TOWARD MORE EFFICIENT REGULATION OF VEHICLES

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ABSTRACT

Fundamental changes are needed in the regulation of vehicle emissions, energy use, and safety. The regulatory system now in place worked moderately well in the past. But it is a rigid, and therefore inefficient system that inhibits innovation and the introduction of many attractive vehicle, fuel, and technology options. In this paper, I present a framework for a flexible and incentive-based regulatory system that would be more appropriate for guiding the complex transition to more benign fuels and vehicles.

THE CURRENT REGULATORY APPROACH

The 1960s ushered in an era of government activism on behalf of various social and environmental issues. Regulatory programs were adopted to improve vehicle safety -- hastened by Ralph Nader's 1964 book, "Unsafe at Any Speed" -- and to reduce air pollution. Fuel use regulations followed in the 1970s. The regulatory system that evolved was a creation of lawyers and engineers whose disciplinary paradigm is one of right and wrong. It was founded on highly specific rules of conduct and design, resulting in an approach that has come to be known as "command and control." While the various regulatory activities affecting vehicles and fuels are not strictly command and control -- they contain some flexibility -- the overriding framework continues to be one of directives that restrict the behavior of vehicle and fuel suppliers.

Regulation of Vehicle Emissions

The process of regulating vehicle emissions is highly formalized and structured. Automakers receive stacks of documents each year from the US Environmental Protection Agency for 49 states and the California Air Resources Board for California, as well as from the European Economic Community and Japan for vehicles sold in those countries. This paper flow contains minutiae on the design and conduct of emission tests and advises them of changes in reporting requirements, test procedures, and control technology. A uniform standard is specified

that each and every car, bus, and truck must meet. Initially, emission standards were established for three pollutants: carbon monoxide, hydrocarbons, and nitrogen oxide. Emissions are measured and tested on a grams per mile basis (except for evaporative hydrocarbons from the fuel tank and elsewhere that are tested separately). Compliance is verified by running a sample of vehicles through a standard driving cycle.

Standards have been tightened intermittently based on subjective judgments of the severity of ambient pollution problems and of what manufacturers were capable of achieving at reasonable cost. In a radical departure from uniform standards, to be addressed later, California instituted emission averaging, trading and banking in 1994.

The strength of this uniform-standard approach is simplicity and apparent ease of enforcement. The importance of this advantage should not be minimized; the ease of understanding the requirement and the directness and transparency of the regulatory actions helped create a strong positive image for the regulations among the general public. But the weaknesses of the current uniform-standard approach cannot be ignored.

Shortcomings of Current Approach to Emissions Regulation

The current approach is fundamentally flawed, and becoming more so as new fuels and vehicles enter the marketplace. Consider, for example, vehicles powered by fuel cells, batteries, biomass fuels, and natural gas fuels. Today's system for regulating motor vehicle emissions addresses only those emissions from the vehicle. The "upstream" emissions -- from powerplants, oil refineries, fuel stations, etc. -- are ignored, even though upstream emissions for these fuels and vehicles will tend to be larger than the "downstream" tailpipe emissions. Even for gasoline vehicles, upstream refinery and fuel station emissions may soon be as large as emissions from the vehicle. The zero emission vehicle (ZEV) requirement in California solves this upstream emissions problem by simply assuming that powerplant emissions are zero -- perhaps acceptable for kickstarting the electric vehicle industry, but clearly unacceptable for the long term.

The first failing of the current system, therefore, is the inability to integrate stationary and vehicle emissions. Emissions from fuel dispensing facilities, electric powerplants, and biomass, natural gas, and petroleum processing facilities need to be considered. Otherwise, truly zero-emitting fuel cell vehicles operating on solar hydrogen would not be distinguished from battery-powered EVs drawing electricity from, for instance, dirty coal-fired powerplants near the Grand Canyon. A new regulatory approach that addresses fuel cycle emissions is urgently needed. California has proposed the creation of an equivalent zero emission vehicle (EZEV) standard that would account, though in a limited way, for upstream powerplant emissions. It is intended to provide the regulatory mechanism for hybrid ICE-electric hybrid vehicles. This proposed rule has not yet been finalized (as of late 1997), but it represents a simplistic first step in the right direction.

A second failing is the exclusionary nature of the current approach. Rigid and fragmented standards have the effect of excluding engine technologies and fuels that may provide substantial

overall pollution and energy benefits, but are unable to meet the emission standard for a particular pollutant. Even innovative internal combustion techniques, such as lean burn, two stroke, and direct injection diesel engines, are hindered by the rigidity and autonomy of uniform emission standards, despite the fact that these technologies appear to be in the public interest.

Lean burn combustion involves mixing less fuel with air during combustion. Because combustion is more complete, fuel efficiency is improved about 5-10 percent. There are also fewer carbon dioxide, hydrocarbon, and carbon monoxide emissions. But because of higher combustion temperatures, nitrogen oxide emissions tend to increase. The central failing of the current regulatory system is the absence of a mechanism to trade the advantage of less fuel consumption and overall reduction in emissions with the disadvantage of somewhat higher nitrogen oxide emissions. This makes it difficult, if not impossible, to introduce lean burn engines, especially as nitrogen oxide emission standards are tightened over time. Indeed, Honda did not sell cars with lean burn engines in California in the early 1990s because the car could not meet the NO_x standard, even though its other emissions and fuel use were lower than most other cars. As emission standards are further tightened, lean burn will be excluded, even with huge fuel economy benefits and overall emission reductions, unless the regulatory approach is made more flexible.

The story is similar for two-stroke and diesel engines. They provide greater fuel efficiency than conventional four stroke gasoline engines, again with somewhat higher emissions of nitrogen oxides (and particulate matter in the case of diesel engines).

It makes no sense that adverse impacts for one pollutant -- as is the case with lean burn and two stroke engines -- should result in banishment. Rarely is there a new strategy or technology that is uniformly positive across the board. A more flexible framework would allow tradeoffs between different pollutants and different energy and environmental goals.

A third shortcoming is the economic inefficiency of uniform standards. Uniform standards are not sensitive to differences in the cost of reducing emissions from one vehicle to another. Worse, because they provide no incentive to reduce emissions below the standard, manufacturers have no incentive to introduce cleaner-burning engines and fuels. In practice, it is even worse: there is a strong disincentive to innovate. Automakers rightly fear that any improvements they make will soon be used against them and that those improvements will either be explicitly required by regulators or used as a justification for tightening the standards.

This disincentive to innovate inevitably leads to a fourth failing: it creates an adversarial relationship between industry and regulators. Industry sees government regulators as trying to take advantage of them, while regulators feel that they cannot trust industry to be straightforward about the cost and difficulty of improving emissions, energy use, and safety. The result is that regulators see themselves as technology-forcers; forcing technology changes by prescription or through more stringent new performance standards, with little evidence of the cost and difficulty of making those changes. This strategy exacerbates mistrust and disrespect.

The disincentive to innovate is not absolute and the auto industry not monolithic. Occasionally a particular company will aggressively pursue a much cleaner or more efficient technology with the hope of creating a market or public relations advantage. The development and unveiling of General Motor's Impact in early 1990 and its commercial release as the EV-1 in 1997, is an example of this occasional breakaway initiative. Indeed, that 1990 unveiling, which GM later came to regret, led directly to California's adoption of the ZEV mandate in late 1990. Another illustration of this phenomena was Ford Motor Company's cancellation of a proposed research program to redesign the Taurus with an all-aluminum body. The reported reason was that the company feared that regulators would use the findings to justify more stringent fuel economy standards.

The shortcomings of the current approach toward regulating emissions can not be ignored, if only because of its reach and influence. The goal of reducing air pollutant emissions from motor vehicles has dominated other policy initiatives in the transportation sector, including not only the introduction of new fuels and vehicles, but also decisions regarding urban land use, transportation infrastructure, telecommuting, transit, carpooling and vanpooling, and even employee work hours.

This irrational situation came about gradually over the past 25 years as the result of two related phenomena: strong popular support for the goal of clean air and the creation of specific and enforceable rules. Environmental advocates have effectively exploited the popular desire for clean air and the rules and laws enacted to realize that goal to pursue a myriad of other goals. In essence, the air quality tail wags the transportation dog -- sometimes to good effect, sometimes not.

The entire regulatory system needs to be redesigned. An effective and efficient system would handle differences across regions, fuels, and engines, provide incentives to industry to innovate and to consumers to buy cleaner vehicles, and allow tradeoffs between prominent social goals. The present system fails on all counts. Because of the political primacy and rigidity of motor vehicle regulation, it sometimes even results in regulations that are a deterrent to the introduction of environmentally-benign vehicles and fuels. While clean air regulation has resulted in many positive changes, a more rational and balanced framework is needed for the long haul.

Fuel Economy Regulation

Fuel consumption standards in the US are somewhat more flexible than those for emissions, but also have major shortcomings. Instead of meeting a uniform standard for all vehicles, manufacturers comply with an average. Compliance is measured by average fuel consumption across all vehicles sold in a particular year. These Corporate Average Fuel Economy (CAFE) standards, created in 1975 and made effective beginning in 1978, allow manufacturers to build a mix of vehicles: some that are larger with powerful engines and others that are smaller and more fuel-conserving. The CAFE standard for cars, set legislatively by Congress, reached 27.5 mpg in 1985, was pushed back to 26.0 for a short while and remains deadlocked at 27.5. The standard for light trucks, set by the US Department of Transportation,

was creeping up at about 0.1 mpg per year through the early 1990s, and is now frozen at 20.7 mpg.

The averaging approach of CAFE standards is still not very flexible. Complex classification procedures have been devised to distinguish imported vehicles from those produced within the United States, and to separate light trucks from cars, leading to many abuses of the spirit of the program. (These many rules were created mostly to protect the domestic Big 3 automakers from Japanese competition.) For example, at one point Ford Motor Company reportedly transferred the manufacture of some minor components on its large Crown Victoria to Mexico so that the percent of imported parts on the car would exceed 25 percent, allowing Ford to count the car as an import. In that way, the Crown Victoria vehicles would count against the company's fuel-efficient imported cars and not against the larger and less efficient domestic cars, allowing the company to produce more large cars and still be within the 27.5 mpg domestic-car standard.

The averaging approach hurts smaller manufacturers who specialize in more fuel-consuming vehicles such as sports cars, luxury cars, and sport utility vehicles. That by itself is not necessarily undesirable -- except that it has the converse effect of not rewarding manufacturers specializing in fuel-efficient cars, which is undesirable.

The principal weakness of the CAFE approach is the disconnect with market forces. Automakers vigorously oppose increases in the standard because they insist, for the most part accurately, that consumers are not willing to pay extra for better fuel consumption. For their part, consumers are acting rationally. With gasoline costs lower than they have been since World War II (taking into account inflation), an additional 5 mpg generates less than $100 in fuel savings per year.

What worked in the past will not necessarily work in the future. Fuel economy regulation had some effect during the late 1970s and early '80s when fuel prices were high. High fuel prices encouraged manufacturers to invest in more efficient vehicles and consumers to buy them, and the schedule of stiffening fuel economy standards created a sense of certainty about the future. High fuel prices and stiffening standards reinforced each other.[1] That dynamic has unraveled with sagging fuel prices.

Safety Regulation

Vehicle safety standards have been highly successful at reducing accidental deaths and injuries. They do not, however, address the special concerns associated with smaller vehicles. They hinder the introduction of very small vehicles and fail to protect the occupants of smaller

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[1]David L. Greene. "CAFE or Price: An Analysis of the Federal Fuel Economy Regulations and Gasoline Prices on New Car MPG, 1978-89," *Energy Journal* 11:3, pp. 37-57, 1990

conventional vehicles. The central failing is the treatment of each vehicle in an autonomous fashion. The challenge is to create a safer transportation system, not safe vehicles.

Vehicle safety standards are a combination of technological and performance standards. Technological standards require the use of specific types of glass, physical restraints, and other devices. Performance standards instead rely on goals such as survivability in prescribed test crashes (by instrumenting crash dummies). Design and enforcement of vehicle safety standards has had little effect on emissions and, for the most part, fuel economy.

The problem is that extensive use of technology-specific standards and unquestioned acceptance of full-sized cars as the norm both hinders the introduction of small and light cars, and fails to protect occupants of those vehicles. Safety regulators single-mindedly pursue their narrow interpretation of safety goals. They focus on vehicle design features needed to survive collisions between large vehicles at high speed -- which is reasonable as long as vehicles and operating environments are fairly homogeneous. But this approach fails to protect the occupants of smaller vehicles, and shuts out new types of vehicle-road system designs based on (less expensive and more benign) neighborhood-scale vehicles. A different approach could be followed that leads to large vehicle designs that are more compatible with smaller vehicles (as Mercedes Benz is doing in designing its sport utility and minicars). It might also lead to the creation of operating environments that respond to the more vulnerable small vehicles. The regulatory solution is complicated, and less amenable to fixes than is the case with emissions and energy use. In any case, a more flexible approach with a broader system perspective is needed.

CALIFORNIA'S LEV/ZEV INITIATIVE

On September 28, 1990, California acknowledged the shortcomings of the uniform standards approach to vehicle emissions regulation, adopting what became known as the low emission vehicle (LEV) program. In addition to tightening vehicle emission standards and mandating the production of zero emission vehicles, it adopted rules allowing vehicle suppliers to average and bank emissions (similar to CAFE), as well as to trade them.[2]

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[2]CARB regulators, however, severely restricted banking by confiscating a large portion of banked emissions after just one year. This is unfortunate because banking adds flexibility to the regulations, can reduce the cost of compliance by as much as 4 percent and, most importantly, can have environmental benefits. By encouraging early cleanup of emissions, banking gets the air cleaner today when the regulations are less stringent and harm per unit is greatest and allows greater emissions in the future when standards are more stringent and per-unit damages are lower. See Jonathan Rubin and Catherine Kling. "An Emission Saved is an Emission Earned: An Empirical Study of Emission Banking for Light Duty Vehicle Manufacturers." *Journal of Environmental Economics and Management*, 25: 3, pp. 257-274, 1993.

This last provision -- the averaging, banking, and trading of emissions -- took effect beginning in 1994. It functions as follows: each vehicle manufacturer averages emissions across all vehicles they sell in a given year, banks or sells emission credits if they beat the standard and buys credits if they do not. Various limitations were imposed to simplify monitoring and enforcement, such as only allowing averaging, trading, and banking of one pollutant (hydrocarbons). It was the first time a major effort had been made to create a market for motor vehicle emissions.[3]

This new program is a sharp departure from uniform standards. It provides manufacturers with far more flexibility in how they reduce emissions, allowing them to choose the most cost-effective strategy. They can, for instance, focus their efforts on cleaning up their gasoline engines or introducing cleaner fuels, or both. A study at UC Davis found that implementation of an emission averaging and trading program in California in 1990 could have reduced emission control costs of vehicles by 13 to 30%, without increasing overall emissions.[4] (If the study had also considered banking, the savings would have been even greater.) With pollution control costs at about $750 per vehicle at that time,[5] this cost saving would have amounted to about $150 to $350 million per year for California, and $1-3 billion nationally.

The flexibility offered manufacturers by this program provides a direct incentive to innovate to beat the standard. It should be recognized, however, that this innovation tends to be strongly conservative, in the sense that companies will innovate incrementally. This type of market-based regulatory system will not be effective at bringing about changes in fuels and vehicles. The start-up costs of leapfrog and revolutionary change will tend to divert innovation toward more conventional technology.

The stringent 1990 California emission standards illustrate this point. It had been expected at that time that the new standards would direct automaker attention to methanol and natural gas fuels, which are inherently cleaner burning than gasoline (and provide other benefits as well). That has not proven to be the case. Instead, automakers have engaged in a massive effort to

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[3]The one other emission averaging, banking, and trading program for vehicles is a US EPA program adopted in July 1990 for heavy duty engine manufacturers. It affects a relatively small number of vehicles. The effectiveness and efficiency of this program have not been evaluated.

[4]Michael Quanlu Wang. "Cost Savings of Using a Marketable Permit System for Regulating Light-Duty Vehicle Emissions." *Transport Policy*, Fall 1994.

[5]Quanlu Wang, D. Sperling, and Catherine Kling. "Light Duty Vehicle Exhaust Emission Control Cost Estimates Using a Part-Pricing Approach." *Journal Air and Waste Management Association* Vol. 143, pp. 1461-1471, 1993.

clean up gasoline engines. Why have automakers not put more effort into developing low emission natural gas and methanol vehicles?

One explanation is the high degree of uncertainty over the future of alternative fuels. Automakers preferred the less risky strategy of sticking with the status quo, even if the cost of doing so was greater than switching some vehicles to alternative fuels. They legitimately feared being stuck with an unsold inventory of "Edsels". A second explanation is that the absence of incentives and mandates for fuel suppliers to sell natural gas and methanol indicated to automakers that the government and the fuel supply industries were not serious about marketing the alternative fuels. And a third explanation is that, because energy security and greenhouse benefits were ignored by the California Air Resources Board (which has no authority to regulate fuel use), the incentives were smaller than they should have been. It is possible that a fuller incorporation of the market externalities of alternative fuels would have been sufficient to convince automakers to invest in new fuels.

Two lessons emerge. First, the extra cost of gasoline use must be very large to convince automakers and oil companies that the risk of switching to other fuels is good business. They will tend to prolong their commitment to gasoline beyond the time when it would be otherwise rational. Because CARB's only mission is air quality, it can not justify policies and rules that encourage fuel switching on grounds other than air quality. By ignoring the other important nonmarket attributes of fuel options, CARB is not acting in society's best interests. As indicated above, a less fragmented regulatory process needs to be developed that is not so narrow.

Second, flexible rules are ineffective at overcoming start-up barriers. Vehicle manufacturers chose to renew their investment in gasoline, the status quo, even though it may not have been the least cost strategy. It was chosen because of the uncertainty and financial risk associated with change. The lesson, therefore, is that specific government directives are appropriate when start-up barriers are large and change is desired with urgency or confidence.

CARB's 1990 LEV initiative was extraordinary in its vision and scope. It was an important step away from command-and-control rules toward an incentive-based approach. It provided a framework to guide the transition to much cleaner vehicles. But it is just a first step. Because it lacked authority to do so, the California program did not establish a mechanism that allows the development of region-specific strategies, did not incorporate or address social goals other than pollution, did not incorporate upstream effects, and did not provide an incentive to energy suppliers to sell clean non-petroleum fuels, including electricity.

TOWARD A MORE FLEXIBLE REGULATORY REGIME

No single person or organization can ever have sufficient knowledge and insight to design and oversee the transition to more energy-efficient, low-emitting, safe transportation. The future is too uncertain, the choices too complex, and too many vehicle costs remain outside the

workings of the marketplace. The transition can not be micro-managed. What is needed is a sophisticated governmental framework for guiding those changes.

In the past, choices and decisions were simpler -- or seemed to be -- and cost implications more modest. It was not unreasonable to expect government administrators to have the foresight to orchestrate choices of fuels and technologies. That no longer is the case. Choices are far more diverse and the implications more far reaching. Given uncertainty about the future, a more efficient and resilient approach would be to offer incentives to industry and consumers that push them toward lower air pollution, reduced greenhouse gases, and perhaps even greater use of domestic resources. By utilizing principles of marginal cost, this approach becomes fundamentally more efficient. It seeks to alter the behavior of individuals and industry by restructuring, rather than overtly limiting, the choice environment. It does not rely on omniscient government bureaucrats.

Two different types of incentive-based approaches can be pursued. One is to make existing market arrangements operate better by manipulating key attributes of the market, particularly prices and information. The second is to create market-like arrangements that mimic real markets in the way they generate incentives. The emphasis of both approaches is on decentralized decision making, driven by self-interest, but guided by a regulatory body that structures the incentives.

Fee-bates and Taxes

Fuel taxes are a prominent example of the first approach: to improve existing markets. They are a simple means of incorporating pollution and energy externalities into fuel prices. In theory, consumers would respond to the tax surcharge by purchasing more fuel-efficient vehicles and driving less. In practice, fuel taxes are immensely unpopular and, because fuel costs are such a tiny part of the total cost of operating a vehicle in the United States (only about 15 percent), they need to be very large to make much difference.

A more promising price-altering method for eliciting change is so called fee-bates -- a program of fees and rebates for buyers of new vehicles.[6] Buyers would receive a rebate if the car they purchased had better fuel economy and air pollutant and greenhouse gas emissions than average, or would pay a fee if the vehicle emitted more pollution or used more fuel than average. The size of the fee and rebate would be proportional to how much better or worse the vehicle was than average. The effect of fee-bates is to provide an incentive for individuals and organizations to purchase cleaner-burning and more fuel-efficient vehicles and for vehicle manufacturers to develop and sell such vehicles. The principal challenge for regulators for this

[6]William Davis, Mark Levine, and Kenneth Train. Feebates: Estimated Impacts on Vehicle Fuel Economy, Fuel Consumption, CO2 Emissions, and Consumer Surplus. Berkeley, Ca.: Lawrence Berkeley Laboratory, 1993, draft.

type of proposal is to determine the appropriate magnitude of fees and rebates to elicit the desired improvements.

Many other such proposals, based principally on vehicle usage and other pollution and energy attributes, are also possible.

These proposals to make the system work better by incorporating energy and environmental externalities into market prices are conceptually attractive and potentially effective at altering behavior, especially when packaged with other technology-based initiatives. But legislators and regulators are wary of policy instruments that impose direct financial transfers on consumers, particularly when these transfers can be labeled as taxes.

In general, taxes and fees are most palatable when they are revenue-neutral (as with fee-bates when fees balance rebates) and when deposited in trust funds and used exclusively for clean air and other popular and clearly specified activities.

Marketable Credits for Vehicle Suppliers

The second incentive-based approach -- creating new market-like arrangements -- includes the use of pollution licenses and permits and marketable credits. Licenses and permits, whereby polluters are allocated a specified amount of pollution, are less attractive than marketable credits because they tend to discourage entry into the market by newcomers; are difficult to adjust for new information and shifting economic, technological and political conditions; and are difficult to assign in an equitable manner. Marketable credits, however, show great promise, not only with respect to vehicles, as pioneered by California, but also with respect to fuels.

Marketable credits are created by setting standards, as is done with uniform vehicle emission standards, but with the added embellishment of allowing vehicle suppliers, or fuel suppliers in the case of fuel standards, to average around the standard. If suppliers do better than the standard, they are allowed to bank and trade those excess credits, thus creating a market -- with marketable credits as the currency.

The heart of a marketable credits scheme is trading excess pollution credits, or excess credits of whatever other attribute is being regulated. The beauty of the scheme is its flexibility. Manufacturers who prefer to focus on less environmentally benign fuels and vehicles -- gasoline, diesel fuel, large engines, jeeps, etc. -- may continue to do so. They simply buy credits from manufacturers who sell fuels and vehicles that better the standard.

Flexibility translates directly to less cost: industry has the flexibility and incentive to reduce emissions in the most cost-effective manner possible. As indicated earlier, the US would have saved billions of billion dollars in 1990 if an effective emission trading scheme had been in place. As emission standards are tightened, the cost savings of these marketable credits should expand.

The benefits of marketable credits would be even larger if the automaker-regulator relationship were to be made less adversarial by the new incentive-based system and if other social costs -- including fuel efficiency, air toxics, greenhouse gases, and energy security -- were brought under the marketable credit umbrella. Bringing other social costs under the umbrella would also have the effect of greatly increasing the dollar value of credits for cleaner and more efficient vehicles. For instance, rating EVs according to their petroleum consumption for purposes of complying with the CAFE standard, even with little or no increase in the standard, would perhaps be worth several thousand dollars per EV -- the result of automakers being able to increase sales of their highly profitable large vehicles.

Marketable Credits for Fuel Suppliers

Like most other regulatory initiatives to reduce pollution and energy use in the transportation sector, California's LEV program placed the burden squarely on motor vehicle manufacturers. With the notable exception of lead removal, regulators mostly ignored transportation fuel supply until recently. As fuel choices enter the air quality and climate change policy calculus, that no longer is tolerable. Extending the marketable credits scheme to fuels may not be welcomed by the oil industry, but could lead to a less costly and more effective transition to cleaner fuels and vehicles. This concept has already been implemented with powerplants -- through the highly successful sulfur oxide emissions trading program (created by the 1990 Clean Air Act amendments).

Transportation fuels were first targeted as a major culprit in the air pollution debate in a July 1989 speech by President George Bush. He proposed substituting methanol for gasoline to meet clean air goals, alarming the oil industry. Arco, a regional oil company headquartered in Los Angeles, along with other oil companies, quickly responded with a counterproposal that had not received any discussion or debate, that regulators had essentially been unaware of as a viable option: cleaner-burning reformulated gasoline.

The barrier was breached. Air pollution regulators in Washington, D.C. and Sacramento quickly embraced the proposals. They adopted stringent new gasoline standards. Though the new rules contain some rudimentary marketable credit elements, they are prescriptive in spirit.

The conversion of these fuel supply rules into a broader marketable credits program would provide three large advantages not otherwise available: they are amenable to region-specific strategies; upstream impacts can be more easily incorporated; and emissions from the existing fleet of gasoline vehicles could be improved. Geographical targeting is an important advantage for air pollution regulation (though not greenhouse gases or energy security) because the magnitude and nature of the pollution problem varies greatly from one region to another. Some regions have major pollution problems while others do not; a few suffer from high concentrations of carbon monoxide, and others from ozone or particulates. And of those suffering high ozone levels, some are due to disproportionately high hydrocarbon concentrations, others to high nitrogen oxides. Region-specific strategies, made possible by marketable fuel credits, are potentially a very cost-effective approach.

Fuels regulation lends itself to region-specific strategies because virtually all the fuel purchased within a region is consumed within that same region. In contrast, vehicles purchased within a region are not readily sold or transferred to another region, and in any case government is unlikely to abrogate the right to sell vehicles in regions different from where they were bought; thus vehicle-based regulation is not suited to region-specific strategies.

The administration of a fuels regulation program would take some effort. It would be more difficult than a comparable program for automotive emissions, principally because there are many more fuel suppliers than vehicle suppliers and because several major fuel-supply industries -- natural gas, oil, electricity, and perhaps even agricultural suppliers of biomass fuels -- must be accommodated. There is also the problem that regulators have little experience with transportation fuels (though they are familiar with the refineries and powerplants that produce the fuels). Also, a method is needed to account for the differing quantities and types of pollutants emitted at different stages of the fuel cycle, differences which vary from region to region. This latter challenge can be met by creating standards for attributes of each fuel. Regulation of fuel attributes readily lends itself to the development of region-specific strategies. The standards can be adjusted to reflect the unique aspects of pollution in an area, and the average standard required of each fuel supplier can be raised or lowered, depending upon the severity of the problem in that area.

In Los Angeles, for instance, the average emission standard that fuel suppliers would have to meet for nitrogen oxides might be 0.1 grams per mile by the year 2005, while in cleaner San Francisco it might be a less stringent 0.3 grams (the exact emissions allowed per unit of energy produced being based on average vehicle energy consumption for the region or country). In fuel-based regulation, each fuel supplier would determine the most cost-effective manner for meeting the specified average ratings. If it is expensive for an oil refiner to reformulate gasoline to reduce its emissions, perhaps due to the design of its refineries, or if the average rating is set lower than what is achievable with reformulated gasoline, then credits could be purchased from a natural gas or electricity company that can meet the required rating at less cost. Or the oil refiner might choose to sell natural gas or even hydrogen or electricity at its own stations.

An important refinement would be to design the fuel rating to incorporate other social goals, such as reduced emissions of greenhouse and toxic gases and greater energy security. This could be accomplished by setting social goals and then allowing fuel suppliers to meet them in the same way that they meet emission standards. For instance, the standard for greenhouse gases could be set at 1.0, with ratings assigned to each fuel depending upon their effect on climate change (measured as a composite CO_2-equivalent value). Methanol and gasoline might be rated at, say, 1.0, while lower emitting options such as domestically supplied natural gas might be 0.9 and hydrogen from natural gas, 0.6.

A simplistic version of this marketable credit concept was considered by the California Air Resources Board in an early version of what became known as the 1990 Low Emission

Vehicle program. As initially proposed, gasoline suppliers were to be mandated to sell a specified amount of methanol and LPG, with the mandated quantities based on the sales of alternatively fueled vehicles in the previous time period and on suppliers' share of total fuel sales. Refiners were to be allowed to satisfy the clean liquid-fuel requirement by either selling those fuels directly or by buying credits from other suppliers who had sold clean liquid fuels in excess of their requirements. Banking of credits was to be allowed, with sharp discounts over time. Up to 10 percent of the fuel sale requirement could have been met by compressed natural gas or electricity sales to motor vehicles. For electricity, credits were to be allowed only for sales above the mandated ZEV level (2 percent in 1998, 5 percent in 2001 and 10 percent in 2003). Most of this proposed clean fuels program was subsequently dropped because of opposition by oil refiners, who claimed that they should not be held responsible for the willingness of consumers to purchase alternative energy.

WHERE INDUSTRY STANDS

Those attempting to craft a successful regulatory program must confront the sobering realization that the industries most affected -- autos, oil, natural gas, and electricity -- are the largest and most powerful in the world, and that inertia supports current technology and investments. The challenge is to create an even-handed regulatory format that is effective and economically efficient and that respects the vested interests of those companies while pursuing the public interest. That is a daunting task.

Some amount of optimism is in order. Interaction between the four industries, although minimal in the past, is now expanding. In the early 1990s, the oil and auto industries invested jointly in a multi-year $30 million study of emission impacts of fuels and vehicles and, along with electric utilities and the US Department of Energy, formed the US Advanced Battery Consortium.

The stodgy electric companies, with little or no marketing expertise, and virtually no knowledge of the transportation market, are the least experienced politically and economically with vehicles. With the trend toward deregulation of electricity supply, the utilities and their regulators are already exploring new relationships. The gradual unshackling of utility participation in the vehicle market is inevitable, but is likely to be slow.

Oil companies have deeper interests and experiences with the transportation market -- with huge investments in oil refineries, pipelines, and storage depots. With few exceptions, gasoline, diesel, and jet fuel remain the heart of their business. They have little experience with non-petroleum fuels, with the notable exception of natural gas production. With the slimming down of corporate staffs in the early 1990s, their ability and willingness to consider new energy options has shrunk. Oil companies would be more likely to accept fee-bates than fuel taxes and marketable credits. Marketable credits do, however, leave considerable discretion to fuel suppliers; one can imagine circumstances under which the concept could be crafted to gain industry acceptance.

The auto industry is, not surprising, less antagonistic to new regulatory formats and even new fuels than oil companies. After decades of heavy regulation, they are regulation-savvy and tend to be more open to more efficient and flexible regulations. They remain conservative, however, befitting the huge investments at stake. Indeed, it is instructive that automakers were willing to devote extraordinary resources to lower gasoline vehicle emissions in the 1990s, largely to escape switching to alternative fuels (and to undermine the motivation for zero emission electric vehicles). While this cause-effect relationship cannot be easily documented, it is notable that automakers responded far more positively (and docily) to California's LEV/ULEV emission standards of 1990 than they had to any previous set of stringent new emission standards.

However, competition between automakers is more intense now than at any time since World War II. The greater competitiveness of the auto industry bodes well for the future. It suggests a greater willingness to innovate and take risks in pursuing promising new designs and technologies. Indeed, the intense competition between GM, Toyota, Mercedes Benz and others to earn the mantle of "environmental" automaker of the 21st century, and the ongoing technological revolution in lightweight materials, power electronics, communications and computing, energy storage, and energy conversion create an environment in which automakers will embrace regulatory flexibility in meeting emissions and energy goals.

CONCLUSION

The commercialization of more environmentally benign fuels and vehicles will be delayed and investment decisions distorted unless the regulatory system is reformed. Regulatory rigidity and fragmentation, coupled with uncertainty over future regulations, is hindering investments in lean-burn, two-stroke, natural gas, and diesel engines, and hybrid ICE-electric vehicles. If this fragmentation and uncertainty continues, investments in fuel cells will be distorted and delayed as well. The creation of a more incentive-based regulatory and policy framework is of paramount importance. The economic benefits to the nation of more flexible, responsive, and incentive-based regulations may be in the billions of dollars per year.