies that produced cost-justified improvements in emissions as soon as possible. Some might have used EGR technology, but others besides Caterpillar might have developed new technologies. Engine customers would also have earned credits by accepting low-NO_x upgrades to their controllers in existing engines.⁵⁸⁴ If the price was right, these upgrades could have been worth the fuel economy penalty the upgrade caused. Such a program would have been adopted in the light of day with full public comment. If the EPA was wasting resources on expensive NO_x reductions in the heavy-duty diesel sector instead of buying cheaper reductions elsewhere, commentators would have pointed this out. If the EPA was paying too much for the credits, environmental pressure groups would have objected. An incentive approach also would have produced benefits immediately in 1998 without waiting until October 2002. The “pre-buy” would thus have been of cleaner engines rather than dirtier engines.

e. Explaining the EPA's Choices

The EPA's choice to proceed with litigation, rather than revising the FTP to include highway conditions, issuing new rules setting either lower FTP-standards, or doing nothing, was derived from the institutional setting we described earlier. The inadequacies of the EPA's models meant that the EPA had a serious rule compliance problem on its hands—one that threatened to undermine compliance with the ozone NAAQS forcing the EPA to either hold back on penalties to protect the economy, risk the wrath of environmental pressure groups for being too lax, or deliver economically crippling blows to nonattainment regions. Neither alternative would have been attractive heading into the 2000 Presidential election campaign. Alternative sources of NO_x reduction would entail squeezing automakers further, which would be a problem for the battleground state of Michigan, or cutting stationary source emissions particularly in the Midwest, another critical political region. Taking on the heavy-duty diesel engine manufacturers must have seemed an attractive alternative, and the EPA was

barred by lead time provisions of SOP).

583. The EPA took precisely this approach in the MY 2007 standards. Control of Emissions from New and In-Use Highway Vehicles and Engines, 40 C.F.R. § 86.007-11(g)(2) (2001); Walsh, *Global Trends*, *supra* note 166, at 12.

584. The General Accounting Office concluded that the EPA's attempt to mandate such upgrades had not proven effective. GAO, EPA COULD TAKE ADDITIONAL STEPS, *supra* note 550, at 24 (indicating that only about 12% of predicted number of trucks “reflashed” with new software).

in a major bind.

The hammer of denying certification to the next year's engines could induce a quick settlement bringing with it headlines about a major victory for the environment. The defendants were a small group of companies making an industry-wide settlement possible. As a concentrated industry with little foreign competition, the U.S. engine makers presented a vulnerable target. The annual certification requirement meant the EPA did not need to win its lawsuit on the merits to force a settlement. No matter the status of the EPA's lawsuit, the EPA could deny certification to any company not willing to settle and put the burden on the company to seek relief in the courts for the failure to certify—a question on which the company as plaintiff would face a difficult burden of proof and a high standard of deference to the agency on the arcane question of what constituted a “defeat device.” By threatening the survival of U.S. manufacturers, the EPA was virtually assured of capitulation. Moreover, the EPA's threats were far more credible than its hollow threats against the auto manufacturers in the 1970s. The “Big 5” diesel engine makers had nowhere near the political clout of the “Big 3” auto companies and the “sex appeal” of the defeat device story meant the EPA would start out ahead in the public relations arena. Finally, the EPA now had institutional players on its side: the ozone nonattainment regions, stationary NO_x sources, and the auto makers would all prefer NO_x reductions to come from the heavy-duty diesel engine makers than from them.

Because of the lead time provisions, the EPA was unable to act through regulation-by-rulemaking to tighten diesel emissions standards before MY 2007. Moreover, the Statement of Principles (SOP) agreed to by the EPA in 1995 would have constrained any regulation-by-negotiation outcome. The engine manufacturers would have surely resisted changing the terms of the SOP to permit faster tightening of regulations, and environmental groups had not accepted the SOP from the start.

The EPA also had strong incentives to proceed by regulation-by-litigation in addition to the disadvantages of regulation-by-rulemaking and regulation-by-negotiation in these particular circumstances. First, the gap between predicted and actual diesel emissions was contributing to the EPA and the states' problems in bringing nonattainment regions into compliance with the NAAQS.⁵⁸⁵ For example, inspection and maintenance programs were causing popular unrest with clean air regulations in several states.⁵⁸⁶

585. See John H. Cushman, Jr., *Makers of Diesel Truck Engines Are Under Pollution Inquiry*, N.Y. TIMES, Feb. 11, 1998, at A16 (“Even if [using controllers to defeat emissions standards] is not intentional, the fact that trucks routinely exceed the pollution standards is a major problem as states try to comply with Federal demands that they clean up their air, pollution experts said.”).

586. See, e.g., J. Russell Capps, Editorial, *Making Ineffective Emissions Tests Even More*

Second, the EPA and the Clinton Administration could reap immediate political rewards by appearing “tough on polluters” during the runup to the 2000 presidential election.⁵⁸⁷ Third, the EPA faced relatively low risks of losing the litigation because the enormous leverage it had over the engine manufacturers made a settlement all but assured.

The discovery of the difference between actual diesel emissions and the model’s predictions had serious consequences and may have contributed to the EPA’s decision to pursue regulation-by-litigation. As one report on the issue’s implications for California put it, “[b]lowing the [compliance] timetables not only prolongs the day when citizens can breath [sic] healthy air but also carries economic penalties ranging from tougher regional pollution control measures to the withholding of millions of dollars of federal highway construction money.”⁵⁸⁸

Regardless of the merits of the EPA’s case, which was vigorously contested by the engine manufacturers,⁵⁸⁹ the EPA and the Clinton

Costly, NEWS & OBSERVER (Raleigh), June 18, 2001, at A10; Daniel L. Stout, Editorial, *No Love Lost over Auto Inspections*, S. FLA. SUN-SENTINEL, May 9, 2001, at 30A; Jason Tyson, *Tougher Emissions Tests Drawing Fire Before Their Time*, MORNING STAR (Wilmington, N.C.), Jan. 5, 2002, at 7B; Editorial, *Worthless Inspections*, SALT LAKE TRIB., Sept. 2, 2001, at AA-1; *Plain Speaking*, PLAIN DEALER (Cleveland), Sept. 11, 2001, at A2; John Griffith & Dave Davis, *E-check Tests Blowing Smoke, Critics Say*, PLAIN DEALER (Cleveland), Sept. 10, 2001, at A1; Randolph E. Schmid, *Panel: Emissions Efforts Misdirected*, AP ONLINE, July 18, 2001, available at <http://www.ap.org> (last visited May 14, 2004).

587. Environmental groups had been pressuring the EPA to act on the “excess” diesel emissions. Jim Mele, *The Drive for Cleaner Air*, FLEET OWNER, Nov. 1998, at 43. See Jim Mele, *EPA, Diesel Makers in Emissions Negotiations*, FLEET OWNER, Mar. 1998, at 10 (noting environmental groups were pressuring the EPA and the Clinton Administration to act). The Clinton Administration also looked at the benefits of carrots: the timing of a “major new public-private partnership” with a federal contribution of more than \$130 million to build cleaner trucks was debated over whether to “save it” for the Al Gore 2000 campaign. George C. Wilson, *Clinton: Build Trucks that Save Bucks*, 45 NAT’L J. 3268, 3268-69 (1999). News reports on the diesel settlements noted the change in the Administration’s approach. See, e.g., Harry Stoffer, *EPA Says Mack Engines Pass Test but Pollute; Truckmaker Sues*, AUTOMOTIVE NEWS, June 22, 1998, at 18 (“Even some EPA officials were privately surprised at the more confrontational stance following years of effort by the Clinton Administration to work cooperatively with businesses.”).

588. Bowman, *EPA Off*, *supra* note 36, at A1.

589. There was (and remains) an important legal issue of whether the Clean Air Act grants the EPA authority to regulate emissions off the test cycle. In a letter commenting on the EPA’s proposed post-1990 Amendments changes to the test procedure, the Specialty Equipment Market Association argued that:

The proposal would essentially mandate emission control under all possible driving conditions. This requirement, in whatever form it would take, could have the potential to essentially extend emission control compliance liability to all operating conditions. There is no statutory mandate or authority for such action. Moreover, under Section 206(h), Congress required that test procedures focus on representative driving behavior. This limitation indicates the desire of Congress to avoid regulation that would cover infrequent or unusual behavior.

By extending emission control compliance liability to all operating conditions, EPA is effectively changing the numerical standards under CAA Section 202(a)(3)(B)(ii), (g), (h) and (i), by requiring numerical standards in vehicle operational modes where previously the emission standard was unlimited.

Administration reaped a publicity windfall from the settlement. Attorney General Janet Reno, for example, was quoted as saying “[e]very polluter in America had better take note of these record penalties—if you pollute America’s air, you are going to pay a very high price.”⁵⁹⁰

The EPA had enormous leverage over the engine companies because of the requirement for annual certification of engines.⁵⁹¹ Mack’s vice president of engineering and product planning, for example, told a reporter that the EPA “held a gun to our head by threatening to withhold certification for 1999.”⁵⁹² Other companies echoed the concern citing the need to litigate with the EPA annually over certification until the issue was resolved.⁵⁹³ The negotiations took place after the EPA had issued “conditional” certificates of conformity for MY 1998 engines that exempted engines that employed defeat devices.⁵⁹⁴ This occurred while the engine manufacturers were seeking certificates for MY 1999 engines and a related “show cause” order from the EPA to the engine manufacturers was pending.⁵⁹⁵ Because the EPA could have denied certificates for the MY 1999 engines for any manufacturer who refused to settle, there was enormous pressure to settle. Keep in mind that although all the engine manufacturers jointly could have resisted the EPA, for the EPA could not

Letter from John Russell Deane III, General Counsel, Specialty Equipment Market Association, to the EPA 10-11 (July 19, 1995) (copy on file with the authors).

590. Jeff Johnson, *EPA Fines Engine Makers*, TRANSPORT TOPICS, Oct. 26, 1998, at 1. Also quoted in Dori Meinert, *Caterpillar Shares Record Civil Penalty*, PEORIA J. STAR, Oct. 23, 1998, at A1; Harry Stoffer, *Diesel Makers to Pay \$1 Billion*, AUTOMOTIVE NEWS, Oct. 26, 1998, at 53. EPA Administrator Carole Browner was also quoted along similar lines. Marla Cone & Art Pine, *\$1-Billion Diesel Settlement OK*, L.A. TIMES, Oct. 23, 1998, at A3; *Diesel Polluters Settle for \$1.6b*, DAILY TELEGRAPH, Oct. 24, 1998, at 118; Steven A. Herman, *Clean Air Act Settlement with Diesel Engine Makers is Historic in Size, Scope, and Environmental Impact*, NAT’L ENV’T ENFORCEMENT J., Nov. 1998, at 18; Joby Warrick & Michael Grunwald, *Diesel Makers Settle Case, Agree to Cut Air Pollution*, WASHINGTON POST, Oct. 23, 1998, at A1. Browner was also quoted differently on the case in other articles. See *Seven Truck Engine Makers Slapped with \$1 Billion Fine*, LEGAL INTELLIGENCER, Oct. 23, 1998, at 4; H. Josef Hebert, *Diesel-engine Builders Fined for Rigging Tests*, CHATTANOOGA TIMES, Oct. 23, 1998, at A14; Stoffer, *supra*, at 53.

591. See ASLEEP AT THE WHEEL, *supra* note 36, at 5 (“[T]hrough the denial of a conformity certification, EPA has the power to shut down production of an engine, resulting in serious economic ramifications for heavy-duty diesel engine manufacturers.”).

592. Galligan, *supra* note 443, at 2 (internal quotes omitted). The settlement prompted several lawsuits against the engine manufacturers under a variety of legal theories, including RICO; most of the suits were quickly dismissed. See Jeff Johnson, *Operators File Lawsuits Against Engine Makers*, TRANSPORT TOPICS, Oct. 11, 1999, at 1 (describing four lawsuits); Charles Cox, *Truckers to Sue Engine Makers*, OVERDRIVE, Apr. 1999, at 25.

593. See Galligan, *supra* note 443, at 2 (quoting a Volvo executive).

594. See, e.g., 1998 Model Year Certificate of Conformity with the Clean Air Act, Issued to: Caterpillar, Inc., Certificate Number CPX-MHDD-98-03 (Nov. 20, 1997) (copy on file with authors) (including a condition that “[a]ny engine which employs a defeat device is not covered by this certificate of conformity” and requiring Caterpillar to show cause within 90 days that “the strategy for fuel injection timing, including but not limited to the Conditional Timing Algorithm, light load timing algorithm and Acceleration Algorithm, is not a defeat device”).

595. See ASLEEP AT THE WHEEL, *supra* note 36, at 16.

have borne the political costs of shutting down the new truck market entirely, each manufacturer had to be concerned that one or more of the others would “defect” from such a strategy and settle with the EPA. Any company that held out while others were cooperating faced ruinous loss of market share while it litigated the issue. The EPA thus created a classic prisoner’s dilemma: Each company would have been better off if no company cooperated with the EPA, but each was individually better off cooperating regardless of what the others did. The dominant strategy was thus to cooperate.⁵⁹⁶ This leverage minimized the political risk that the EPA might lose the litigation because it increased the probability of settlement. Indeed, industry analysts have praised tightening emissions controls as good news for market leaders, citing a number of manufacturers’ exits from engine markets.⁵⁹⁷ Later, however, the cooperation has broken apart.

The settlement short circuited the public participation that would have been possible in a rulemaking proceeding.⁵⁹⁸ Truck manufacturers, for example, expressed concern that the settlement provided inadequate lead time for designing new trucks to accommodate the redesign of the engines that would be necessary as soon as they learned of the settlements.⁵⁹⁹ But

596. If a manufacturer cooperated and the other companies did not, the manufacturer would receive increased market share, an outcome preferable to the joint noncooperation outcome. If others cooperated, a manufacturer who cooperated would maintain its market share, an outcome superior to the losses that would result from being the only noncooperator. The situation was different than it had been in the 1970s when the Big 3 automakers could successfully “play chicken” with the EPA, relying on the lack of credibility behind any EPA threat to shut down any of the companies. See WHITE, *supra* note 43, at 74-75 (“It is virtually unthinkable that one of the three large manufacturers would be closed down for failure to comply with emissions standards.”). The EPA’s threat against the engine makers was more credible because it had an intermediate threat of using fines that would raise engine costs for noncomplying companies and because there were more options for engine consumers. *Id.*

597. See Melinda Amberg-Vajdic, *Cummins: EPA Emissions Regulations Pose Challenge and Opportunity*, INDIANAPOLIS BUS. J., Mar. 29-Apr. 4, 1993, at 10A (quoting a Prudential Securities Research analyst that “Cummins’ technological prowess is likely to serve the company well in meeting future demands on the regulatory front”). Cummins claimed that a quarter of its R&D budget went to meeting future regulatory requirements. *Id.*

598. GAO, EPA COULD TAKE ADDITIONAL STEPS, *supra* note 550, at 13 (MY 2007 standards, “unlike the consent decrees established as the result of an enforcement action, were developed through a public rulemaking process that gave stakeholders from across the industry sectors the opportunity to provide input to [the] EPA for consideration”).

599. See Johnson, *supra* note 436, at 1:

Another concern is that the new engines, which will likely need a bigger radiator, will require the front ends of trucks to be changed in order to fit. “What we’re hearing is that some of the time frames of the settlement are very aggressive and the manufacturers of the trucks feel that they can’t possibly do what the engine makers have agreed to with the EPA in those time frames,” said [an American Trucking Association representative].

Id. See also Tom Berg, *EGR is the Next Thing to Worry About*, TRANSPORT TOPICS, Dec. 18, 2000, at 1 (“Long lead times to order bracketry and other items to accommodate EGR means that ‘time is just about run out,’ complained Jim Hebe, president of Freightliner

because the EPA implemented its response through regulation-by-litigation, the truck manufacturers had no ability to participate in the regulatory process. There was no notice of the settlement proposals analogous to a notice of proposed rulemaking that let the public know what the EPA intended to seek. If the EPA had issued such a proposed rule, the truck manufacturers could have brought their concerns into the process before the deals were made with the engine manufacturers. Although the Truck Manufacturers Association sought to intervene in the litigation to make its views opposing the terms known,⁶⁰⁰ its request to do so was denied. Environmental groups were also shut out of the process, and they objected to the terms of the settlement as insufficiently stringent.⁶⁰¹ In particular, they argued that the EPA should require immediate recall and retrofitting of the trucks with the objectionable controllers rather than allowing them to be changed only during a regular rebuild.

8. Regulation-by-Rulemaking Since the Consent Decree

The EPA continues to view heavy-duty diesel engines standards as in need of additional tightening, finalizing a rule in 2001 requiring a significant reduction for MY 2007.⁶⁰² These standards incorporate elements based on the settlements from the litigation with the engine

LLC . . .”).

600. See John H. Cushman, Jr., *Top E.P.A. Official Not Backing Down on Air Standards*, N.Y. TIMES, June 1, 1997, at 1 (“The American Trucking Association wrote President Clinton to protest the deal, saying it would require significant changes in new engines and trucks in overly short and unreasonable time periods.”).

601. See Dori Meinert, *Caterpillar Shares Record Civil Penalty*, PEORIA JOURNAL STAR, Oct. 22, 1998, at A1 (“Environmental groups weren’t pleased with the settlement and threatened to challenge it in court, demanding the government immediately recall the engines instead of allowing the companies to fix the engines when they’re brought in by truck owners over three years for overhauls.”).

602. See, e.g., Walsh, *Global Trends*, *supra* note 166, at 8 (“EPA has announced a strategy to significantly reduce emissions from on-highway heavy-duty vehicles and is well along in putting it in place.”). On-road heavy diesel NO_x limits are to fall by 95% for MY 2007 from the already more stringent MY 2004 regulations and particulate standards to fall another 90%. Timothy V. Johnson, *Diesel Emission Control—Last 12 Months in Review*, DIESEL AFTERTREATMENT, 2000, at 33 [hereinafter Johnson, *12 Months*].

Even with more stringent heavy-duty highway engine standards set to take effect in 2004, these engines will continue to emit large amounts of nitrogen oxides and particulate matter, both of which contribute to serious public health problems in the United States. These problems include premature mortality, aggravation of respiratory and cardiovascular disease, aggravation of existing asthma, acute respiratory symptoms, chronic bronchitis, and decreased lung function. Numerous studies also link diesel exhaust to increased incidence of lung cancer. We believe that diesel exhaust is likely to be carcinogenic to humans by inhalation and that this cancer hazard exists for occupational and environmental levels of exposure. We are establishing a comprehensive national control program that will regulate the heavy-duty vehicle and its fuel as a single system.

Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, 66 Fed. Reg. 5002, 5002 (Jan. 18, 2001) (to be codified at 40 C.F.R. pts. 69, 80, 86).

manufacturers.⁶⁰³ Japanese and European regulators are also significantly tightening heavy-duty diesel emissions standards.⁶⁰⁴ The standards proposed for MY 2007 in the United States are significantly tougher than those proposed for Europe and Japan.⁶⁰⁵ The new standards shift the emphasis to NO_x and particulate control, requiring the development of new technologies.⁶⁰⁶

The MY 2007 standards reflect a significant cost increase relative to earlier standards. One study concluded that compared to the EU2 regulations in effect after 1998, the MY 2007 U.S. regulations were 32-37 percent worse for heavy-duty trucks, depending on the technology used, and were more costly on at least 10 of 14 design criteria and better on only one.⁶⁰⁷ The ever-increasing stringency of the U.S. standards will again require major engine redesign⁶⁰⁸ for those using EGR technology to meet the October 2002 standards.

The EPA's 2000 rule adopting new standards for MY 2004 and MY 2007 also provided that the EPA receive the documentation necessary to read and interpret engine on-board computers that relate to emissions systems⁶⁰⁹ and that engines include onboard diagnostic equipment that allowed operators to know if emissions systems malfunctioned.⁶¹⁰

The MY 2004 and MY 2007 regulations adopted in 2000 adopted test procedures "to more closely represent the range of real world driving conditions of heavy-duty diesel engines,"⁶¹¹ including "Not-to-Exceed" test procedures for testing engines in use, applicable over a wide range of ambient conditions, that limit emissions to 1.25 to 1.5 times the test standard.⁶¹²

603. See Walsh, *Global Trends*, *supra* note 166, at 9.

604. See Johnson, *12 Months*, *supra* note 602, at 33; Desantes et al., *supra* note 183, at 51 (stating that further reductions of 30% NO_x and 80% in particulates were to be required compared to 2000 levels).

605. See *id.* at 34.

606. See *id.* at 43; Johnson, *Review*, *supra* note 106, at 23 (noting that diesel particulates "are emerging as the heart of concern to health experts and regulators").

607. See Moser et al., *Impact*, *supra* note 182, at 61-62, Tables 2-3.

608. See *id.* at 59 ("The emission legislation has an effect on base engine design not only because of the packaging of the EGR system, but also because of the required higher peak firing pressure potential and the increased heat load on combustion chamber walls, EGR cooler and charge air cooler."). The designs of the following engine components are affected: cranktrain, piston, bearings, cylinder head/block structure, head gasket, and cooling system. *Id.*

609. See Walsh, *Global Trends*, *supra* note 166, at 9; Control of Emissions from New and In-Use Highway Vehicles and Engines, 40 C.F.R. §§ 86.004-21(n) (2001) (including hardware, passwords, and other documentation).

610. See Walsh, *Global Trends*, *supra* note 166, at 9; Control of Emissions from New and In-Use Highway Vehicles and Engines, 40 C.F.R. § 86.005-17(a) (2001) (discussing heavy-duty vehicles under 14,000 GVWR).

611. Walsh, *Global Trends*, *supra* note 166, at 9.

612. See Control of Emissions from New and In-Use Highway Vehicles and Engines, 40 C.F.R. §§ 86.007-11(a)(3)(ii), (a)(4) (2001).

A final innovation in the MY 2007 regulations was to offer engine manufacturers "clean engine credits" for selling cleaner engines before the regulatory deadlines. For every "clean" engine sold in advance, a manufacturer could sell fewer "clean" engines in MY 2007 and later.⁶¹³ To induce early selling, the EPA offered enhanced credits (1.5 to 2) per early sale.⁶¹⁴

The regulations are forcing increased vertical integration, with truck makers offering fewer choices of engines with their trucks.⁶¹⁵ They are the major driving force in engine development today. An *Overdrive* cover story summed up their impact: "The near future of heavy-truck engines can be summed up in two numbers, 2002 and 2007—the years the EPA has chosen to further tighten the regulatory clamps on exhaust emissions."⁶¹⁶ Both the 2004 and 2007 standards will require substantial increases in control systems complexity, both in controlling combustion and adding after-treatment devices.⁶¹⁷ Emissions regulations will also divert research efforts from fuel economy to emissions control, reducing the future gains from enhanced fuel economy.⁶¹⁸ Some observers predict a pre-buy before the MY 2007 engines go on sale similar to that which occurred before the October 2002 engines entered the market because of the uncertainties in the new technologies needed, the greater costs,⁶¹⁹ and the expected fuel economy penalties despite the longer lead time for testing the new engines.⁶²⁰

Despite the increasing stringency of the regulations, the EPA continues to regulate only a few of the significant diesel pollutants. For example,

613. See Control of Emissions from New and In-Use Highway Vehicles and Engines, 40 C.F.R. § 86.007-11(g)(2); Walsh, *Global Trends*, *supra* note 166, at 12.

614. See *id.*

615. See Linda Longton, *Expect Fewer Component Choices, Truck Makers Say*, *OVERDRIVE*, Apr. 2002, at 14 ("The cost of producing trucks with engines that meet the Environmental Protection Agency's tough emissions goals is forcing truck makers to partner with fewer suppliers, the leaders of four truck makers said during a panel discussion . . ."); Linda Longton & Avery Vise, *New Freightliner Chief: Used Truck Surplus, Emissions Regulations Pose Challenges*, *OVERDRIVE*, Jan. 2002, at 13 (stating that the EPA regulations will speed vertical integration by quoting Freightliner CEO Rainer Schmueckle that "[i]t's an enormous expense to carry a model range through three major engine overhauls over the next five years"). See also RHEIN, 7TH EDITION, *supra* note 185, at 10 (predicting increased consolidation and captive engine companies as a result of emissions regulations).

616. Paul Hartley, *When Will My Diesel Engine Become a Dinosaur?*, *OVERDRIVE*, Jan. 2000, at 64.

617. See Peter Schihl, *Control Strategies for Heavy-Duty Diesel Engine Emissions*, *IEEE INSTRUMENTATION & MEASUREMENT MAGAZINE*, June 2001, at 11, 15 (explaining that complexity will increase due to "active devices, injection timing and duration, and VGT blade position").

618. See Duleep, *supra* note 30, at 187 (forecasting that improvements in fuel efficiency could decrease by half from 2002 to 2015).

619. See RHEIN, 7TH EDITION, *supra* note 185, at 22 (predicting cost increases of \$5,000 to \$10,000).

620. See *id.* at 214 (noting that engines were available for testing in mid-2003 but that some suppliers still anticipated a pre-buy).

diesels emit aldehydes and polycyclic aromatic hydrocarbons, which are both mutagens, and which are an important part of the "negative image" of diesel engines.⁶²¹ The EPA does not directly regulate engines with respect to either,⁶²² although some control technologies for regulated pollutants reduce emissions of these as well.⁶²³

As engine manufacturers began to prepare for the MY 2007 standard, several began to focus on selective catalyst reduction (SCR) systems, in which an additive, urea, is injected into the fuel mixing chamber. The addition renders the exhaust easier to scrub NO_x from but requires operators to maintain their trucks' urea supplies. The EPA has been quietly lobbying and privately urging manufacturers not to use SCR systems out of concern that truckers will not purchase the urea and that the emissions reductions will not be possible to obtain.⁶²⁴ Instead, the EPA is promoting a competing technology that does not require additional inputs.⁶²⁵

CONCLUSION

In his discussion of regulation-by-litigation, Richard Epstein described two responses that might be taken by a constitutional government to address harms imposed by some members of the community on others against their will.⁶²⁶ The first response he described called for a determination of the number being harmed and, implicitly, the cost of their organizing common law suits against the parties that had invaded their property rights, assuming, of course, a common law framework exists.⁶²⁷ If private action was feasible, then there would be no further role for the state. Epstein implies that government has a responsibility to assist in defining and enforcing property rights. The provision of a system of justice for settling property rights disputes provides adequate protection of the public

621. See Zelenka et al., *Clean*, *supra* note 92, at 11; see also DIESEL ENGINE REFERENCE BOOK, *supra* note 64, at 473 ("Other emissions, such as formaldehyde for example, can be an important component of diesel exhaust but are not currently regulated in many countries."); IPCS, CRITERIA 171, *supra* note 57, at 91 ("Diesel engine exhaust emissions contain hundreds of chemical compounds . . .").

622. Thus far the EPA has largely addressed hazardous air pollutants through fuel regulations rather than through regulation of vehicles. See Control of Emissions of Hazardous Air Pollutants from Mobile Sources, 66 Fed. Reg. 17,230 (Mar. 29, 2001) (to be codified at 40 C.F.R. pts. 80 & 86); see also Regulation of Fuels and Fuel Additives, 40 C.F.R. §§ 80.40-80.83 (2001) (including reformulated gasoline & diesel regulations).

623. See Zelenka et al., *Clean*, *supra* note 92, at 10-11 (discussing use of an oxidation catalyst to reduce NO_x and these pollutants).

624. See Jeff Johnson, *EPA Working Against Engine Technology*, 16 LIGHT & MEDIUM TRUCK, Feb. 2003, at 12.

625. See *id.*

626. See Richard Epstein's comments, in MANHATTAN INSTITUTE FOR POLICY RESEARCH, REGULATION BY LITIGATION: THE NEW WAVE OF GOVERNMENT-SPONSORED LITIGATION, CONFERENCE PROCEEDINGS 61, 61-62 (1999) [hereinafter NEW WAVE].

627. See *id.* at 61.

interest. Epstein goes on in his comment to consider briefly those situations where many unwilling individuals are harmed, situations where the collective harm is large but the individual harm is too small to justify taking private action.⁶²⁸ In these cases, he suggests, government can act for the citizens, following a tradition that relates to a "distinction between general and special damages as early as 1535."⁶²⁹

Epstein moves from antiquity to the present, explaining that our modern interpretation of government calls for government to act; if, after proper deliberations among appropriately elected officials, government fails to act, then government has failed.⁶³⁰ Under this theory, any failure to intervene in the name of public health, no matter the cost, is a failure to serve the public interest. Given that government has failed, special interest groups that claim to be serving the public interest move to the courts. As Epstein puts it, "so-called public health positions are always going to get at least two bites at the apple. They, in effect, have to win only one war; industries in defensive positions are going to have to fight their battles over and over again."⁶³¹ Epstein's discussion focused on suits undertaken by attorneys general in suits against hand-gun and cigarette producers; the discussion was not about the use of regulation-by-litigation by federal agencies in their pursuit of firms or industries already regulated. But while this was not the focus of Epstein's comments, it is still possible to glean something from them for the case at hand. In doing so, we return to Epstein's point about constitutional government and the democratic process and apply to the diesel engine case.

It seems clear enough that the harms imposed on individuals by diesel engine emissions coming from trucks and other equipment are so small that no one person or small group could justify organizing a suit against the emission producers.⁶³² Indeed, we will not attempt to reach a judgment as to whether or not the collective harms would justify action, but we will assume that to be the case. Assuming that a case for general harm can be

628. *See id.*

629. *See id.*

630. *See id.* at 62.

631. *See id.*

632. Environmental groups do bring "citizen suits" under a variety of environmental laws seeking enforcement of permit terms against sources. The citizen suit provisions are explicitly designed to overcome the collective action problem by providing attorneys fees for the victorious group and eliminating the requirement to show direct harm to the plaintiff's property or person. They thus arguably provide incentives for too much litigation. Citizen suits do not, however, lead to substantive regulatory changes, merely to enforcement of existing regulations. *See generally* Daniel J. Dunn, *Environmental Citizen Suits Against Natural Resource Companies*, 17 NAT. RESOURCES & ENV'T 161 (2003) (discussing use of citizen suits); Richard A. Epstein, *Standing in Law & Equity: A Defense of Citizen and Taxpayer Suits*, 6 GREEN BAG 2D 17 (2002) (arguing citizen and taxpayer suits should be routinely allowed in equity and that current standing law is mistaken).

made, then, as Epstein suggests,⁶³³ government can act for the harmed individuals. The passage of the Clean Air Act and its amendments is the first result. The regulations affecting diesel engine emissions that evolved from the Statute is the continuing result. When Congress debated the statute, the affected industry and all other interested parties had access to the debate. When the EPA engaged in regulation-by-rulemaking and regulation-by-negotiation, the industry and all other interested parties had access to the regulatory process and to the courts if the regulatory process was seen as being improper. Everyone had the same number of bites at the apple. In the process, some modicum of regulatory certainty was assured for the industry and for all who favored stricter standards. The process was transparent to the participants and to the monitors of the regulatory process in the legislative and executive branch.

The EPA's decision to litigate did not necessarily represent a second bite at the apple for those who support cleaner air. It was rather a fresh bite by the regulator. The EPA, as a regulator, faced a political challenge. On the one hand, the northeastern states faced the cost of nonattainment status demanded action and the administration wished to be recognized as being tough on polluters in the run-up to the 2000 elections. The EPA also had to recognize that its own past estimates of improvements in air quality were faulty and played a role in creating the crisis. If the EPA recognized that the problem stemmed from its faulty predictions and modeling and granted relief to the upwind states, it would anger northeastern voters whose states would then require increased stationary source restrictions and look soft on pollution nationally. If it attempted to reduce restrictions on both the northeastern states and the upwind states, it would anger "environmental" voters. If it required tighter stationary source controls in upwind states, there would be important political costs to pay there. Mobile source regulation offered a way out of this dilemma. On the other hand, the EPA was constrained by the regulatory process from taking swift action through issuing new standards there by the lead time restrictions and the impact of fleet turnover.

By employing regulation-by-litigation, the EPA took a bite from the apple it had been forbidden to eat. Circumventing the lead time restrictions, the EPA was able to do what Congress had said it could not and tighten mobile source emissions standards sooner than it could through regulation-by-rulemaking. Environmentalists would be happy with the "tough" action and northeastern states would get relief as the model predicted lower emissions from the stricter emissions standards, while upwind states would not be required to reduce their emissions. The

633. See *NEW WAVE*, *supra* note 626, at 61.

solution was “win-win” for everyone but the consumers of heavy-duty diesel engines and firms that made or used the engines. In other words, the benefits were concentrated on environmental pressure groups and state regulators, while the costs were spread among essentially all consumers, since transportation services affect most products. Moreover, by employing litigation, the agency insulated its regulatory action from changes in the political control of the executive branch. A new administration might consider rolling back a regulation but it would be unlikely to return to court to seek to reduce the burdens of a “voluntary” settlement agreed to by sources alleged to have committed significant wrongdoing.

The cost of this episode cannot be reckoned in terms of the magnitude of the settlement, which was a transfer from the owners of the diesel engine producers to federal taxpayers. Nor can it be reckoned just in terms of its effects on the cost of diesel engines and related effects on transportation and other activities powered by large diesel engines. These are clearly costs to consider, and to be minimized if possible. The more serious cost of the diesel regulation-by-litigation relates to the integrity of the regulatory process itself and the effect of regulation-by-litigation on the behavior of participants in future regulatory episodes.

The EPA's recent and extensive employment of regulation by litigation has set a new precedent in the already controversial annals of federal regulation. It remains to be seen if regulation-by-litigation will become a dominant form of regulation or if the EPA's expansive and recent use of the process will spark a reform process that leads to the end of regulation-by-litigation. We have no reason to predict that regulation-by-litigation will end any time soon. Indeed, the public choice logic we have employed to explain this episode suggests that when the conditions that triggered this episode arise again, then regulation-by-litigation will just as surely emerge again, unless this form of regulation is precluded by congressional action.

TABLE 1: DIESEL EMISSIONS STANDARDS

Smoke Standard					
MY 1970-1973	20% opacity (acceleration) 40% opacity (lugging)				
MY 1974-current	20% opacity (acceleration)				
(MY 2007)	15% opacity (lugging) 50% opacity (peak)				
Gaseous emissions (grams/brake-horsepower-hour)					
Model Year	HC+NO _x	CO	HC	NO _x	PM
1974	16	40			
1979 – either or	5	25			
	10	25	1.5 max.		
1984 Steady state OR Transient	--	15.5	0.5	9.0	
	--	15.5	1.3	10.7	
1985		15.5	1.3	10.7	
1988		15.5	1.3	10.7	0.60
1990		15.5	1.3	6.0	0.60
1991		15.5	1.3	5.0	0.25/ 0.10
1993		15.5	1.3	5.0	0.25/ 0.10
1994		15.5	1.3	5.0	0.01/ 0.07
1998		15.5	1.3	5.0	0.01/ 0.07
2004 either or	2.4 2.5	15.5 15.5	-- 0.5 max	--	0.01/ 0.07
2007		15.5	0.14	0.20	0.01