

THE NEXT GENERATION OF MOBILE SOURCE REGULATION

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I. WHERE WE ARE NOW

We are at an important divide in the history of air pollution regulation. The black-smoke-belching tailpipes of 1960s-era cars and trucks are no more; today's automobiles and heavy duty diesel trucks are significantly cleaner than their counterparts from 1970. As early as the beginning of the 1980s, new vehicles were 96 percent cleaner for hydrocarbons, 76 percent cleaner for nitrous oxide (NO_x), and 96 percent cleaner for carbon monoxide (CO) than in 1970.¹ This is dramatically demonstrated by Figure 1, which graphically illustrates the tightening of emissions standards for volatile organic compounds (VOCs). Similar tightening has occurred with respect to other criteria pollutants. The consequence of these significant reductions in emissions from mobile sources is that we have reached the point where further reductions in per-mile emissions from individual mobile sources of the criteria pollutants will be both tiny and expensive. And these limits on future reductions of per-mile emissions of criteria pollutants are not ones that can be overcome by the discovery of a new catalyst for treating emissions or invention of a new end-of-the-tailpipe device. We have simply arrived at the point where there is little else we can do to internal combustion and diesel engines or gasoline or diesel fuel that we have not already done. (The one exception is to increase the efficiency of these engines, reducing emissions per mile by reducing the amount of fuel that must be burned to move the vehicles. But increasing efficiency results in the Jevons

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¹ J. ROBERT MONDT, CLEANER CARS: THE HISTORY AND TECHNOLOGY OF EMISSION CONTROL SINCE THE 1960S 57 (2000).

Paradox—greater efficiency produces greater use because the increased efficiency reduces the cost of operations.)²

This is a tremendous success worthy of celebration.³ Air pollution in the developed world generally has largely been transformed from a visible problem into a debate over the impact of quite small levels of pollutants. Killer smogs are no longer the concern of developed world air pollution regulators, having been relegated to the history books in their countries. Similarly, fuels have significantly improved. Lead in gasoline has ceased to be a major airborne pollutant, sulfur levels in transportation fuels have declined dramatically, and in virtually every dimension transportation fuels are cleaner and less polluting than they were in 1970. The situation is quite different in developing countries, where indoor air pollution from burning wood, charcoal, dung and other solid fuels continues to be a major problem and where transportation fuels are not always as clean.⁴

² See W. STANLEY JEVONS, THE COAL QUESTION 140 (A.W. Flux ed., 3rd ed. Augustus M. Kelley 1965) (1906) (“It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth.”). There is empirical support for the Jevons Paradox with respect to automobile mileage. See Kenneth A. Small & Kurt Van Dender, *The Effect of Improved Fuel Economy on Vehicle Miles Traveled: Estimating the Rebound Effect Using U.S. State Data, 1966–2001* 21, University of California Energy Institute, Paper EPE-014 (2005), available at <http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1026&context=ucei>.

³ See generally YOU HAVE TO ADMIT IT’S GETTING BETTER: FROM ECONOMIC PROSPERITY TO ENVIRONMENTAL QUALITY (Terry L. Anderson, ed.) (2004). This is not the place for a debate over either the costs and benefits of regulation to this point or whether the same levels of reduction could have been achieved at lower costs by alternative means of regulation. For the purposes of this Article, I am accepting the world as it is today as the starting point.

⁴ On indoor air pollution, see Majid Ezzati & Daniel M. Kammen, *Evaluating the Health Benefits of Transitions in Household Energy Technologies in Kenya*, 30 ENERGY POLICY 815, 815 (2001) (summarizing studies showing indoor air pollution’s role in disease burden for developing countries) and WORLD HEALTH ORGANIZATION, FUEL FOR LIFE: HOUSEHOLD ENERGY AND HEALTH (2006). The WHO report dramatically illustrates the scope of the problem:

Burning solid fuels produces extremely high levels of indoor air pollution: typical 24-hour levels of PM10 in biomass-using homes in Africa, Asia or Latin America range from 300 to 3000 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$). Peaks during cooking may be as high as 10 000 $\mu\text{g}/\text{m}^3$. By comparison, the United States Environmental Protection Agency has set the standard for annual mean PM10 levels in outdoor air at 50 $\mu\text{g}/\text{m}^3$; the annual mean PM10 limit agreed by the European Union is 40 $\mu\text{g}/\text{m}^3$. As cooking takes place every day of the year, most people using solid fuels are exposed to levels of small particles many

The success in reducing per-mile emissions of criteria pollutants and in raising overall air quality levels is not going to end the debate over mobile source emissions, however. First, despite (and in part because of) the decline in per-mile emissions, there are more Americans driving, and Americans are driving more, every year. And other transportation needs are also growing: more goods are shipped and more things are available to be shipped. Between 1980 and 2004, the number of gallons of fuel burned by commercial trucks went from 19.96 million gallons to 33.968 million gallons, an increase “due to a substantial increase in the number of trucks on the road, an increase in the average number of miles traveled per truck, and a doubling of truck vmt [vehicle miles traveled].”⁵ In short, as population grows, transportation methods become more efficient, and our economy grows, our transportation needs are likely to continue to grow despite the increased efficiency of transportation—another instance of the Jevons Paradox. As those needs grow, so will the numbers of vehicles on the road and the number of miles those vehicles drive.

Total mobile source emissions in developed countries are therefore likely to increase (or, at least, are highly unlikely to decrease significantly) as our ability to engineer reductions on a car-by-car, truck-by-truck basis reaches its technological limit and

times higher than accepted annual limits for outdoor air pollution . . .

The more time people spend in these highly polluted environments, the more dramatic the consequences for health. Women and children, indoors and in the vicinity of the hearth for many hours a day, are most at risk from harmful indoor air pollution.

Id. at 11. On transport fuels in the developing world, see Ken Gwilliam, et al., *Transport Fuel Taxes and Urban Air Quality*, POLLUTION MANAGEMENT IN FOCUS, Discussion Note 11 (2001) available at http://rru.worldbank.org/Documents/PapersLinks/transport_fuel_taxes.pdf (discussing problems of fuel subsidies in developing countries) and Asian Institute of Technology (Thailand) & National Institute of Environmental Studies (Japan), *Alternative Policy Study: Reducing Air Pollution in Asia and the Pacific* (2000), available at <http://www.unep.org/Geo2000/aps-asiapacific/index.htm> (discussing role fuel switching can play in reducing pollution levels in developing countries). The United Nations Environment Programme is working on a “Global Partnership toward Cleaner Fuels” to assist developing countries in moving toward cleaner transport fuels. See UNEP, *Global Partnership toward Cleaner Fuels*, available at <http://www.unep.org/energy/act/tp/fqp.htm>.

⁵ Freight Facts and Figures 2006, Table 5-7, available at http://ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/06factsfigures/table5_7.htm. “VMT” is vehicle miles traveled and is the standard unit of measure of trucking volume.

is overwhelmed by the rising numbers of miles driven by vehicles, a rise which is increased by increasing efficiency. And mobile source emissions world-wide are going to climb as other countries' living standards improve and greater wealth in the developing world fuels the demand for mobility. If we compare the number of vehicles per 1,000 population for various countries relative to that same number for the United States at different points we can get a sense of where world motor vehicle use is headed. For example, in 1994, China had the same number of cars per 1,000 population as the United States in 1911; by 2005, the number had risen to the level equivalent to the U.S. in 1915.⁶ Even if China adopts an aggressive program of urban design and mass transit comparable to that in Western Europe, bringing China to the level of vehicles of Western Europe in 2005 (the same as the United States in 1970) will dramatically expand the number of cars and trucks in China. And the development of the inexpensive "one lakh" car in India is likely to dramatically expand automobile use in developing countries around the world, a prospect that environmental regulators say gives them "nightmares."⁷

Moreover, our choices are no longer, if they ever really were, simple ones between "clean" and "dirty" air. Because we now face a complex series of choices implicating a diverse set of tradeoffs, there is no obvious "green" answer to many environmental regulation policy questions. Not only will we confront technological barriers unlike those we have solved in the past as we continue to tighten existing air quality standards (e.g., ozone) and regulate additional air pollutants (e.g., greenhouse gases), but having previously done the easy, relatively low marginal cost pollution control measures, we now face difficult tradeoffs in making future emissions control decisions. Do we increase the efficiency of combustion in engines, reducing particulates but increasing NO_x emissions or the reverse? Do we emphasize controlling carbon dioxide (CO₂) by encouraging a switch from gasoline to diesel engines at the cost of increasing

⁶ S.C. Davis & Susan W. Diegel, *TRANSPORTATION ENERGY DATA BOOK 3-2* (26th ed. 2007).

⁷ See, e.g., *Rs 1 lakh car a threat to environment: Pachauri*, THE ECONOMIC TIMES (INDIA) (Dec. 15, 2007), available at http://economictimes.indiatimes.com/Rs_1_lakh_car_a_threat_to_nature_Pachauri/articleshow/2624634.cms.

NO_x emissions?⁸ Or do we focus on controlling particulates, at which spark-ignition engines have an advantage?⁹ If we choose to create incentives for diesel use, will the greater fuel efficiency of diesel engines relative to gasoline engines lower the cost of operation and encourage more mobile source use? These are hard questions to answer, and likely harder still to explain to the general public.

Even the traditional narrative of environmental regulation as a series of battles between “environmentalists” and “business” has broken down. It may have been possible in the mid-1970s to cast mobile source regulation as a battle between, on the one side, recalcitrant Detroit automakers, Rep. John Dingell, and the UAW and, on the other, environmental activists seeking to stave off a future of choking fumes.¹⁰ But at least since the battle over the 1977 Clean Air Act Amendments documented in Ackerman and Hassler’s landmark *Clean Coal/Dirty Air*, we have known that powerful financial interests exist on all sides of environmental regulatory disputes and that environmental groups have no

⁸ Emissions standards for a gasoline and diesel 2005 car are:

	Gasoline	Diesel
Total HC	1.25 g/mi.	0.58 g/mi.
Exhaust CO	12.57 g/mi.	1.57 g/mi.
Exhaust NOX	0.92 g/mi.	1.32 g/mi.

See U.S. Dept. of Transportation, Freight Facts and Figures 2006, Table 5-11, available at http://ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/06factsfigures/table5_11.htm.

⁹ See Mondt, *supra* note 1, at 28 (“Compared to spark-ignition (Otto-cycle) engines, Diesel-cycle engines produce larger quantities of particulates because the fuel charge is injected into a combustion space that is essentially filled with air. At the end of the combustion event, the flame front is cooled before all the fuel is oxidized, and the unburned carbon in the fuel is oxidized by surrounding air, producing particulates or particulates.”).

¹⁰ During the debate over air pollution control legislation in the 1970s, a congressman termed the internal combustion engine the “most serious and dangerous source of air pollution in the Nation today.” Andrew P. Morriss, *The Politics of the Clean Air Act*, in *POLITICAL ENVIRONMENTALISM: GOING BEHIND THE GREEN CURTAIN* 289 (Terry L. Anderson ed. 2000). A California Assemblyman proposed outlawing internal combustion and diesel engines after January 1, 1975 in a bill introduced in 1969. See Russell Mokhiber & Robert Weissman, *Conspiracy of Polluters*, MOTHER JONES (July 28, 2000), available at <http://www.motherjones.com/news/feature/2000/07/fotc31.html>.

reasonable claim to sainthood.¹¹ And Enron's involvement in lobbying for federal action on global warming illustrates that even some of the less saintly business people can perceive profits to be made from environmental regulatory matters.¹² As a result, the tradeoffs are not only no longer a choice between obviously "clean" and "dirty" policies but even the lobbyists involved can no longer be easily scored by their "green" or "business" labels.

The final piece of the regulatory picture is the move toward regulation of mobile source emissions of greenhouse gases in the wake of the Supreme Court's decision in *Massachusetts v. EPA*.¹³ For the most part, greenhouse gas emissions from mobile sources are simply the product of combustion and cannot be readily reduced without increasing engine efficiency. (Increasing engine efficiencies, however, buys fewer reductions than it might first appear because of the Jevons Paradox.) Since these are a new concern, one might expect there to be low cost reductions available. But since greenhouse gas emission reductions are primarily achieved by increasing the efficiency of the engine, there are fewer cheap steps to take than might be the case if the government began regulating some other pollutant. Auto makers have been working on efficiency for many years, albeit with less enthusiasm than some might wish. Further increases will likely not be cheap.

Imagining where environmental law and policy might go in light of these basic facts about the world requires that we examine some of the underlying reasons for them. Why do vehicle miles traveled keep going up in the United States, on a trend line virtually devoid of changes in slope regardless of the health of the economy, oil prices, or any other variable? Why are China and India (and Vietnam, Indonesia, Egypt, Tanzania, Nigeria, Brazil, Peru, and virtually everywhere else) likely to increase their level of use of transportation services to something closer to the United States' level than to their present levels? Where are future

¹¹ BRUCE ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL / DIRTY AIR (1983). See generally ANDERSON, *supra* note 10.

¹² See, e.g., Patrice Hill, *Enron Cash Got Access to Bush, but not Results; White House Rejected Plea for Favorable Legislation*, WASH. TIMES, Jan. 21, 2002, at A1.

¹³ See *Massachusetts v. Environmental Protection Agency*, 127 S.Ct. 1438 (2007); Andrew P. Morriss, *Litigating to Regulate: Massachusetts v. Environmental Protection Agency*, CATO SUPREME COURT REVIEW 193 (2006–2007).

emissions reductions going to come from if each individual car is already emitting quite low levels of pollutants? To answer these questions, this Article examines the demand for transportation and the regulation of transportation fuels, and then assesses the possible steps for future regulation.

While the full analysis is developed at greater length below, the short answer to the question of the future of mobile source regulation is three-fold:

(1) When we care about total loading of pollutants in the atmosphere (e.g., CO₂), it will be cheaper and more effective to buy at least some of the reductions outside the developed world than to attempt to reduce emissions only within the developed world. This is also true with respect to localized problems—greater marginal gains in human and environmental health are possible by purchasing larger reductions elsewhere than by spending the same money on smaller marginal reductions in the developed world. Mobile source environmental policy must therefore become global. To do so will require developed countries to negotiate with developing countries to provide them with incentives to institute environmental controls.

(2) Changing driver behavior is the least exploited area of mobile source emissions control. Future efforts at reducing mobile source emissions will need to induce changes in individual driver behavior. To do so, carrots will work better than sticks.

(3) Tighter integration of fuels and engines will be necessary to reduce mobile source emissions. Persuading refiners, retailers, trucking firms, car fleet operators, auto manufacturers, auto mechanics, and other parts of both the transportation fuel and transportation industries to collaborate to achieve these reductions will require overcoming the private sector participants' well-justified fear of antitrust prosecution. Again, carrots will be more likely to produce results than sticks.

Even these measures, however, are likely to fall short in some respects in light of the limited gains available in domestic countries and the likely increases in transportation demand, putting greater pressure on reducing air pollution from stationary sources. One important lesson from the future of mobile source regulation is that stationary source regulation is going to have to pick up a larger portion of the future burden.

II. TRANSPORTATION, CARS, TRUCKS, AND AIR POLLUTION

We must begin with the basics of how mobile sources produce transportation services and pollution, and the reasons why people want those services, in considering how we might control pollution from mobile sources. If we do not take into account the reasons for the increasing demand for transportation services in both the developed and the developing world, we will fail to design effective policies.

First, there is the obvious point that no one desires to create mobile source emissions for their own sake. What people do want is transportation for themselves and their goods, making mobile source emissions an unwanted byproduct. Of course, no one wants to pay to reduce emissions either, but because emissions are an unwanted side effect of consuming transportation services they are a problem which is different in kind from problems such as pollution related to pesticide use, where toxicity (at least to the target pest) is a crucial element of the demand for the product.¹⁴ When reducing emissions requires reducing characteristics of the transportation services that people do want (e.g., by lowering mileage), people resist emissions controls. In the developed world, where most of the easy methods of emissions reduction have already been put into place, further reductions are likely to require acceptance of the reduction of other, desirable characteristics of transportation services. In the developing world, however, there is the potential to leapfrog the history of relatively dirty mobile sources and move to cleaner mobile sources, since the desire is for transportation services.

Second, transportation services are valuable. Transportation is needed for trade in goods and services; people need to get themselves to work to trade their services for wages and producers need to get goods from where they are produced to where the goods are consumed (including consumption in further production processes). Indeed, transportation services are becoming more important in our national economy and will likely continue to do so both domestically and internationally over the next fifty years

¹⁴ See generally Andrew P. Morriss & Roger E. Meiners, *Market Principles for Pesticides*, 28 WM. & MARY ENVTL. L. & POL'Y REV. 35 (2003); Andrew P. Morriss & Roger E. Meiners, *Property Rights, Pesticides and Public Health: Explaining the Paradox of Modern Pesticide Policy*, 14 FORDHAM ENVTL. L. REV. 1 (2002).

(at least). As a result, mobile source use is most likely going to continue to grow by large amounts for the foreseeable future.

Any future regulatory policy must take into account the importance of transportation services for both individuals and firms. Further, future emissions reductions strategies must take into account the need to persuade (through incentives or penalties) users to change their behavior with respect to transportation services.

A. *Where American Transportation Occurs*

Transportation can occur by a variety of means—planes, trains, and automobiles all provide transportation. Where and how people use them to provide transportation services is dependent in large part on the location of the places where people live and where they wish to go and where goods are located and where goods are desired. Because the United States is a large, not-particularly densely populated place (outside a few areas like the Northeast Corridor from Washington, D.C. to Boston),¹⁵ most of the transportation needs in the United States are for transportation *among a diverse web of locations* rather than *within a limited network of densely populated areas*.¹⁶ That is likely to remain true in the future.

¹⁵ Population density for the United States as a whole is 31 persons/sq. km., but, among the 48 contiguous states, population densities range from almost 440 persons/sq. km. in New Jersey to 1.96 persons/sq. km. in Wyoming. CENSUS 2000 GATEWAY, <http://www.census.gov/main/www/cen2000.html> (last visited Sept. 18, 2008). Eight of the ten most densely populated states are in the Washington-Boston corridor.

¹⁶ The Transportation Research Board of the National Academies of Sciences summarized the trends in commuting flows as follows:

From 1990–2000, about 64% of the growth in metropolitan commuting was in flows from suburb to suburb. Commuting from suburb to suburb rose in share from 44% of all metropolitan commuting in 1990 to 46% in 2000. The next largest growth area was the “reverse commute” from central city to suburbs, which had almost 20% of the growth in commuting and rose in share from 8% in 1990 to 9% in 2000. The “traditional commute” from the suburbs to the central city obtained only 14% of the growth and dropped in share from 20% in 1990 to 19% in 2000. Commuting from central city to central city saw only 3% of the decade’s growth, which resulted in a fall from over 28% share of all metropolitan commuting in 1990 to 26% in 2000. Thus, suburban destinations received 83% of the growth while central cities obtained the remaining 17%.

TRANSPORTATION RESEARCH BOARD, COMMUTING IN AMERICA III (2006) at xiv, available at <http://onlinepubs.trb.org/onlinepubs/nchrp/CIAMIII.pdf>.

If we examine population patterns we can discern some crucial facts that will influence future demand for transportation. Urban economist William Bogart has done so and he argues that three features will define our cities in the twenty-first century. These three features have important implications for controlling mobile source pollution.¹⁷

First, cities and regions prosper only through connections with each other. As Bogart notes, “[a]ttempts to improve the prospects of one subset of the region are praiseworthy, but only if they do so by consciously increasing the connections of the neighborhood to the other parts of the region. Public policy that reinforces autarky only makes matters worse.”¹⁸ The implication for mobile source pollution is that the link between trade and prosperity requires that, if we remain a prosperous society, we will continue to shift large volumes of goods, both final and intermediate, from place to place. Indeed, we are likely to do so in ever more complex ways that require ever more transportation services. For example, trade economist Douglas Irwin argues that a substantial portion of trade today consists of intermediate goods being shifted among suppliers.¹⁹ To illustrate his point, he quotes a description of a Ford factory in Toronto, Canada from a story in *The Economist*, where a logistics subcontractor

organizes 800 deliveries a day from 300 parts makers. . . . Loads have to arrive at 12 different points along the assembly lines without ever being more than 10 minutes late. Parts must be loaded into trucks in pre-arranged sequence to speed unloading at the assembly line. To make all this run like clockwork takes a team of ten computer-wielding operations planners and 200 unskilled workers, who make up the loads in the right sequence at a warehouse down the road.²⁰

Our economy is now so dependent on the logistics revolution that there is no turning back.²¹ Transportation services of physical

¹⁷ See WILLIAM T. BOGART, DON’T CALL IT SPRAWL: METROPOLITAN STRUCTURE IN THE TWENTY-FIRST CENTURY (2006).

¹⁸ *Id.* at 182.

¹⁹ DOUGLAS A. IRWIN, FREE TRADE UNDER FIRE 16 (2d ed. 2005).

²⁰ *Id.* at 16 n.11 (quoting THE ECONOMIST (Dec. 7, 2002)).

²¹ For example, the impact of containerization, which is only a portion of the logistics revolution, on trade volume, was to boost the volume of trade, as Marc Levinson’s definitive history concludes:

The revolutionary days of container shipping were over by the early 1980s. Yet the after effects of the container revolution continued to

goods, despite all the media hype about an “information economy,” remain a critical part of our economy and are more likely to grow in importance than they are to decline. Even more importantly, the logistics revolution will increasingly take hold in other economies as well. Brazil, Russia, India, and China (the “BRIC” countries), as well as growing economies like Mexico, Indonesia, and South Africa, will seek to imitate the gains from enhancing logistics, which is likely to increase the demand for transportation services in the rest of the world independently of what happens in the United States.²² U.S. customers of suppliers in those economies will also demand that their foreign suppliers adopt such techniques for exports to the U.S. to reduce costs to the American buyers.²³ The demand for transportation services will

reverberate. Over the next two decades, as container shipping began to drive international freight costs down, the volume of sea freight shipped in containers rose four times over. Hamburg, Germany’s largest port, handled 11 million tons of general cargo in 1960; in 1996, more than 40 million tons of general cargo crossed the Hamburg docks, 88 percent of it in containers, and more than half of it from Asia. . . . Low-cost products that would not be viable to trade without container shipping diffused quickly around the world.

MARC LEVINSON, *THE BOX: HOW THE SHIPPING CONTAINER MADE THE WORLD SMALLER AND THE WORLD ECONOMY BIGGER* 271 (2006). On the impact of the logistics revolution more generally, see *Chain Reaction: A Hidden Industry Has Changed All Our Lives; but Some Companies Are Operating Rather Close to the Edge*, *THE ECONOMIST*, June 17, 2006, 14 (noting that containerization “has slashed the cost of shipping,” advanced shipping “services are within the grasp not just of the supply departments of giant multinationals but also of anyone trading on eBay from the spare bedroom,” and “[m]any of today’s most successful companies . . . have risen to the top of their industries in large part by rewriting the rules of competition through the organisation of their supply chains.”); *A Survey of Logistics: Chain Reactions: Delivery Companies Are Consolidating*, *THE ECONOMIST*, June 17, 2006, at 14, 17 (Companies “are starting to realise that if they can move goods through a supply chain faster and more efficiently, the effect on their performance can be profound, going well beyond being able to keep stocks low.”); *A Survey of Logistics: The Physical Internet*, *THE ECONOMIST*, June 17, 2006, at 3, 4 (Supply chain management “can also be used to increase revenue and boost profits without necessarily lowering costs. Indeed, some companies have re-engineered their supply chains to gain a huge competitive advantage.”). For a brief history of the logistics revolution, see W. Bruce Allen, *The Logistics Revolution and Transportation*, 553 *ANNALS AM. ACAD. POL. & SOC. SCI.* 106 (1997).

²² See, e.g., James C. Cooper, *Logistics Strategies for Global Businesses*, *INT. J. OF PHYSICAL DISTRIBUTION & LOGISTICS MANAGEMENT*, 12, 23 (1993) (describing rise of global supply chain management).

²³ For examples of the impact of the logistics revolution on Mexico, see, Ricardo Castillo Mireles, *Mexico Offers Logistics Alternative: Becoming Part of the U.S. Supply Chain*, *BUSINESS MEXICO*, May 2005, available at

therefore continue to grow as trade grows among cities, among regions, and among nations. While increasing efficiencies in transportation may reduce the per pound energy costs, the increasing volume of trade will at least partially offset such efficiencies. We should expect, therefore, that the future holds larger volumes of trade and increasing mobile source emissions from transporting goods.

Second, Bogart argues that the future of personal transportation remains the individual automobile. “[M]ass transit was dominant for only a particular confluence of technological conditions that have not obtained since at least the 1920s. The combination of mass transit and density observed in the late 1800s and early 1900s was not a harbinger of things to come, but rather a temporary anomaly.”²⁴ As a result, he concludes that “[p]ublic policy that is based on replacing cars with mass transit is not based in reality.”²⁵ The future of individual transport is thus not going to be built around either subways or bicycles but around something that looks a great deal like today’s cars. The cars of tomorrow may be fueled differently or use new forms of engines, but they will be individual vehicles and not buses. The possibilities for new fuels and new engines will be discussed more below, but the crucial thing to note here is that even if we shift to a radically different form of providing energy to individual means of transportation like plug-in electric vehicles, we will merely have shifted the emissions from tailpipes to power plants.²⁶

<http://www.entrepreneur.com/tradejournals/article/132870637.html> (discussing development of intermodal transport in Mexico and competition for U.S. shipping business); Ricardo Castillo Mireles, *For Coca-Cola Mexico, Things Go Better with Logistics*, LOGISTICS TODAY, Sept. 12, 2005, available at <http://www.logisticstoday.com/displayStory.asp?sNO=7420> (describing advances in supply chain management at Coca Cola Mexico).

²⁴ BOGART, *supra* note 17, at 182.

²⁵ *Id.*

²⁶ Mass transit may not be less polluting than individual-vehicle-based transit, as the calculations depend on a wide range of factors. Transportation expert Randal O’Toole of the Cato Institute calculates the CO₂ emissions (lbs. per passenger mile) from various forms of transportation as follows:

Prius	0.26
Average SUV	0.69
San Francisco heavy rail	0.14
Cleveland heavy rail	1.02
Washington, DC heavy rail	0.62
Pittsburgh light rail	1.18
San Diego light rail	0.13

Third, in twenty years our cities are still going to look a lot like our cities do today. Even if we decide that major lifestyle changes are needed to combat environmental problems, Bogart argues that “investment under uncertainty implies that durable construction only occurs at discrete intervals rather than in continuous small increments. . . . [G]iven the huge costs of removing and replacing entire cities at once, we must gradually modify what was there before.”²⁷ Just as our cities today are a “weighted average of the past,”²⁸ so cities of tomorrow will be influenced by the investment decisions made by their previous residents. As Bogart notes,

more than two-thirds the office space available in 1999 already existed in 1990, whether the metropolitan area is rapidly growing or slowly growing, Sun Belt or Rust Belt, geographically constrained or open to expansion. An ambitious plan to reshape a metropolitan area in a decade needs to take into account that the vast majority of the shape of the metropolitan area will not change in a decade.²⁹

Thus even if Al Gore somehow swept into the presidency in 2008 (despite not being a candidate) and brought with him a compliant Congress and a mandate to reshape American life radically to combat global warming and is then reelected to complete his program in 2012, our physical infrastructure when he leaves office in 2017 would look much like our physical infrastructure in 2007. Since even President Gore is likely have to deal with Rep. Dingell,³⁰ the more politically realistic options are even less likely to significantly alter our urban landscapes.

Not only is radical change in our physical infrastructure

Crucial to O’Toole’s calculations are considerations of the sources of electricity (San Francisco derives about half of its electricity from fossil fuels, Cleveland’s electricity is mostly fossil fuel based) and ridership (these calculations use the national averages of 1.57 people per car and 1.73 people per SUV). For example, O’Toole reports that San Jose’s light rail emits 2.5 times the CO₂ per passenger mile than San Diego’s and carries fewer people than San Diego’s. Email from Randal O’Toole, Cato Institute to Andrew Morriss, H. Ross & Helen Workman Professor of Law and Business, University of Illinois, (Feb. 21, 2008, 22:18) (on file with journal).

²⁷ BOGART, *supra* note 17, at 182.

²⁸ *Id.* at 34.

²⁹ *Id.* at 35.

³⁰ *See, e.g.*, JACK DOYLE, TAKEN FOR A RIDE: DETROIT’S BIG THREE AND THE POLITICS OF POLLUTION 128–29 (2000) (describing Dingell’s role as “Detroit’s man” in early clean air legislation battles).

unlikely for the reasons Bogart identifies, it is also unlikely because such changes do not fit Americans' revealed preferences for how they live their lives. Environmental pressure groups often point to polls in which large numbers of respondents offer support for major environmental initiatives.³¹ Economists prefer to rely on analyses of how people actually make choices with real resources as a better guide to what people really want.³² For example, environmental critics of American lifestyles often point to federal subsidies for automobile and truck use as an important reason for our land use patterns.³³ While such subsidies undoubtedly encourage low density development, they are far from the only cause—Americans' preferences, the low cost of land because of its relatively large supply compared to Europe, and technological changes that improve transportation also play a significant role. And even the subsidies for roads reflect the political demand for such subsidies; given American preferences, it would be surprising if American governments did not subsidize roads since doing so is politically popular.

The key point is that individual transportation through personal vehicles, whether powered by batteries or internal combustion engines, is going to remain an important part of the transportation network for people, and transportation of goods via trucks is going to remain a key part of the transportation network for goods into the foreseeable future.

The implications for mobile source pollution control are two-fold:

³¹ See, e.g., Global Stewards, *U.S. Public Opinion Survey Results on the Environment, Trade, and Campaign Finance Reform*, available at <http://www.globalstewards.org/survey.htm> ("86% [of Americans in a survey] are concerned about the quality of our environment, with 57% 'very concerned.'"). But see PEW GLOBAL ATTITUDES PROJECT, *RISING ENVIRONMENTAL CONCERN IN 47-NATION SURVEY: GLOBAL UNEASE WITH MAJOR WORLD POWERS 30* (2007), available at <http://pewglobal.org/reports/pdf/256.pdf> ("[P]ollution is a lower-rated concern in the U.S. than in any other advanced industrial country.").

³² See Andrew P. Morriss, *Real People, Real Resources, & Real Choices: The Case for Market Valuation of Water*, 38 TEX. TECH L. REV. 973 (2006) (citing Fredrik Segerfeldt, *WATER FOR SALE* 44–58 (2005)).

³³ See, e.g., STANLEY I. HART & ALVIN L. SPIVAK, *THE ELEPHANT IN THE BEDROOM: AUTOMOBILE DEPENDENCY & DENIAL* 1 (1993) ("The nation labors under policies which created, between the 30s and the 50s, its automobile dependency. Until these policies are rectified, the nation's efforts to escape dependency will be frustrated by the subsidies—the free use by motorists and the trucking industry of costly urban space and municipal services.").

(a) Policies that are aimed at promoting mass transit as a substitute for personal automobile use will fail. If they are given “credit” in EPA’s modeling of mobile source emissions, the model will inevitably diverge from reality until the agency is forced to make adjustments.

(b) The future of the market for personal transportation services looks remarkably like the present. We may be driving hybrids instead of Hummers³⁴ but we will still be driving in our own vehicles. Barring a major technological breakthrough soon, those vehicles will be burning a hydrocarbon of some kind as a significant source of their fuel over the next twenty to thirty years at least, either in an internal combustion engine or in a central power station.³⁵

B. *Future Emissions from Mobile Sources*

Once we accept that trucks and personal cars are going to remain vital parts of our transportation network and that their use is likely to increase in the coming decades, the question is then how these vehicles will affect air quality in the future. Broadly speaking, we can imagine two sorts of vehicles: those powered by their own energy source (e.g., internal combustion engines) and those powered by stored energy produced elsewhere (e.g., cars running on electric batteries). The latter shift the pollution problem to the stationary sources that charge their batteries; the former will likely emit pollutants of some kind as they operate.³⁶ And, of course, there are environmental consequences to the production of vehicles as well as to their operations—consequences that may reverse the sign on the net environmental impact of a vehicle.³⁷ Given the technical hurdles facing stored energy vehicles³⁸ and the demand for individualized transportation,

³⁴ If we are, the social benefits may be less than the differences in miles per gallon would lead us to suspect. See CNW Marketing Research, Inc., *Dust to Dust: The Energy Cost of New Vehicles from Concept to Disposal* (2005), available at <http://cnwmr.com/nss-folder/automotiveenergy/DUST%20PDF%20VERSION.pdf>.

³⁵ Fleet turnover, which I discuss below, is an important part of why this is so.

³⁶ Yes, fuel cells may save us from the internal combustion engine. If they do, it isn’t likely to be soon, however.

³⁷ See CNW Marketing Research, Inc. *supra* note 34, (discussing the life cycle tradeoffs between a Prius and a Hummer).

³⁸ See, e.g., Sharon Terlap, *Electric Cars Face a Battery of Hurdles*, DETROIT

it seems fair to assume that the operation of large numbers of individual cars and trucks that burn fuel will continue to affect air pollution well into the foreseeable future. And, of course, production of fuels can have environmental consequences—refineries emit pollutants into the air, hydrogen plants require energy to create fuel cells and so increase emissions from power plants, ethanol production produces adverse consequences due to water use and intensive farming practices.³⁹

Vehicles that burn fossil fuels cause air pollution in three ways. First, and most obviously, the consumption of fuel results in emissions of byproducts of the consumption and of partially consumed fuel. Second, vehicles can emit pollutants through leaks in the fuel storage and consumption systems within the vehicle (e.g., evaporation from fuel tanks). Third, fueling vehicles can cause pollution through contact between the fuel and the atmosphere during fueling (e.g., evaporation from gasoline pumps during fueling). Because cars and trucks today emit much less from each of these sources than they did in the past, there is no low hanging fruit to pick in any of these instances.⁴⁰

Some, but not all, air pollution from power generation in a truck or car is the result of incomplete combustion. Improving combustion efficiency reduces these pollution streams. Other pollutants come from combustion and improving combustion efficiency increases these pollution streams (e.g., CO₂). As a result, altering engine operation can result in increasing some pollutants while decreasing others. Consider just a few examples of the tradeoffs involved in engine operation and design:

- Soot from diesel engines can be reduced by higher injection

NEWS (Feb. 19, 2008), available at <http://www.detnews.com/apps/pbcs.dll/article?AID=/20080219/AUTO01/802190349/1148/rss25> (describing technological challenges).

³⁹ See, e.g., J.P.W. Scharlemann & W.F. Laurance, *How Green Are Biofuels?*, 319 SCIENCE 4 (2008) (describing environmental challenges of biofuel production).

⁴⁰ It appears that there are significant energy efficiency gains possible, albeit currently at relatively high costs, from capturing waste energy from vehicle operation and converting it to a usable form. For example, hybrid vehicles make use of energy released by braking to charge batteries that can then power the vehicle. These technologies hint at the possibility of dramatically reducing energy costs for operation of vehicles. Of course, as the cost of operation falls, we would expect vehicle use to increase. Some of the reductions in pollution per mile from such technologies are thus likely to be offset by increases in total miles of vehicle operation due to lowered costs.

pressure but doing so will produce more NO_x.⁴¹

- Timing changes to reduce particulates can increase NO_x.⁴²
- The “natural tradeoff between particulate emissions and NO_x” as “one of the critical challenges in the design of diesel combustion systems.”⁴³
- “While it is feasible to program new [diesel] 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.”⁴⁴

Indeed, some of the amounts of exhaust emissions of different pollutants vary inversely with one another as operators adjust the air-fuel ratio.⁴⁵

Taking these tradeoffs into account is particularly important for the future because “[m]ost trade-off curves are approximately

⁴¹ DIESEL ENGINE REFERENCE BOOK 93 (BERNARD CHALLEN & RODICA BARANESCU, EDS., 2nd ed. 1999); *see also* Hajime Fujimoto, Jiro Senda, Ichiro Shibata, and Koji Matsui, *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).

⁴² *See* Nigel N. Clark, Justin M. Kern, Christopher M. Atkinson, and Ralph D. Nine, *Factors Affecting Heavy-Duty Diesel Vehicle Emissions*, 52 JOURNAL OF THE AIR & WASTE MANAGEMENT ASSOCIATION 84, 92 (2002); Kashmir S. Virk and 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); Carcinogenic and Mutagenic Effects of Diesel Engine Exhaust (Norburu Ishinishi, et al., eds.) 506 (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.”).

⁴³ DIESEL ENGINE REFERENCE BOOK, *supra* note 41, at 93. *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, 24 (1995) (“One of the problems with controlling diesel emissions is the tradeoff between emissions of particulate matter and emissions of oxides of nitrogen.”).

⁴⁴ *United States v. Caterpillar, Inc.*, 227 F. Supp. 2d 73 (D.D.C., 2002); U.S. ENVIRONMENTAL PROTECTION AGENCY, MEMORANDUM OF LAW OF THE UNITED STATES OF AMERICA IN SUPPORT OF MOTION TO ENTER CONSENT DECREE AND RESPONSE TO PUBLIC COMMENTS at 13.

⁴⁵ Mondt, *supra* note 1, at 21–23.

hyperbolic in shape, so that the first increment of control produces only small degradation of performance while later increments cause accelerating degradation of performance.⁴⁶ Progressive tightening of emissions standards, as EPA has done over the last thirty years with NO_x, will move tradeoffs onto the less favorable portion of the curve, where large increases in emissions of other pollutants are the price of small increases in NO_x control.

An additional type of tradeoff is also important. Research on ozone formation has found that there are multiple mechanisms at work in the atmosphere leading to the formation of ozone.⁴⁷ When there are high levels of hydrocarbons in the atmosphere, reducing NO_x cuts ozone formation. When there are high levels of NO_x, however, reducing hydrocarbon levels is the better strategy. As diesel trucks emit proportionately more NO_x than hydrocarbons, while automobiles do the reverse, the impact of the weekend drop in truck traffic is different depending on whether NO_x or hydrocarbons are the critical factor in determining ozone levels. As a result, in some areas ozone levels fall on the weekends and in others they rise.⁴⁸

There are three important consequences for the future of mobile source emissions of these facts that we can add to our list:

(c) Future emissions control decisions are going to be decisions about tradeoffs among different pollutants rather than choices between clean and dirty technologies for transportation.

(d) The cheap reductions per vehicle mile traveled have already been accomplished; future emissions reductions will be high marginal cost measures and so will be expensive.

(e) The relationships between emissions and air quality levels are more complex than we previously believed, making it important that future emissions control measures be carefully

⁴⁶ 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 23 (1981).

⁴⁷ See generally Andrew P. Morriss & Nathaniel Stewart, *Market Fragmenting Regulation: Why Gasoline Costs So Much (and Why It's Going to Cost Even More)*, 72 BROOK. L. REV. 939 (2007) (giving background on ozone).

⁴⁸ 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 ENVIRONMENT 2327, 2334-45 (2002); N.A. Kelly & R.F. Gunst, *Response of Ozone to Changes in Hydrocarbon and Nitrogen Oxide Concentrations in Outdoor Smog Chambers Filled with Los Angeles Air*, Atmospheric Engineering 24a, 2991, 2991 (1990).

tailored to specific locations.

C. Future Control Methods for Mobile Sources

Pollution control from mobile sources can occur in five different ways. First, the emissions stream from the source can be altered by changing the combustion process, by altering the fuel's characteristics, or by changing the operating conditions. This will run into the tradeoff problems described above. Second, the engine's exhaust stream can be treated after it is produced to change its composition. Gasoline engine exhaust after-treatment is a relatively mature technology and is unlikely to have a dramatic impact on future emissions reductions. Diesel exhaust after-treatment is a newer technology (there are additional technical challenges involved), but it is already a major part of emissions controls.⁴⁹ Again, major improvements are unlikely to occur. Third, the engine and fuel system can be made more leak-proof, preventing pollution from evaporation. The low hanging fruit here has already been picked as well. Fourth, the fueling process can be changed to reduce incidental pollution during fueling. Again, we have already taken the easy steps.

Moreover, even if researchers devise new technologies that will further reduce mobile source emissions, the lengthening life of car and truck fleets means that as improvements in pollution control are introduced in new models, the improvements affect total mobile source emissions only gradually because of slow fleet turnover.

One control method remains under-exploited: How a mobile source is operated and maintained significantly affects emissions. For example, a 1998 study of twenty-four drivers operating a single vehicle on a standard route revealed statistically significant differences among drivers which the study authors attributed primarily to differences in "intensity of operating with a mode rather than the frequency of different driving modes."⁵⁰ Reducing emissions through altering owner/operator behavior is under-

⁴⁹ See Andrew P. Morriss, Bruce Yandle, & Andrew Dorchak, *Regulating by Litigation: The EPA's Regulation of Heavy-Duty Diesel Engines*, 56 ADMIN. L. REV. 403 (2004) (giving a review of diesel technology).

⁵⁰ Britt A. Holmen & Debbie A. Niemeier, *Characterizing the Effects of Driver Variability on Real-World Vehicle Emissions*, 3 TRANSP. RES.-D 3, 117, 127 (1998); see also David Schoenbrod, Joel Schwartz & Ross Sandler, *Air Pollution: Building on the Successes*, 17 N.Y.U. ENVTL. L.J. 284 (2008).

exploited for a reason, however. Existing forms of use controls are extremely unpopular. The main efforts where the federal government has actually tried to alter individuals' behavior have been serious failures. Efforts under the 1990 Clean Air Act Amendments to require employers to create "trip reduction programs" to shift commuters out of individual automobiles failed miserably.⁵¹ Even programs requiring inspection and maintenance of pollution control systems, which can play an important role in ensuring engines are properly maintained and so operate effectively, are often wildly unpopular.⁵²

Perhaps the most significant change in engine control is the widespread use of programmable electronic engine controllers.⁵³ Mobile source manufacturers quickly focused on this new technology. As Lee Iacocca, then president of Ford, 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."⁵⁴ Electronic controllers spread rapidly: by model year 1994 almost every heavy

⁵¹ See Craig N. Oren, *Getting Commuters Out of Their Cars: What Went Wrong?* 17 STAN. ENVTL. L. J. 141 (1998) (describing failure of 1990 Clean Air Act measures).

⁵² Todd A. Stewart, *E-Check: A Dirty Word in Ohio's Clean Air Debate*, 29 CAP. U. L. REV. 265, 285-87 (2001). See also Schoenbrod et al., *supra* note 50.

⁵³ The increasing stringency of pollution control requirements and complexity of emissions control technology created an increasing incentive for manufacturers to treat the federal emissions tests as the blueprint for their products. Electronic engine controllers made this possible. See Morriss, Yandle, & Dorchak, *supra* note 49, at 437-42 (discussing evolution of engine controllers). In brief, the clean air regulations in the 1970s and 1980s successfully forced manufacturers to invest in developing control of combustion in order to implement a set of features not demanded by their customers (emissions reductions). Cars and trucks had relatively crude mechanical controllers in 1970. Responding both to demands for pollution reduction and to consumer demand for other features made possible by increased control of combustion, electronic controllers gave vehicle designers much greater control over combustion.

⁵⁴ *Detroit Finally Wakes Up to Electronics*, BUSINESS WEEK 90, 90 (October 11, 1976). See also *Integration of Truck Electronics: A Look at the 90's*, AUTOMOTIVE ENGINEERING 115, 115 (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) 50, 51 (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.").

duty truck had electronic controllers,⁵⁵ and cars had them even earlier.⁵⁶

Technology may make it possible to squeeze some emissions reductions from changing driver behavior without provoking a revolt, however. Given the high level of control over engines, information on location available from onboard GPS units, and the ability of vehicles to communicate through cell phones, it is possible to imagine that drivers could be rewarded for taking measures that increase the efficiency of pollution controls. GM already offers its OnStar™ package, which transmits vehicle location and safety information to a central office to allow the company to sell a wide range of roadside assistance. Adding interactive modification of engine operation is possible to imagine because this set of technological improvements, some driven by air pollution regulation and some by market demand for fuel efficiency and other features, both allow for much more precise control of internal combustion engines today than existed in 1970 and allow real time communications between engines and potential buyers of pollution reductions (e.g., auto manufacturers).

We thus have two more important facts to consider in evaluating the future of mobile source regulation:

(f) The least regulated aspect of mobile source emissions is driver behavior. Elementary economic theory suggests that relatively cheaper emissions reductions (e.g., lower marginal cost reductions) are more likely to be available where prior regulatory efforts have been least intensive than where thirty years of regulatory measures have already pushed emissions reductions efforts toward higher marginal cost means.

(g) New technology makes it possible to engage with drivers in real time, to obtain changes in engine operation based on time and place, and to offer incentives based on operating conditions.

III. FUELS

Since the late 1980s, federal and state regulators have introduced increasing levels of regulation of fuel formulation and distribution in an effort at least nominally aimed at reducing mobile source emissions. Unfortunately, when combined with the

⁵⁵ Kenneth Stadden, *Engines with Brains*, HEAVY DUTY TRUCKING 54, 54 (Feb. 1994).

⁵⁶ Morriss, Yandle, & Dorchak, *supra* note 49, at 440.

legacy of decades of economic regulation of petroleum industries and special interest lobbying on biofuels issues, the results have been problematic.⁵⁷

The problems with the regulation of fuel formulation can be seen from the first regulatory step taken in the area, EPA's efforts to remove lead additives from gasoline beginning in the 1970s. Lead had been added to gasoline beginning in the 1920s to boost octane ratings and reduce engine knocking.⁵⁸ Lead needed to be removed from gasoline partly because lead emissions from cars were problematic,⁵⁹ but also because the presence of lead in exhaust gases prevented proper operation of the catalytic converters introduced after the 1970 Clean Air Act Amendments.⁶⁰ Anticipating the problem, the 1970 Amendments authorized the EPA to order refiners to alter gasoline formulations to protect the catalytic converters⁶¹ and EPA moved relatively quickly to ban lead additives.⁶²

⁵⁷ The arguments in this section are developed in greater detail in Andrew P. Morriss & Nathaniel Stewart, *Market Fragmenting Regulation: Why Gasoline Costs So Much (and Why It's Going to Cost Even More)*, 72 BROOK. L. REV. 939 (2007).

⁵⁸ PAUL H. GIDDENS, *STANDARD OIL COMPANY (INDIANA): OIL PIONEER OF THE MIDDLE WEST* 287–92 (1956).

⁵⁹ 37 Fed. Reg. 3882 (Feb. 23, 1972). The final rule was issued in January 1973. 38 Fed. Reg. 1254 (Jan. 10, 1973). Although the lead additive makers challenged EPA's actions, the D.C. Circuit upheld the rule. *Ethyl Corp. v. EPA*, 541 F.2d 1 (D.C. Cir. 1976) (*en banc*).

⁶⁰ See Thomas O. McGarity, *MTBE: A Precautionary Tale*, 28 HARV. ENVTL. L. REV. 281, 294 (2004) (When Congress set automotive emissions standards with the Clean Air Act Amendments of 1970 it "assumed that the automobile manufacturing industry would meet those standards by installing catalytic converters in the exhaust stream.").

⁶¹ The authority was phrased broadly, however, allowing EPA to control the use of additives on environmental grounds generally. See 42 U.S.C. 7545(c)(1) (2000).

⁶² In 1971, the newly formed EPA announced consideration of restrictions on lead as an additive. 36 Fed. Reg. 1486 (Jan. 30, 1971) (to be codified at 40 C.F.R. pt. 479). In 1972, the agency proposed regulations, 37 Fed. Reg. 11786 (June 14, 1972) (to be codified at 40 C.F.R. pt. 80), and in 1973, EPA exercised its Clean Air Act § 211(c)(1)(A) authority to require a series of lead additive reductions beginning January 1, 1975 to a final level of no more than 0.5 grams per gallon by January 1979. 38 Fed. Reg. 33,734 (Dec. 6, 1973) (to be codified at 40 C.F.R. pt. 80). Refiners challenged EPA's actions and lost, *Amoco Oil Co. v. EPA*, 501 F.2d 722 (D.C. Cir. 1974), although the challenge resulted in a less restrictive phase-out schedule. ROBERT L. BRADLEY, JR., *OIL, GAS, AND GOVERNMENT: THE U.S. EXPERIENCE*, VOL. II 1252–53 (1996). This relaxation resulted from the delay in investment needed to convert refineries to unleaded

Not surprisingly given the history of energy regulation, the politically astute and powerful small refiners⁶³ were the beneficiaries of special treatment, winning an exemption from the rule until January 1, 1977 “in recognition of [their] special lead-time problems”⁶⁴ and then an additional partial extension from Congress through October 1, 1982.⁶⁵ The result was the appearance between 1979 and 1982 of “a small subindustry of ‘blenders,’” firms created “to take advantage of the small refiner exemptions,” which “would purchase inexpensive, low-octane gas from foreign markets and blend in just enough high-octane leaded gas to stay within the small-refiner exemption.”⁶⁶ An important result of the lead-removal efforts was intensive and successful special interest lobbying and future fuel formulation regulation proved no different, particularly as biofuel mandates appeared.⁶⁷

“Gasoline” does not refer to a specific formulation; it refers to a wide range of products with characteristics making them suitable for use in automobile engines. As one refinery executive noted,

production caused by the regulatory uncertainty resulting from the litigation; in addition, unleaded production reduced the volume of gasoline produced from each barrel of crude and the government feared shortages. *Id.* at 1254–55; Richard B. Manke, *The American Response: “On The Job Training”?* in OIL DIPLOMACY: THE ATLANTIC NATIONS IN THE OIL CRISIS OF 1978–79, 27, 34 (1980) (“Higher operating costs, stemming from larger crude oil requirements and the multimillion-dollar capital investments needed to modify a large refinery to produce unleaded gasoline, entail that unleaded gasoline is substantially more expensive to manufacture than leaded gasoline.”).

⁶³ Morriss & Stewart, *supra* note 57, at 1023–24 (summarizing small refiner biases in lead phase out). For a thorough public choice analysis of the history of petroleum regulation, see BRADLEY, *supra* note 62.

⁶⁴ 38 Fed. Reg. 33,740.

⁶⁵ Clean Air Act Amendments of 1977, Pub. L. No. 95-95, sec. 223, 91 Stat. 685, 764 codified at 42 U.S.C. 7545(g).

⁶⁶ Thomas O. McGarity, *Radical Technology-Forcing in Environmental Regulation*, 27 LOY. L.A. L. REV. 943, 950 (1994).

⁶⁷ See Jonathan H. Adler, *Clean Fuels, Dirty Air*, in ENVIRONMENTAL POLITICS: PUBLIC COSTS, PRIVATE REWARDS 19, 28–37 (Michael S. Greve & Fred L. Smith, Jr. eds., 1992). The interaction of the environmental regulation with 1970’s economic regulation of energy prices also caused problems for refiners. The price controls did not allow refiners to fully pass through to consumers the additional costs of producing unleaded gasoline; as a result, “most oil companies chose to go slow in expanding their unleaded gasoline capacity.” Manke, *supra* note 62, at 35. This then produced periodic shortages of unleaded gasoline in the 1970s. *Id.* at 35. These shortages prompted EPA to slow down the lead phase out. McGarity, *Radical Technology Forcing*, *supra*, note 66, at 949.

“[g]asoline is not gasoline anymore. It is a specialty chemical.”⁶⁸ Refineries are just specialized chemical plants that transform crude oil inputs into a wide range of outputs. Refinery operations are essentially the solutions of a complex constrained optimization problem, with operators facing constraints imposed by the characteristics of the input stream of crude oil, the equipment mix, and the desired characteristics of the output streams. As fuel formulation requirements grow in number, this problem becomes more complex to solve and the solutions can lead to unforeseen consequences, particularly when mixed with the heady brew of politics that seems to inevitably surround energy regulation.

This can be seen in microcosm by examining the response to the lead phase out. Lead additives had played an important role in fuels and their loss produced “a desperate search for ways to maintain the octane level of [refiners’] gasoline pool.”⁶⁹ One method was to change how refineries operated. The prevailing solution was to change the output mix to produce higher octane product streams. In industry terms, this meant refiners “crank[ed] up the severity of the cat reformer,” but this reduced the volume of gasoline produced, making it a costly step.⁷⁰ Refiners sought lead substitutes that would boost octane.⁷¹ Some turned to an alternative additive, methylcyclopentadienyl manganese tricarbonyl (MMT), previously approved by EPA.⁷² However, under the 1977 Clean Air Act Amendments, refiners were not allowed to market gasolines for catalytic converter-equipped vehicles that were not substantially similar to the gasolines used to certify the vehicle, hampering MMT use.⁷³ And in late 1978, EPA restricted refiners’ use of MMT.⁷⁴ However, the agency approved

⁶⁸ D.J. Peterson & Sergej Mahnovski, *New Forces at Work in Refining: Industry Views of Critical Business and Operations Trends* 21 (2003) (quoting a “technology and services executive”).

⁶⁹ William L. Leffler, *Petroleum Refining in Nontechnical Language* 141 (2000).

⁷⁰ *Id.*

⁷¹ *Id.*

⁷² McGarity, *MTBE*, *supra* note 60, at 296; *see also* Arthur M. Reitze, Jr., *The Regulation of Fuels and Fuel Additives Under Section 211 of the Clean Air Act*, 29 TULSA L.J. 485, 506–07 (1994).

⁷³ McGarity, *MTBE*, *supra* note 60, at 296.

⁷⁴ *Id.* The agency is currently reviewing the safety of MMT. *See* COMMENTS ON THE GASOLINE ADDITIVE MMT (methylcyclopentadienyl manganese tricarbonyl), http://www.epa.gov/otaq/regs/fuels/additive/mmt_cmts.htm (last visited September 17, 2008).

the use of methyl tertiary-butyl ether (MTBE) as an octane boosting additive a few months later.

Unfortunately, MTBE's introduction proved one of the best examples of the consequences of lack of knowledge among regulators. In 1990, Congress required adding oxygenates to gasoline in order to reduce emissions in carbon monoxide nonattainment areas⁷⁵ as "a relatively minor and late-arriving aspect" of the 1990 Clean Air Act Amendments.⁷⁶ (The mandate was the result of a special interest coalition of farm state senators interested in boosting ethanol use and environmental pressure groups and passed without any consideration of the environmental impacts of any of the additives, including MTBE.⁷⁷) The problem was that MTBE had serious environmental problems of its own.⁷⁸ The end result was a series of new environmental problems, no obvious environmental gains, increased costs for refiners and consumers, and a further entanglement of regulators with the operation of refineries.

A second formulation requirement began in the late 1980s. The summer of 1988 delivered "some of the worst ozone excursions on record" and research fingered high volatility gasoline as a factor.⁷⁹ States initiated fuel formulation controls on volatility in an effort to address their ozone problems.⁸⁰ EPA then set national upper Reid vapor pressure (RVP) limits for summer gasoline for the first time in 1989.⁸¹ The Clean Air Act Amendments of 1990 "substantially expanded" the agency's

⁷⁵ 42 U.S.C. 7545(m), 7512a(b)(3).

⁷⁶ McGarity, *MTBE*, *supra* note 60, at 306.

⁷⁷ *Id.* at 309. *See also* Reitze, *Fuels*, *supra* note 72, at 526–28 (describing interest group maneuvering over oxygenates).

⁷⁸ Reitze, *Fuels*, *supra* note 72, at 528 (noting that rulemaking ultimately had "a tilt away from a fuel neutral approach to one that carved a place for ethanol").

⁷⁹ National Academy of Sciences, *Ozone-Forming Potential of Reformulated Gasoline* 108 (1999), available at <http://books.nap.edu/openbook/0309064457/gifmid/R1.gif>. One problem was that EPA allowed vehicles to be certified with lower volatility gasoline than was used in practice, leading to higher emissions than anticipated. *See* Reitze, *Fuels*, *supra* note 72, at 515–16.

⁸⁰ Reitze, *Fuels*, *supra* note 72, at 516 (describing efforts of Northeast States for Coordinated Air Use Management, an eight state coalition, and a subgroup of the coalition to impose volatility requirements in 1989.). Before the 1990 Amendments, California refiners led a push toward "cleaner" fuels out of concern that the state not mandate a mixture of 85% methanol and 15% gasoline and ultimately introduced a wide range of fuels built around the addition of MTBE. McGarity, *MTBE*, *supra* note 60, at 305–06.

⁸¹ National Academy of Science *supra* note 79, at 109.

authority over formulation, mandating a federal reformulated gasoline (RFG) program.⁸²

The federal RFG requirement produced three fuels: a “northern” RFG, a “southern” RFG, and uncontrolled gasoline used outside the areas where states or EPA mandated one of the RFG gasolines. These regulatory requirements produced several changes in gasoline refining. The first level of RFG controls was met primarily through reductions in the butane content of gasoline, which required compensating for the loss of octane from butane removal through increased catalytic cracking and alkylation of gasoline.⁸³ The next set of standards was met by increasing downstream processing of gasoline and blending lower volatility components with higher octane ones.⁸⁴ Both of these steps required “large capital investments” by refiners.⁸⁵ An additional set of constraints on refiners came from EPA’s order under the 1990 Amendments that transportation fuels, including gasoline,

⁸² *Id.* The 1990 Amendments allowed EPA to impose a baseline set of requirements for gasoline, including mandating (RFG) to help meet federal standards for ground level ozone. The 1990 amendments specified a wide range of characteristics of “base” gasoline. See 42 U.S.C. 7581(4). The first set of RFG requirements were applied in 1995, with a second, tighter phase following in 2000. EPA initially required the RFG formulations in nine metropolitan areas, although others were added later. 42 U.S.C. 7545. The initial nine were Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York City (including suburbs in other states), Philadelphia, and San Diego. Reitze, *Fuels*, *supra* note 72, at 524, n.307. States were allowed to add more areas to the RFG program, although EPA could delay “opt-ins” if RFG supplies were insufficient. 42 U.S.C. 7545(k)(6)(B)(ii). The initial specification for RFG gasoline required an oxygen content of at least two percent by weight, a benzene content of no more than one percent by volume, no lead or manganese, a year-round average NO_x emission level of a 1990 summer baseline gasoline, and reduced toxic air pollutant and volatile organic compound emissions. See Reitze, *Fuels*, *supra* note 72, at 532–36 (describing initial regulations). The federal RFG program set different targets for northern and southern states, reflecting “the historical industrial practice where southern gasoline had lower RVP [Reid vapor pressure] than northern gasoline to compensate for higher ambient temperatures.” National Academy of Science *supra* note 79, at 116–17.

⁸³ U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF COMPLIANCE, PROFILE OF THE PETROLEUM REFINING INDUSTRY 83 (1995). Because n-butane also raises the average octane, however, a substitute was needed to maintain the blend’s octane level. Needless to say, refineries also found themselves with seasonal surpluses of n-butane. JAMES H. GARY & GLENN E. HANDWERK, PETROLEUM REFINING: TECHNOLOGY AND ECONOMICS 8–9 (4th ed. 2001).

⁸⁴ EPA, *Profile*, *supra* note 83, at 83.

⁸⁵ *Id.* at 84.

have dramatically reduced sulfur content.⁸⁶ These restrictions reduced the permissible sulfur content in highway diesel.⁸⁷ Combined with the shift in world crude supplies to heavier, sour (e.g., higher in sulfur) crudes, this required refiners producing fuel for the U.S. market to make substantial capital investments.

EPA imposed additional requirements on fuel formulations, both requiring refiners to use a more complex model of fuels' emissions properties in 1998⁸⁸ and regulating deposit control additives in fuel after 1990.⁸⁹ The key point is that as the regulations became more complex, EPA's involvement in fuel design steadily increased. Moreover, these "boutique" fuel requirements are not simply a matter of the government specifying a particular set of gasoline characteristics. The technique used to add one required ingredient may affect the completed fuel's characteristics in other dimensions.⁹⁰

States also began to impose formulation requirements through their Clean Air Act State Implementation Plans (SIPs), as did local governments.⁹¹ There is no comprehensive list of formulations

⁸⁶ J. G. Calvert, J. B. Heywood, R. F. Sawyer, & J. H. Seinfeld, *Achieving Acceptable Air Quality: Some Reflections on Controlling Vehicle Emissions*, 261 SCIENCE 37, 42 (1993) (reducing sulfur content both lowers sulfur oxide emissions and makes catalytic reduction of HCs, CO, and NO_x more efficient).

⁸⁷ Reitze, *Fuels*, *supra* note 72, at 507–12. 40 C.F.R. §80.195 et seq. contain the gasoline sulfur requirements.

⁸⁸ D.R. Blackmore, *Gasoline and Related Fuels*, in 2 MODERN PETROLEUM TECHNOLOGY 217, 247–48 (Alan G. Lucas, ed. 2000) (describing model).

⁸⁹ *Id.*

⁹⁰ For example, EPA was concerned

about potential abuse of the process of adding oxygenate to gasoline downstream of a refinery. This practice, called 'splash blending,' involves mechanical mixing of finished gasoline or gasoline blending stock having front-end volatility set at a typical warm season value (RVP of 7 to 8 psi) with a liquid oxygenate (such as ethanol). Splash blending, unlike refinery-performed match blending that renormalizes product output to the required properties of an RFG, can change the proportional constituents of a gasoline by diluting (replacing) their mass and volumetric share in each gallon. It also has the potential to increase the quantity of total fuel that evaporates from vehicles if the fuel's resulting RVP is significantly higher. EPA sought to obviate this possibility by requiring the type of oxygenate that can be added be stipulated at the refinery and thus maintain RVP integrity.

National Academy of Science *supra* note 79, at 126–27. The problem was ultimately solved by EPA's "in situ" sample audits, which led most refiners blending at refinery. *Id.* at 127.

⁹¹ See U.S. ENVIRONMENTAL PROTECTION AGENCY, REFORMULATED GASOLINE (Aug. 2007), available at <http://www.epa.gov/oms/rfg/faq.htm> (last

mandated by all levels of government, but there appear to be at least seventeen different formulations—a major increase from the single standard (the lead standard) in place in the mid-1980s.⁹² In addition, some state and local governments have imposed “biofuel” requirements.⁹³

Formulation requirements have important effects on gasoline markets. First, they isolate some geographic markets from the overall gasoline market, making it harder to bring new supplies to a region or uneconomical to shift supplies out of a region.⁹⁴ Second, they often require additional capital investment to produce boutique fuels, limiting the number of current refineries able to produce a particular fuel, creating both incentives to exit a market and barriers to entry. Econometric investigations, comparing prices and price volatility between matched pairs of boutique fuel and non-boutique fuel cities, have found that not only is there evidence that boutique fuel requirements raise the cost of gasoline, but that the price impact varies with the geographic isolation and degree of competition in the relevant market.⁹⁵ Third, such

visited September 17, 2008) (discussing SIP revisions for state-mandated gasoline formulations).

⁹² U.S. SENATE, COMMITTEE ON GOVERNMENT AFFAIRS, MAJORITY STAFF OF THE PERMANENT SUBCOMMITTEE ON INVESTIGATIONS, *Gas Prices: How Are They Really Set?* 94 (2002), available at http://senate.gov/~gov_affairs/042902gasreport.htm.

⁹³ See, e.g., HAWAII REV. STAT. 486J-10 (requiring 10% ethanol content for all unleaded gasoline sold after April 2, 2006).

⁹⁴ For example, if a boutique fuel is more costly to create than conventional gasoline, refiners may be unwilling to divert supplies of it to meet a shortage in an area that does not require the boutique fuel. There is evidence that boutique fuels are more costly to produce than standard gasolines. See Jennifer Brown, Justine Hastings, Erin T. Mansur, & Sofia B. Villas-Boas, *Reformulating Competition? Gasoline Content Regulation and Wholesale Gasoline Prices*, CUDARE Working Papers, No. 1010, 4 (2006), available at http://repositories.cdlib.org/are_ucb/1010. Additional strong evidence indicates that the boutique fuel requirements, where they occur together with limited refinery capacity and pipeline connections to other regions, affect prices. After examining regional prices, the FTC found that differences in price variability across regions began appearing in 1992 and have increased since 1995. U.S. FEDERAL TRADE COMMISSION, *GASOLINE PRICE CHANGES: THE DYNAMIC OF SUPPLY, DEMAND, AND COMPETITION* 88–89 (2005).

⁹⁵ Brown et al., *supra* note 94, at 4–5. A forthcoming EPA analysis reportedly finds that boutique requirements are not a factor in increasing gasoline prices, claiming that the refining and distribution network is “able to provide adequate quantities of boutique fuels, as long as there are no disruptions in the supply chain.” See H. Josef Herbert, *Gas Blends Don’t Raise Prices*, Associated Press (June 23, 2006) (quoting EPA report). We have not yet seen the EPA

mandates alter the path of technological change, diverting investment away from improving production processes to meet regulatory requirements.⁹⁶

As discussed earlier, running a modern refinery is essentially a complex optimization problem in which refiners must solve the problem of creating the highest value mix of end products by managing the streams of intermediate products manufactured at different stages.⁹⁷ The boutique fuel requirements thus increase the number of constraints in the optimization problem. If the constraints are binding (and they are meaningless if they are not), then the constraints have costs.⁹⁸

This brief survey of fuel formulation regulation suggests three important facts for consideration in designing the next generation of mobile source regulation:

(h) Fuel formulation regulation has proven more costly than anticipated, as it has fallen victim to special interest lobbying/public choice problems on a wide scale, as both the lead phase-out and the ethanol episodes demonstrate.

(i) Efforts at fuel formulation regulation have introduced

report but the quote suggests the agency focused on the wrong question. It is precisely when there are disruptions in the supply chain that a broad, deep market makes a difference. The agency concluded that “[t]he timing of price changes . . . suggests that they may bear some relationship to the introduction of Phases I (1992) and II (1996) of the stringent and specialized CARB requirements for gasoline sold in California.” FEDERAL TRADE COMMISSION *supra* note 94, at 90. While the FTC study found evidence of a boutique fuel price effect in California, it did not in the Gulf Coast, where the agency concluded that the larger amount of refinery capacity in the Gulf Coast region and greater interconnection of that region with other areas reduced the impact of disruptions at any particular facility. *Id.* at 94. The FTC found similar results in the East Coast, Rocky Mountain, and Midwestern states. *Id.*

⁹⁶ One summary of industry trends concluded: air pollution “has driven the direction of our technological development.” P. Ellis Jones, *Introduction* in 2 MODERN PETROLEUM TECHNOLOGY xv, xxiii (Alan G. Lucas, ed. 2000).

⁹⁷ See A. Ogden-Swift, *Control and Optimization*, in 2 MODERN PETROLEUM TECHNOLOGY 181, 181 (Alan G. Lucas, ed. 2000) (“Refinery planning and scheduling, optimization, process control and monitoring are essential to achieving [maximum profits]. Typically savings from improvements in these areas exceed \$20 million per year for a world-scale refinery by choosing the best feedstocks, the best way to operate the refinery, effective control at the best point, and efficient detection and management of abnormalities.”).

⁹⁸ See Jones, *supra* note 96, at xxi (“The development of products that meet the required quality standards has not generally been unduly difficult; where problems have arisen they have frequently arisen from the need to ‘trade off’ one characteristic against another.”).

considerable complexity into refining and distribution with questionable gains in environmental quality.

(j) Existing fuel formulation regulations have revealed the difficulty in centrally directing the complex relationship between fuels and engines.

IV. THE FUTURE OF MOBILE SOURCE EMISSIONS REGULATION

The preceding discussion has argued that there are ten important facts that must be taken into account in future mobile source regulations if the regulations are to actually produce improved environmental quality. To recap, these are:

(a) Policies that are aimed at promoting mass transit as a substitute for personal automobile use will fail. If they are given "credit" in EPA's modeling of mobile source emissions, the model will inevitably diverge from reality until the agency is forced to make adjustments.

(b) The future of the market for personal transportation services looks remarkably like the present. We may be driving hybrids instead of Hummers but we will still be driving in our own vehicles. Barring a major technological breakthrough soon, those vehicles will be burning a hydrocarbon of some kind as a significant source of their fuel over the next twenty to thirty years at least, either in an internal combustion engine or in a central power station.

(c) Future emissions control decisions are going to be decisions about tradeoffs among different pollutants rather than choices between clean and dirty technologies for transportation.

(d) The cheap reductions per vehicle mile traveled have already been accomplished; future emissions reductions will be high marginal cost measures and so will be expensive.

(e) The relationships between emissions and air quality levels are more complex than we previously believed, making it important that future emissions control measures be carefully tailored to specific locations.

(f) The least regulated aspect of mobile source emissions is driver behavior. Elementary economic theory suggests that relatively cheaper emissions reductions (e.g., lower marginal cost reductions) are more likely to be available where prior regulatory efforts have been least intensive than where thirty years of regulatory measures have already pushed emissions reductions

efforts toward higher marginal cost means.

(g) New technology makes it possible to engage with drivers in real time, to obtain changes in engine operation based on time and place, and to offer incentives based on operating conditions.

(h) Fuel formulation regulation has proven more costly than anticipated, as it has fallen victim to special interest lobbying/public choice problems on a wide scale, as both the lead phase-out and the ethanol episodes demonstrate.

(i) Efforts at fuel formulation regulation have introduced considerable complexity into refining and distribution with questionable gains in environmental quality.

(j) Existing fuel formulation regulations have revealed the difficulty in centrally directing the complex relationship between fuels and engines.

What might a regulatory effort that took these facts into account look like? To answer this question, we must first examine why the current laws are inadequate to do so. There are four areas where current laws are inadequate to deal with a future characterized by these ten facts.

First, the Clean Air Act has approached air pollution by dividing pollution sources into two categories, mobile and stationary sources, and then controlling emissions of particular pollutants from each through quite different regulatory regimes. Mobile source regulation has been further divided between regulation of fuels and regulation of cars and trucks. Stationary source pollution control is driven by a combination of federal and state regulations. These divisions needlessly complicate and burden the task of reducing air pollution in three ways: (1) they create incentives for interest groups to attempt to shift the burden of reducing pollution to someone else (e.g., fuel refiners prefer car and truck manufacturers to bear the burden of reducing mobile source emissions and vice versa; stationary sources prefer that mobile sources reduce emissions and vice versa); (2) they reduce the incentive to produce emissions reductions beyond the regulatory mandate; and (3) they divert regulators' attention from the best opportunities to reduce pollution, focusing regulatory energies instead on what are ultimately side issues in the environmental policy debate. Particularly as efforts are made to create "plug in" electric vehicles, any policy that does not recognize the interchangeability of mobile and stationary source emissions is doomed to encourage only rent-seeking as interest

groups attempt to shift pollution problems from their shoulders to someone else's (e.g., from car manufacturers to power plant operators in the case of plug in electric vehicles.)

Second, the Clean Air Act does not adequately recognize the tradeoffs that exist in air pollution control. There are at least seven important tradeoffs in mobile source emission controls:

- (1) Between maximizing fuel efficiency and minimizing pollution emissions;
- (2) Among control of different pollutants;
- (3) Between pollution control and mobility;
- (4) Between pollution control and vehicle safety;
- (5) Between pollution control and the robustness of the market for fuels;
- (6) Between pollution control and energy security; and
- (7) Between air pollution control and other environmental goals.

Each of these tradeoffs has an impact on how mobile source regulations are regulated and how they might be regulated differently to produce greater improvements in environmental quality and reductions in regulatory costs. The current regulatory framework created by the Clean Air Act does not address any of these impacts. Instead, we observe piecemeal regulatory measures designed to shore up a failure in one area by extending regulations to another. The expansion of air pollution regulation to fuel formulation is a classic example of this sort of "ratchet" effect and the problems introduced by EPA's efforts at fuel formulation regulation are a testament to the problematic nature of such efforts.

Third, current law does not take advantage of market mechanisms but instead frustrates market responses. Nowhere is this better illustrated than in the fuel formulation debate, where EPA (and states) are utilizing command-and-control approaches without regard to the detrimental impacts these measures have on energy markets. And strikingly absent from most of EPA and states' mobile source regulatory efforts are any attempts to use positive incentives to secure improved environmental quality.

Fourth, antitrust law has frustrated cooperative efforts among mobile source manufacturers and fuel companies to improve emissions. There are several prominent examples. A federal antitrust action in 1969 ended a joint effort of the U.S. auto industry to cooperate on technology to address emissions. Several

subsequent efforts at cooperation have floundered on antitrust concerns. (Cooperation has been greater in Europe.) Similarly, oil companies have been subject to antitrust actions repeatedly, making them leery of cooperative efforts.⁹⁹

Despite this history, fourteen oil companies, together with the Big Three U.S. auto makers, formed the Auto/Oil Air Quality Improvement Research Program (AQIRP) in 1989 “to develop data on fuel/vehicle systems” to study emissions, with modeling focused on ozone and economic analysis of alternatives.¹⁰⁰ The participants ultimately spent \$40 million on the program and produced data suggesting that the impact of gasoline formulation varied considerably across vehicle types and ages.¹⁰¹ It also showed that at least some changes traded decreases in one pollutant for increases in another,¹⁰² while others had unambiguously positive impacts on emissions.¹⁰³ Encouraging such research through clear restrictions on antitrust actions against companies that undertake them could vastly expand our knowledge of how fuel composition affects the environment.

My first conclusion from the discussion above is that we have reached the end of the line with respect to centralized command-and-control solutions based on modification of vehicles and fuels. There is simply little left to do to vehicles at the point of sale or through area-wide fuel restrictions. Even with respect to greenhouse gas emissions, much of the easy gains have already

⁹⁹ See Morriss & Stewart *supra* note 57, at 978–1021 (discussing economic regulation’s impacts).

¹⁰⁰ Blackmore, *supra* note 88, at 247; MONDT, *supra* note 1, at 199. The program involved Chrysler, Ford, and GM plus Amoco, Arco, Ashland, BP, Chevron, Conoco, Exxon, Marathon, Mobil, Phillips, Shell, Sun, Texaco, and Unocal. JOHN K. PEARSON, IMPROVING AIR QUALITY: PROGRESS AND CHALLENGES FOR THE AUTO INDUSTRY 83 (2001). This cooperation was motivated in part by fear that alternative fuels (e.g., methanol) would be mandated based on their perception as “clean” fuels. *Id.* at 82.

¹⁰¹ PEARSON, *supra* note 100, at 85 (“Reduction of gasoline aromatics content from 45% to 20% produced the interesting result of hydrocarbon emissions being reduced by some 6% for current vehicles and increased by 14% for older vehicles. . . . Nitrogen oxides were reduced by 11% in older vehicles, yet there was no significant effect in current vehicles.”).

¹⁰² *Id.* at 88 (“Reducing gasoline olefin content from 20% to 6% increased hydrocarbons by 6% and decreased nitrogen oxides by 6% for both current and older fleets.”).

¹⁰³ *Id.* (Reducing sulfur from 450 ppm to 50 ppm reduced hydrocarbon emissions by 18%, carbon monoxide by 19%, nitrogen oxides by 8%, and air toxics by 10%).

been achieved as engines have become more efficient under market pressure and past CAFE regulations. (Fleet efficiency has not increased as rapidly as vehicle technology has improved, because of consumer substitution toward less efficient vehicles like pickup trucks and sport utility vehicles. This obviously can change—over time—relatively easily as higher fuel prices shift demand toward more efficient vehicles.)

The trends discussed at the outset of this Article also suggest that future emissions increases will be coming from growth in vehicle miles traveled for both passenger and freight vehicles. That leaves open a number of questions concerning current regulations. One alternative might be to abolish current mobile source regulations and begin anew with some more market-oriented reform built on the technology discussed earlier. This seems both impracticable and will likely yield few benefits. Politically, it is simply not feasible to consider abandoning the current Clean Air Act regulatory framework. Not only are there enormous vested interests among auto manufacturers, pollution control equipment manufacturers, and state and federal regulators who have a strong interest in the continuation of the current framework, but the politics of reform argue against any sudden discontinuities. Any Republican politician who attempted to undertake such a fundamental reform (and there is no evidence that any current Republican officeholders have any interest in such reforms) would be savaged by the press as “anti-environment.” And no Democrat politician is likely to undertake a “Nixon to China” strategy of bringing reform to the Clean Air Act because of the strong influence of the established national environmental organizations over Democrat officeholders. The prediction I offer with the greatest confidence is that there will be no major changes in the existing structure of the Clean Air Act’s regulation of mobile sources. It is likely that we would be better off had we started down a different road to mobile source regulation, but the benefits of retracing our steps seem minimal compared to the disruption to manufacturers, maintenance service providers, and regulators. The appropriate measure seems to be to maintain the current system and to rely on new methods of achieving future reductions.

One relatively painless way to migrate to an alternative approach would be to make compliance with current regulations a regulatory safe-harbor but allow opt-outs for any auto

manufacturer or fuel refiner that could demonstrate that an improvement in environmental quality would result. This would have the added benefit of giving both manufacturers and refiners an incentive to develop data on the current system (to establish a baseline) and on their proposed alternatives (to gain approval for their opt-out). While far from perfect, such a system would provide some incentives for future improvements.

My second conclusion is equally pessimistic (from an emissions perspective): vehicle miles traveled will continue to increase domestically as well as internationally. This conclusion stems in part from the seeming invariance of the slope of the line of a graph of these transportation statistics. Further, the future holds considerable economic growth around the world from increasing trade (unless politics interferes). A key part of producing that growth, and also a key result of that growth, is that vehicle miles traveled will continue to increase—and to do so not just in the United States but also in developing countries like China and India. To the extent that we care about global loadings of pollutants, we will need to take steps to purchase (since we cannot coerce) major reductions in emissions per vehicle mile traveled in those nations as well as at home. American emissions control policy thus must focus on global emissions rather than purely on domestic ones. Such a focus has the benefit of requiring a shift toward incentive-based programs, a silver lining to a dark cloud of increasing emissions from the rise in global vehicle miles traveled.

Despite my pessimism about the potential for further emissions reductions from centralized measures, I think there are two alternative paths to cleaner mobile source emissions that future clean air regulatory efforts could exploit to produce gains in environmental quality.

The first area of potential gains comes from changes in vehicle driver/owner behavior. This has proven too controversial in the past to pass political muster but new technologies offer the possibility of doing so without provoking a revolt. Opposition to changes in driver behavior in the past has stemmed largely from their coercive nature. In Ohio's remarkably unpopular E-Check program, for example, drivers were required to take their vehicles to inspection stations where the cars were run on treadmills, with engines racing, by E-Check employees. Not surprisingly, mostly apocryphal stories soon circulated about damage to vehicles.

Worse, vehicle owners had to pay for the privilege of having the test administered, as well as for any repairs required to bring vehicles up to the standards. And Ohio's contract with the firm administering E-Check was so ineptly negotiated by the state that publicity about its terms fueled further public outrage.¹⁰⁴

We now have the technology to change driver behavior by offering incentives. For example, as noted earlier, we could exploit the large degree of control over engine operations that is now possible due to the powerful engine controllers present in virtually all vehicles. Moreover, cars and trucks are increasingly equipped with GPS units, potentially providing the engine controllers with location information, and cellular phones, allowing regular communication between the controller and pollution control authorities. It is not too difficult to imagine a combination of the three technologies in which pollution control authorities could bid for reductions in particular pollutants during peak ambient levels and engines could be programmed to respond by operating to minimize those particular pollutants. (Something similar already occurs with utilities and consumer and industrial electric use.) Payments would not need to be large to gain a positive response from large fleet operators (trucking companies, taxi companies, etc.) where the volume of their operations could make even small payments add up, and the responsiveness of automobile drivers to the grocery store fuel price incentive programs¹⁰⁵ suggests that small rewards (perhaps implemented through tax reductions at the pump) can drive consumer behavior. Similarly, pollution control authorities could provide incentives to adjust fuel characteristics in particular markets. Given the length to which people are often willing to go to obtain cheaper gas, the amounts involved could well be relatively small. Similarly, congestion pricing efforts could be adapted to include an emissions charge.

Who might pay for such changes? When we consider that the Clean Air Act's division between mobile and stationary sources is simply an artificial regulatory convenience, we can see that the market for mobile source emissions reductions of both current criteria pollutants and other pollutants such as greenhouse gases is

¹⁰⁴ See generally Stewart, *supra* note 52.

¹⁰⁵ See, e.g., FUELPERKS!, <http://www.gianteagle.com/fuelperks> (last visited Sept. 17, 2008).

quite large as any source would be willing to buy reductions from someone who can produce them at a lower cost. The demand for mobile source emissions reductions would thus be from those who needed to obtain reduced emissions to offset their own activities.

The transactions costs of buying changes in behavior from individual drivers are likely to be quite large, particularly at first. The first transactions are thus most likely to come from firms that control large numbers of vehicles. Trucking companies, bus fleet operators, rental car firms, taxi cab firms, local governments, and other operators of fleets are the most likely early adopters of the technology that could make sales possible. Stationary sources, mobile source manufacturers, and carbon credit firms are the most likely buyers.

How much would such payments likely be? On the supply side, the payments would need to cover any increased operating costs and give the operator a profit. For example, one way to increase engine efficiency is to drive more slowly. A trucking firm that operated its fleet at lower speeds would thus reduce its greenhouse gas emissions. The cost of doing so would be slower deliveries and some higher operating costs (longer hours for drivers, for example) offset in part by the fuel savings.¹⁰⁶

How could such a market operate? Fleets might make contracts with buyers of emissions reductions, but it is easy to imagine a spot market as well as brokers appearing. Organizations like the American Automobile Association or car insurance companies could offer members and policyholders the opportunity to participate in such markets. A firm whose plant needed to operate for longer hours to meet a rush order might bid on a spot market web site for offsetting reductions. In short, there are many possible forms such a market might take.

The second path toward cleaner mobile source emissions is to change the mix of vehicles on the road. As the vast majority of mobile source pollutants come from a relatively small number of vehicles, this approach also holds promise. We have much better remote sensing technology today than we did twenty years ago and identifying high-emission vehicles is increasingly possible without

¹⁰⁶ See FUELECONOMY.GOV, DRIVING MORE EFFICIENTLY, <http://www.fueleconomy.gov/feg/driveHabits.shtml> (last visited Sept. 18, 2008) (“You can assume that each 5 mph you drive over 60 mph is like paying an additional \$0.26 per gallon for gas.”).

inspecting every vehicle. A number of alternatives are available, ranging from emissions taxes to vehicle buy back programs. Identifying and removing high emission vehicles from the fleet is thus an important but under-exploited strategy.

Further, to the extent that emissions problems are more than local (e.g., greenhouse gas emissions), the inevitable rise in mobile source use in China, India, and elsewhere suggests that we need to think about exporting control efforts as well. Politicians' claims to the contrary, emissions standards in China are below U.S. standards and we can buy much cheaper reductions by subsidizing improved vehicle performance there than we can through regulation at home. This is particularly easy to do, if expensive, since many developing country truck and car fleets are built largely from used vehicles from developed countries. Developed countries seeking emissions reductions in developing economies can simply buy polluting vehicles and scrap them, creating demand for newer vehicles. Buyers could also pay a premium for the high emissions vehicles, enabling the sellers to make enough from the sale to afford a better vehicle. Developing countries could also subsidize improvements in fuel formulations for developing countries, reducing emissions by cleaning the fuel. Neither solution requires infrastructure, neither requires monitoring behavior, and both are relatively cheap to implement.

The virtues of these approaches are three-fold. First, states, rather than the federal government, can administer them. If federal efforts are required, they can complement the state approaches rather than replacing them. A federal effort to buy lower emissions of NO_x, for example, would be entirely compatible with a state effort to do the same.

Second, they rely on markets to change behaviors rather than on command-and-control regulations. The government has proven remarkably inept at handling complex technologies. EPA's failure to anticipate the controller-test cycle issue (if that is indeed what happened) is a good case.¹⁰⁷ If we switch to using positive incentives, it will become in the interest of mobile source operators and owners to demonstrate that they have reduced emissions rather than in their interest to defeat costly controls.

Third, these measures will allow the tradeoffs outlined earlier to be addressed locally. To the extent air pollution is a local issue,

¹⁰⁷ See Morriss et al., *supra* note 49.

and it often is, there is little reason to require drivers in North Dakota to meet Los Angeles emissions standards. There may even be no reason to require drivers in San Diego to meet Los Angeles emissions standards. Technology may offer us the opportunity to localize engine operation constraints.

The final piece of the puzzle is that something appears to need to be done with respect to antitrust law and cooperation. Collaboration between refiners and car manufacturers holds a great deal of promise, but is not likely to take place on a large scale without some sort of safe harbor provision. Allowing vehicle manufacturers and refiners to collaborate on the fuel-engine interface could yield further improvements.

Three questions that immediately come to mind with respect to implementing these suggestions internationally are (a) who is going to pay for these reductions; (b) who will be paid; and (c) how to document and verify the reductions. These questions already arise with respect to carbon offset programs, and there is considerable and justified skepticism about whether the promised reductions in atmospheric loadings of greenhouse gas emissions actually will materialize.

The answer to the first question will not comfort those who envision massive cutbacks—American taxpayers (and possibly European ones as well) will have to dig deep into their wallets to buy reductions in emissions elsewhere. The reductions in air pollutants that have occurred thus far have been paid for (in varying shares) by the consumers of transportation services and the stockholders in the firms contributing to the provision of those services through a hidden regulatory tax. Buying emissions reductions in China or India, whether by purchasing technology for emissions reductions at power plants there or upgrading cars there to have better pollution control equipment, cannot be financed through such backdoor methods as EPA's writ does not extend that far. Some potential emission reduction programs will certainly prove too costly or too difficult to monitor, but others could be surprisingly inexpensive. For example, EPA could purchase technology from existing car manufacturers that would aid in emissions reductions (e.g., engine controller technology) and license the technology to companies like India's Tata Group, which plans the "1-lakh" car that causes environmental activists nightmares.

The second question is whether polluters will be paid. Some

of those polluters might be individuals, who will be compensated either explicitly or implicitly for taking steps to reduce emissions. EPA might purchase dirty vehicles from drivers outside the U.S., for example. Others will be large entities like the Tata Group, who might be given free or low cost technology at U.S. taxpayers' expense for use in cars sold outside the U.S. (If we want polluters to reduce emissions, it seems inevitable that the people getting the payments will be polluters.)

The third question is trickier. Where pollution control does not produce any benefits to the individual, there is little incentive to follow through on promises to change behavior to reduce emissions. However some efforts (e.g., engine controllers) can both reduce emissions and improve performance in other dimensions. And individuals can be offered modest rewards for allowing upgraded controller software to be loaded on their engines when new programs are necessary. In general, however, we can rely on the market to generate verifiable opportunities once it is clear that there are rewards for doing so.

The U.S. can implement all of these options with a wide variety of methods. Authorities might conduct various types of auctions, with polluters bidding by offering different reductions for particular prices. Alternatively, a regulatory agency could simply offer a fixed price menu for particular increments in reductions. In all likelihood we would need a period of experimentation, in which agencies tried different methods.

A second set of questions arises when considering any alternatives to the current set of command-and-control regulations. Our current system is built around both a state/federal division of authority and the California/other set of state standards. Just as with the existing standards, I am confident that this will not change. The current Clean Air Act division between California standards (with opt ins for other states) and federal standards will continue because no political figure will have an interest in making such a change. As with the existing set of emissions standards and regulations, disturbing these features of the current system is likely not worth the cost in disruption, with one exception.

One of the reasons I think that some reliance on implementing technology that varies engine operations from location to location has merit is that it allows multiple levels of government to combine their efforts without introducing conflicts. For example, California could offer incentives to adapt engine operations to Los

Angeles's specific needs that would be layered on top of federal incentives to reduce carbon dioxide emissions. Trucking companies could accept one or both of the incentive packages so long as California and EPA had negotiated an acceptable controller program implementing both of their requirements.

To be successful in improving environmental quality, the next generation of mobile source emissions regulations is thus likely to need to:

- (1) Be incentive-based rather than primarily command-and-control;
- (2) Focus on driver-behavior and vehicle ownership and maintenance to encourage lower emission methods of operating vehicles; and
- (3) Expand the geographic scope of the incentives beyond the borders of the United States to buy emission reductions in developing economies.

The danger, however, is that we will instead see more of what we have seen over the past forty years. That is, we will get instead ever more costly command-and-control measures aimed at auto manufacturers that produce ever-more-slight marginal reductions in emissions together with special-interest driven fuel formulation requirements and other measures that enrich a few while failing to deliver benefits worth anything like their costs. If history is any guide, the latter outcome is unfortunately more likely than the former.

FIGURES

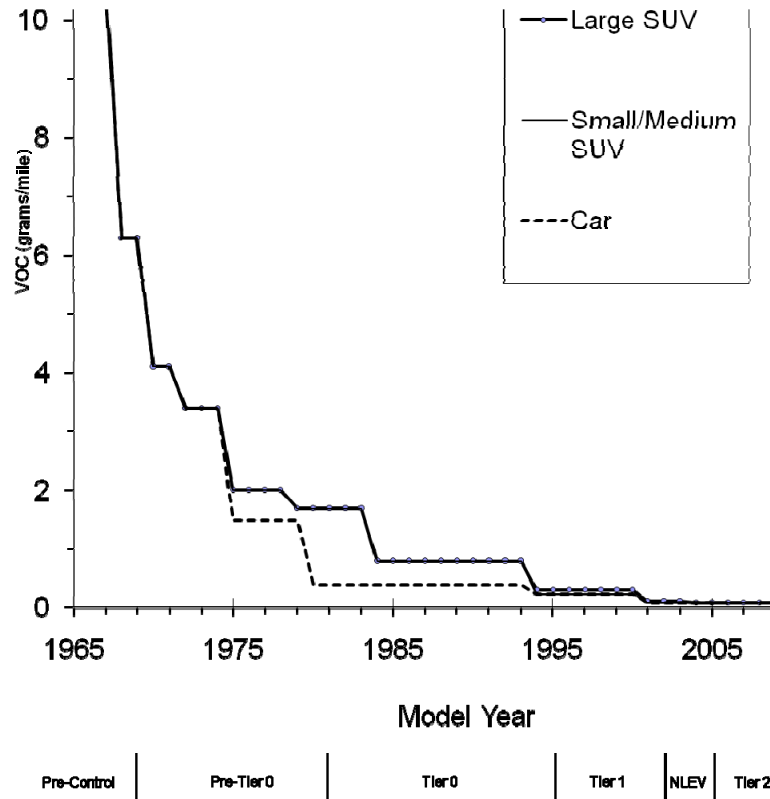


Figure 1 – U.S. Emissions Standards

Chart courtesy Joel Schwartz, AEI. Notes: Standards shown here apply up to 50,000 miles. Tier 1 added standards that apply between 50,000 and 100,000 miles, while Tier 2 added standards that apply between 50,000 and 120,000 miles. Tier 1 phased in during model years 1994–1996. Tier 2 phased in during model years 2004–2007. Designations along the bottom of the chart refer to the names EPA uses to refer to each set of standards. The NLEV, or National Low-Emission Vehicle program, was implemented nationwide in 2001. However, nine northeastern states implemented NLEV in 1999.

See D. Bearden, *Air Quality and Vehicle Emission Standards: An Overview of the National Low Emission Vehicle Program and Related Issues* (Washington,

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