Leasing the Air:
An Alternative Approach to Regulation?

by Roger Noll

THE CONCEPT of leasing the air is one of using market processes to provide an efficient way to satisfy air-quality objectives. By a "market," I mean an organized process and set of rules for buying and selling a well-defined commodity or property — in this case, a government permit to emit pollutants. A market for emissions permits is an alternative to the present approach of dealing with air pollution by writing technical standards for every one of the millions of orifices through which pollutants pass into the atmosphere. Though the idea may seem straightforward, each year about 40 percent of the new markets that are established fail to survive, and usually for reasons that are never really understood. Simply setting up a situation in which people can engage in trade does not always mean that trades will take place or, if transactions do occur, that the market performs efficiently. Thus, to use this method to achieve the goal of more efficient air-quality control requires solving two problems — first, establishing the market and, second, making sure it performs as intended.

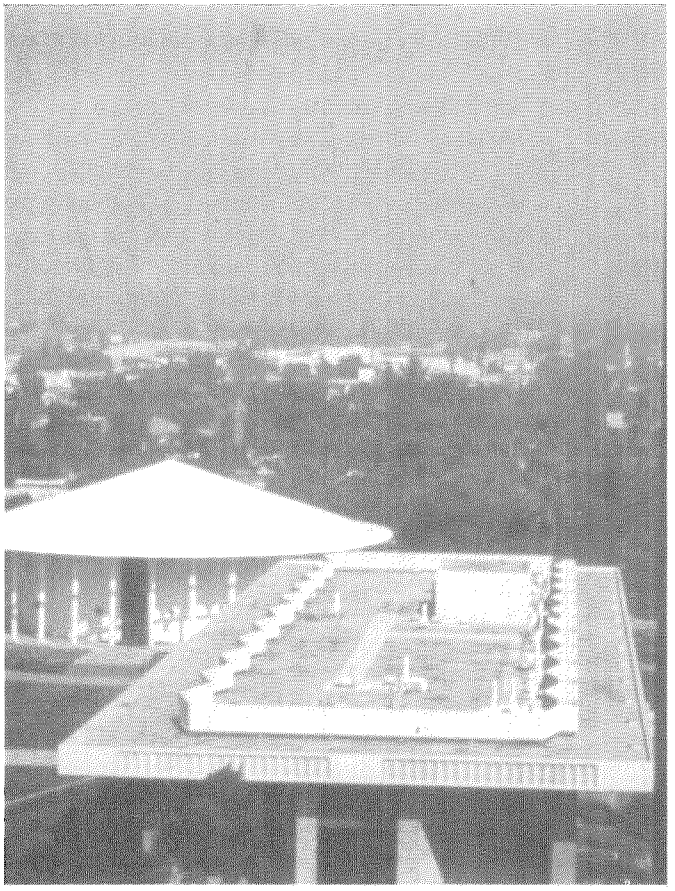
For the past three years, several Caltech faculty and graduate students have been attacking this problem for a specific case — sulfate particulates in the Los Angeles air basin. The results of this work were recently submitted in a three-volume report to the California Air Resources Board. This article summarizes our report.

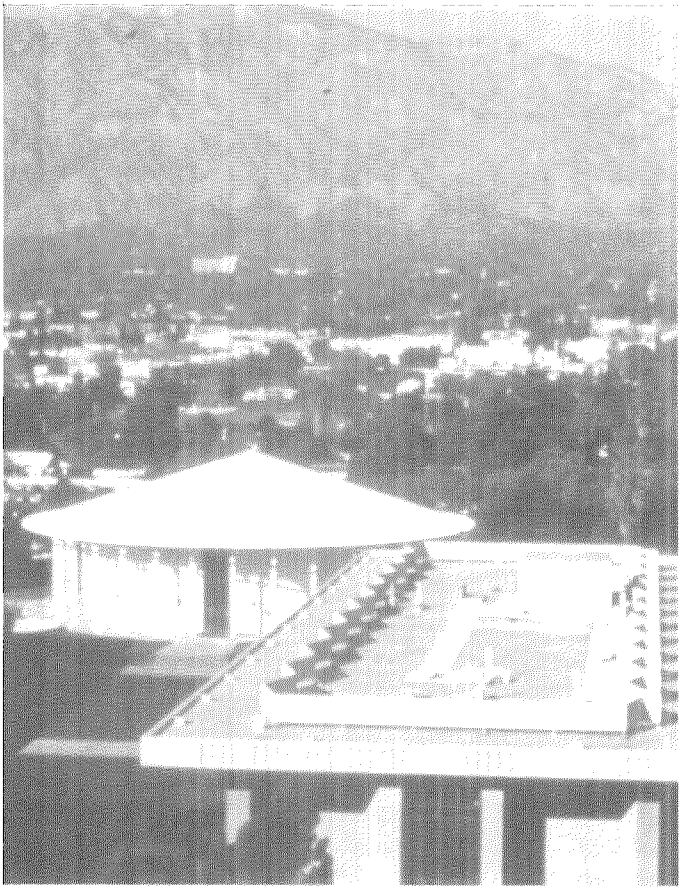
The details of how society might organize a market in emissions are as follows. First, some regulatory or legislative process would establish a limit on the quantity of pollutants that can tolerably be emitted into the atmosphere, and would create permits to emit that amount. Businesses can then purchase these rights. In doing so they will be motivated by the same incentives as they are in hiring labor, purchasing land, buying machines, and acquiring other inputs into their production processes. Among their incentives will be the desire to minimize costs, including the cost of permits to use the atmosphere. The point of establishing a market for emissions permits is to channel normal business incentives into conserving the environment and minimizing abatement costs.

The case of sulfur emissions into the Los Angeles "airshed" provides a useful setting in which to study how a market for pollution could be established. Almost all of the sulfur emitted in Los Angeles arrives in a barrel of oil and is put into the air by burning petroleum products. Most of the sulfur comes out of the combustion process as sulfur dioxide (SO_2). The federal government has set ambient air quality standards for the allowable amounts of it in the atmosphere, and Los Angeles is in compliance with this standard.

The interaction of SO_2 with sunlight and other matter in the atmosphere produces sulfate particulates, which are part of another category of pollutants called total suspended particulates. At the national level, total suspended particulates are also regulated, and once again Los Angeles is not out of compliance. Los Angeles, however, has the problem that sulfate particulates account for a very large part — probably more than a third — of the reduced visibility due to air pollution in the basin. So the California Air Resources Board has established an ambient air quality standard requiring that about two-thirds of the sulfur emitted into the airshed be removed. With the late 1980s as the current target for achieving this standard, Los Angeles is only about halfway there.

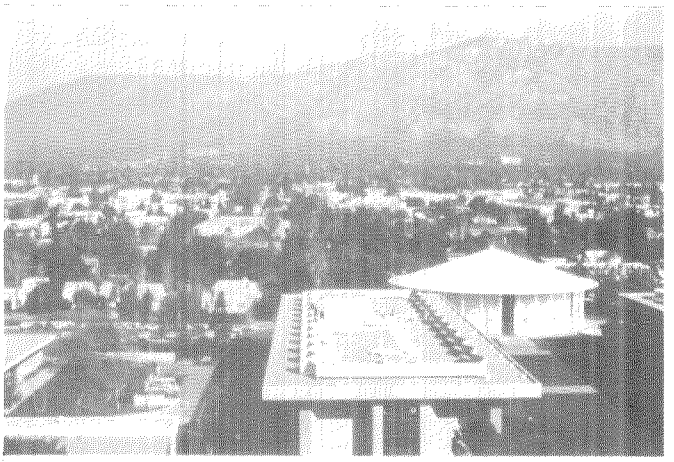
The method of environmental regulation used to get even that far along toward the goal has been an extraordinarily complicated and difficult





The foothills of the San Gabriel Mountains are located less than five miles north of the Caltech campus, but on smoggy days they might as well be a thousand. The two views above were photographed from the ninth floor of Millikan Library on two different days, and they provide a graphic illustration of the effects of particulate air pollution on visibility.

Two more views of the same scene. The one above was taken in October 1980, and the one on the right in January 1980.



one. According to the requirements laid out in state and federal law, the regulator holds a formal proceeding at which each specific category of sources is scrutinized. Then a regulation is established specifying what is to be done about that source. These regulatory procedures take a long time and consume a lot of resources. In Los Angeles, approximately 40 different categories of sources emit significant amounts of sulfur. These categories encompass numerous companies, and within each company there may be several sources. Because regulations are written for each hole through which something leaks into the atmosphere, there are literally thousands of specific regulations that deal with sulfur.

Because of all this, only a few industries can be in the process of having regulations for their emissions under consideration at any given time, and it takes several years from the beginning of the process to the completion of a written standard. The process starts with a proposed set of instructions to a firm to use the best technology for abatement that is economically feasible at the time, but by the time the process stops, this standard is several years out of date. Moreover, many other industries are still standing in the queue waiting to be regulated, and still others are operating with standards that were written for them more than a decade ago.

Because various firms have different vintages of technology that they have been required to use, widespread differences exist among them in the cost of achieving the current amount of pollution abatement. Naturally, a firm is very reluctant to adopt new technology, because that reopens the very long, expensive, and uncertain regulatory process. To sum up, the way regulation is done erects a barrier to technological change, either for doing a better job of abating pollution or for creating new production processes that achieve the goals of a business in a cheaper way.

These inefficiencies mean that we are achieving the current amount of reduction in air pollution at a cost that is substantially greater than the least expensive way of doing it. The main purpose of setting up a market is to convey to polluters — new and old — appropriate price signals about the social cost of emissions. Each can then select a combination of capital investments, operating practices, and emissions releases that minimize the sum of abatement costs and the cost of permits to pollute.

If markets show promise, the question remains whether that promise can be realized. Would just saying, "Let's have a market, and let 'er rip," really work?

Not necessarily. A number of potential problems could thwart the creation of a market. The first has to do with the fact that the market may not be competitive. The reason competitive markets are efficient is that the prices conveyed through them are honest signals to businesses about true costs. Only if permit prices represent the true incremental cost of abatement will each business make a decision about how much to spend on abatement that is consistent with the objective of achieving an air-quality goal at minimum total cost for the region. A monopolist would engage in strategic games to alter the price to his own benefit, thereby destroying the connection between permit prices and incremental abatement costs.

The second problem we have to worry about is market "thinness"; that is, transactions may not occur frequently enough for the market to work. A business wants to minimize the total costs of being a polluter, which includes the cost of abatement itself plus the cost of buying permits for the amount of pollution produced after abatement activities have been adopted. To make this calculation, business needs to know the price of permits. If market transactions do not occur very frequently, business will not have that information. In the past few years, the Environmental Protection Agency has sought to introduce some limited opportunities for trades of emissions permits. These have not yet proved very successful because the way the markets have been set up, combined with the limitations on allowable trades, has produced a very thin market.

A third issue has to do with the geographic distribution of emissions. Right now standards are set on a firm-by-firm basis regardless of their geographic distribution. But if all the permits to pollute were concentrated in one geographic area, the possibility of a market might be destroyed. If, for example, a permits market ended up with a situation in which one square block in Los Angeles was the sole source of all the sulfur emitted into the airshed, the people living downwind from that block would not be enthusiastic about the permits market.

Another concern is called "distributional equity" or fairness. Permits to pollute are valuable commodities, and the political system is going to be very sensitive about how they are distributed. If the value of the permits is very great, whoever sells them is going to be rich, but the businesses that have to pay abatement costs and also to buy permits are not likely to be eager to do so. After all, business now gets the permits for free from the regulatory process.

The final problem surrounding the creation of a market is long-term stability versus short-term

flexibility. One of the legitimate complaints businesses have about regulation is its unpredictability. In order for businesses to make rational decisions, they need to have long-term stability in permits; that is, they must have some confidence that, if they make a capital investment, the strategy for environmental regulation on which it is based will be constant long enough to give them some chance of amortizing the cost.

Equally legitimately, society wants to have flexibility in the regulatory process. As society learns more about the effects of air pollution and the technologies for abating it, it will want to have the freedom to change air pollution policies.

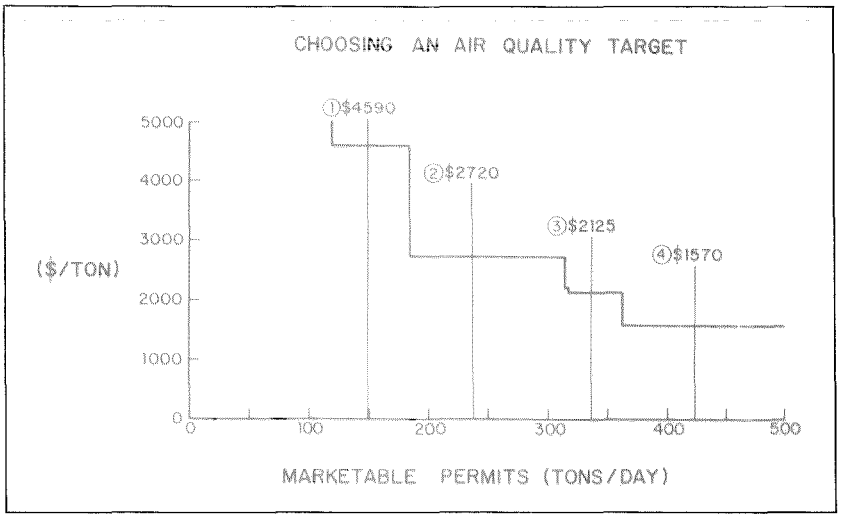
With this as background, let us now review the Los Angeles sulfur problem and see how we might characterize and then attack each of the obstacles to setting up a market. The table above shows the amount of emissions in tons that would be allowed each day in Los Angeles to satisfy four different targets for air pollution. The first is the one that would allow us to achieve the current California ambient air quality standard. Number 2 is a slightly more relaxed version that would satisfy the standard all but two weeks a year. The third item is slightly better than where we are today. It assumes current controls and relatively accessible supplies of natural gas. Number 4 is where we were in the late 1970s when the regulation and resulting shortage of natural gas made it extraordinarily difficult to purchase as an alternative to oil as a fuel.

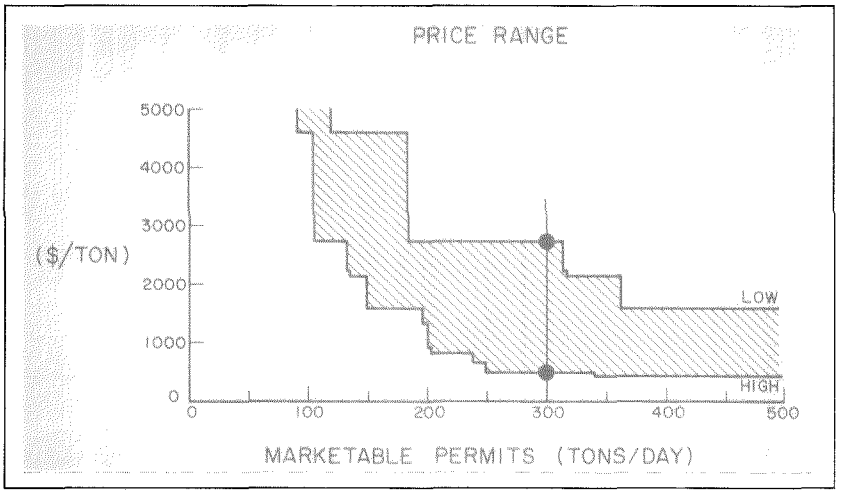
One aspect of the work at Caltech has been to use simulation methods to examine how the market would work under these and other possible standards and under different conditions of natural gas availability. These simulations can be used to estimate the distribution of emissions among sources that would result in a market. In order to undertake this analysis, several research projects were needed. The first, undertaken by Glen Cass, assistant professor of environmental engineering at Caltech, was to construct a model of the relationship between emissions and air pollution. The second was to estimate the abatement-cost functions for every single source category in Los Angeles. This information was then used to construct a model of how cost-minimizing companies would behave in a permits market, a task that was successfully undertaken by Robert Hahn, PhD '81, as part of his doctoral dissertation work in social science. The Hahn model was used to estimate the distribution of emissions among sources for several different ceilings on total emissions, three assumptions about the availability of natural gas, and both a competitive market and a "monopsony" (a situation in which one firm accounts for all purchases of permits). The figure below shows one output of this analysis — the "demand" for permits in a competitive market under conditions of low natural gas supplies. The curve shows, for each possible ceiling on total emissions, the price of permits to emit a ton of sulfur that would clear the market. When multiplied by 365, these prices become the amount business would pay to emit one ton per day for a year. At 150 tons per day, which is the final target of the ambient air-quality standard, this comes to about $1.7 million for a ton-a-day, one-year permit.

Target	Allowable Emissions
1. Achieve California Sulfate Air Quality Standard of 25 micrograms per cubic meter over a 24-hour averaging time.	149
2. Violate California Sulfate Air Quality Standard 3-5½ of the time.	238
3. No additional controls with an above average natural gas supply.	335
4. No additional controls with a low natural gas supply.	421

The allowable emissions levels shown above are in tons per day of sulfur dioxide, and the standards on which they are calculated refer to those in effect in 1977. More stringent standards are scheduled to be applied to some sources in 1985.

The first major result of the study is to show that the reform of environmental regulation with the greatest effect for the amount of money spent would be the decontrol of natural gas. Currently there is excess demand for natural gas at its regulated price. Use is curtailed by limiting the use of gas by industries and electric utilities as boiler fuel. If gas were deregulated, the price would go up and the market would clear. This would allow industry to choose to burn natural gas as one way of abating sulfur if it were a cost-effective option. Generally speaking, industry would do this even at a higher price because it is a relatively cheap





abatement strategy. The figure above illustrates this point. For example, at 300 tons per day, the market-clearing price for the right to emit a ton of sulfur into the Los Angeles airshed would be about $600. At low natural gas availability, the price would be about $3,000.

One of the problems in setting up a market for air pollution permits would be the potential for creating a monopoly. The table below shows the most important sources of sulfur pollution in Los Angeles. Mobile sources are cars, trucks, and the like, and the best way to deal with sulfur coming from them is to have less sulfur in fuel. If a permits market is set up so that oil companies must have the permits for the sulfur in vehicle fuels, the percent of total emissions from mobile sources would be distributed among the oil companies shown in the table. Adopting this approach, the two most important source categories are oil refineries and electric utilities, which account for approximately 40 percent of the sulfur emitted in Los Angeles. One of the utilities emits almost a third of the total amount of sulfur in the airshed. With a single pollution source of that size, maybe the market is not going to be as competitive as we might hope.

The actual 1980 figures for sources of sulfur emissions in Los Angeles differed somewhat from those projected in this table. This is because natural gas was more available then than it was for most of the 1970s.

1973 Emissions		1980 Projection Low Natural Gas Scenario	
SOURCE TYPE	% OF TOTAL EMISSIONS	SOURCE TYPE	% OF TOTAL EMISSIONS
Utility	28	Utility	31
Mobile Sources	16	Mobile Sources	27
Utility	11	Utility	10
Oil Company	8	Oil Company	4
Steel Company	7	Coke Calcining Company	4
Oil Company	3	Oil Company	4
Coke Calcining Company	3	Steel Company	3
Oil Company	3	Oil Company	3
Oil Company	2	Oil Company	2
Oil Company	2	Oil Company	2

Actually, the situation is worse than this. Suppose we allocate the permits initially by "grandfathering"; that is, we give permits to everyone in a number equal to the amount of their current regulated emissions. In that case the largest electric utility would end up with 31 percent of the permits. Our calculations indicate that it would be the only firm that would want to buy more permits. Everybody else would want to sell them. Private electric utilities are by far the most heavily regulated of all businesses, and they over-abate relative to everyone else, so the cost-minimizing way to achieve current emissions would be to increase emissions at utilities and reduce them everywhere else. This creates the opposite of a monopoly — a monopsony, or a situation in which a single buyer faces a large number of sellers.

Economic theory enables us to predict the outcome of a permits market if a monopsony exercised its full power in manipulating the market to its own advantage. The best strategic behavior for a monopsonist would be to understate the intensity of its desire to hold permits, thus depressing the price in order to get them cheaper. We have simulated the outcome of a market that allowed a single firm to exercise the maximal amount of monopsony power. According to these results, at the current level of emissions, the amount of emissions by the largest source would change by only one percent if a fully monopsonized market were established. By contrast, in a competitive market the largest single source of emissions would seek to increase its total emissions by about 15 percentage points, from 30 to 45 percent of the total for the airshed. This big change is a measure of how far things are from the cost-minimizing, efficient allocation in Los Angeles. To underscore that point, 14/15 of the potential gains of switching from a regulatory-standard system to a market system would be lost if the market were monopsonized. The lesson is that in designing a market, the simple solution, which is to grandfather the permits and to let those who want to engage in trades do so, may not work because there may be no significant trading.

Another possible problem in designing a market is the sensitivity of the design to changes in geographical patterns of emissions. Here the news is good. We ran a number of complicated simulations at Caltech and concluded that the nature of the abatement problem in Los Angeles is such that we do not have to worry about the geographic pattern of emissions. The sources are sufficiently dispersed and face sufficiently similar

abatement-cost opportunities that the concentration of emissions in one place would not be likely to occur.

The final problem is that of equity. If the price for the permit to put a ton of sulfur into the atmosphere in Los Angeles is $1,000 to $4,000, emissions amount to somewhere between 150 and 400 tons per day for 365 days per year, and permits are to be valid for several years, the implicit value of all permits is upwards of a billion dollars. Naturally, the state legislature is going to get very concerned about who gets such a sum. It could, for example, attack the budget problems of the schools by giving them the right to sell air pollution permits.

I have already pointed out that businesses are going to be reluctant to pay for something they now get for free, and that too is going to be an important political factor. This would seem to argue in favor of a grandfathering method of distributing the permits, but that would raise the possibility of a monopsony problem. How can we grandfather the system so it does not generate one or two billion dollars of new business taxes for the reform? How can we avoid the monopsony problem and still have a "thick" market that will provide clear price signals?

One solution is something called the "zero revenue" auction. The trouble with a standard auction is that the seller receives the amount bid for the items that are auctioned. The mechanism we have devised to prevent that is to grandfather the permits but make it mandatory for them to be sold in the market through an auction. The regulatory agency would initially allocate so many tons per day to each company in Los Angeles according to how much it is currently emitting. Then, every potential source of pollution would have to submit a bid on how many permits it would like to hold at each possible price. If the price is $4,000 per ton, for example, how many permits does a company want to buy? If it's $1,000, how many? Then the regulator would add up the quantities requested at every price for all companies, and pick the price at which the number desired exactly equals the number that are available. Each bidder then gets the number of permits requested at that price.

What then happens to a specific business? It pays into the system the base price times the number of permits it buys. It receives from the system the same price times the number of permits it was initially allocated. This means that the total revenue collected in the auction from all firms is exactly equal to the total revenue that is returned to the people who initially held the permits. But it also means that every business in this auction is on the same side of the market; they are all buyers. Consequently, there is no monopsony problem, which threatened the market based on voluntary trades from the grandfathered position.

Given that it takes at least three years to write a regulation, our solution to the flexibility issue is to create permits of nine-year duration, one-third of which expire every three years. At the end of each three-year period, the regulators can define a new ratio between expiring permits and new permits. If permits for 50 tons per day are expiring, they could reduce the number available to 45 to make the air quality better, or increase it to 55 if they were willing to accept worse air quality. Under these circumstances, each firm has permits that will last long enough for it to make rational decisions about capital investment. At the same time, within the three-year planning horizon of the regulatory agency, it would be possible continually to be adjusting emissions in response to new information about air quality and its effects.

We have proposed our approach to the California Air Resources Board and to the Environmental Protection Agency in Washington, D.C. There is only one slight problem; it's illegal. The regulatory agencies would be in violation of virtually every environmental law if they were to implement it fully. Yet, with some changes from its purest form, there is hope that this kind of approach could be adopted in one market as an experiment to test the validity of the idea. We believe that there is a good chance that a market in emissions permits could reduce the cost of achieving air quality objectives, but the idea can be proved only by trying it out. □

Another pair of views from the top floor of Millikan Library. These two pictures of Pasadena were taken looking northwest on very different days.