Energy, Transportation, and Air Quality

Speakers in this session were Glen Cass, professor of environmental engineering and mechanical engineering at Caltech; John Holdren, the Class of 1935 Professor of Energy at UC Berkeley; and Mary Nichols, director of the Los Angeles office of the National Resources Defense Council. The panel discussion, moderated by Roger Noll, the Doyle Centennial Professor in Public Policy at Stanford University, also included John Bryson, chairman and chief executive officer of Southern California Edison.

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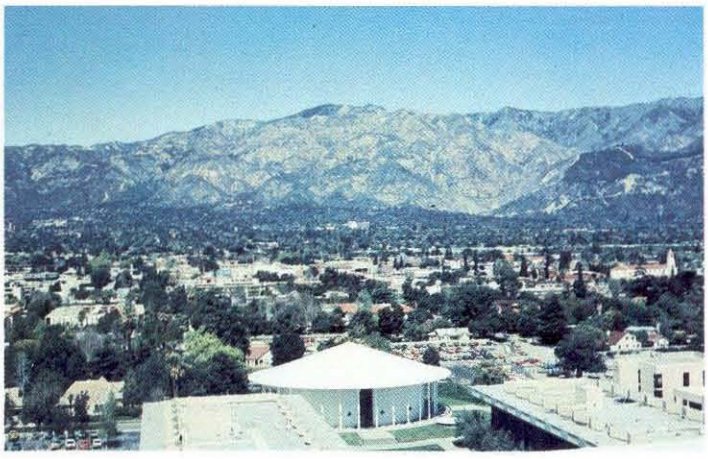
California's concerns about energy, transportation, and air quality of the future converge principally in the automobile. John Holdren, who spoke in general terms about the efficiency of energy production and use, pointed out that, although California has less-energy-intensive industries than the rest of the country, the state is "basically as fossil-fuel dependent as everybody else—some 83 percent of what it uses comes from fossil fuels. But if you look at where it goes, California uses a smaller percentage in industry and a much larger percentage in transport."

In her talk, Mary Nichols laid the blame for this on the state's land-use patterns. "California's urban growth has always been characterized by urban sprawl," she said. "The people who came here wanted to get away from what was perceived as the unhealthy concentration of the old-style civilizations of Europe and the eastern United States. The notion of being able to spread out and (later, after the electric streetcars were replaced by automobiles) being able to move from your problems by just going beyond the city limits to the next rural area have characterized our politics and our land-use planning from the very beginning."

The automobile's ultimate impact has been on air quality. Glen Cass discussed the local air-pollution problem in his talk, "How Can We See the Future Through All of That Smog?" He started out describing the evolution of the problem because, he said, "I think it's instructive for the future to understand how we got where we are." The air-pollution problem in southern California is extremely complex, Cass said. "It's really at least a half dozen and probably many more air-pollution problems all mixed into the same air mass. We have to be concerned with control of emissions of sulfur dioxide, carbon monoxide, an entire family of the oxides of nitrogen, hundreds of individual hydrocarbon species, not to mention reactions between the oxides of nitrogen and hydrocarbons that produce ozone, and the small particles suspended in the atmosphere that obscure visibility." To confine his talk to the time limit, Cass concentrated on the past and possible future of ozone and photochemical smog in Los Angeles, touching briefly on the problem of visibility caused by light scattering due to fine particles in the atmosphere (a situation Cass's lab figures could theoretically be cut by 40 to 50 percent—not perfect, according to Cass, but at least "the mountains would become apparent to the person on the street on a greater number of days per year").

Scientific understanding of the ozone problem is relatively well advanced, according to Cass. Sunlight acting on nitrogen dioxide gas in the atmosphere leads to ozone formation. The ratio of nitrogen dioxide to nitric oxide determines the amount of ozone, and reactive hydrocarbons increase that ratio, thereby increasing the ozone concentration. Cass and his graduate students are using mathematical simulation models of what happens in the air over southern California (taking into consideration such elements as the atmospheric chemistry, the spatial distribution of emission sources, the amount of sunlight, and wind speed and direction), dividing the area into a grid system of small air volumes that can each



From the top of Millikan Library, the peaks and canyons of the San Gabriel Mountains stand out clearly on a smog-free day, but on a smoggy summer day the mountains disappear. Visibility impacts of air pollution have been one of the focal points of Glen Cass's research group. (Photos from Susan Larson's PhD dissertation, 1988.)

be treated as a chemical reactor. They can thus calculate and predict an expected amount of ozone production, which agrees quite well with actual observations of ozone concentrations over time. They can also use models of this sort to examine the emissions allowable to achieve air-quality objectives with respect to ozone. It has been known for nearly 20 years that the maximum air-pollutant emissions that are compatible with attainment of the federal ozone air-quality goals total only a couple of hundred tons of reactive hydrocarbons per day and about 400 tons per day of oxides of nitrogen.

Attacking the ozone problem via the hydrocarbons has been the route of choice. Cass noted that "we've made incredible progress toward reducing emissions of reactive hydrocarbons in Los Angeles. From an emission rate of approximately 1 pound per day per capita in 1940, we have declined now to the point where we're emitting about 0.23 pounds per day per capita, a reduction of more than 75 percent—a tremendous accomplishment. It's worth noting that Los Angeles is approximately 30 years ahead of the rest of the United States in terms of emission control on a per capita basis."

The number of people in the air basin, however, has increased dramatically—from 3 million just before World War II to approximately 12 million now (and projected at 15 to 16 million by 2010). "Not surprisingly," according to Cass, "the effect of declining emissions per capita and an increasing number of individuals has resulted in a tug of war, and lo and behold, emissions of reactive hydrocarbons today and emissions in 1940 are substantially the same —about 1,500 to 1,600 tons a day." So we still need an order of magnitude decrease in present emissions to reach present air-quality goals.

In addition to motor vehicles, Cass pointed to a category of hydrocarbon sources that come from evaporation, not combustion—the evaporation of solvents contained in a multitude of consumer products: paints, industrial adhesives, furniture polish, dry-cleaning materials, and so on. These sources, each of which constitutes only a few percent of the overall emission inventory, come from diverse activities occurring at the personal level all over the economy, but together pour several hundred tons of hydrocarbons into the southern Californian air. Cass described these "small fugitive emitters" as "sort of a death by a thousand cuts," and was not optimistic about an easy solution to cutting off these sources.

Automobiles, however, are another story. Cass and graduate student Rob Harley used their air-quality models "to completely delete gasoline-powered motor-vehicle emissions from the atmosphere and project the effect that would have on air quality in southern California." There was a drastic improvement, but still not enough to eliminate the local ozone problem. Motor vehicle emissions control is clearly a necessary part of a solution to the problem, but it is not the whole solution. "My personal opinion," he said, "is that in the next 50 years, if not at present, it is technologically feasible to eliminate motor-vehicle emissions as a contributor to this problem." He listed a number of different ways, including gasoline-powered cars that are truly durable and

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well maintained, cars that burn alternative fuels, and electric vehicles. He placed most of the blame for current emissions, which are actually higher than government estimates, on old, poorly maintained automobiles. One study of pre-1971 cars showed that they had 65 times the hydrocarbon-emission rate of new cars.

Even if technology permits the control of motor vehicles, said Cass, the hydrocarbon contribution of the small fugitive emitters "may mean that hydrocarbon control as the ultimate solution to the Los Angeles ozone problem can only go so far. Either we will wind up with air quality that is better than at present, but not what we would ultimately desire, or, alternatively, very serious study must be given to trying to starve the atmosphere of oxides of nitrogen. I think this is probably more feasible in a technical sense because at least we're working against a zero baseline." (Hydrocarbons also come from biological sources, which really can't be controlled.) "But clearly, we *can* control the motor vehicle," said Cass. "The more interesting question is whether or not we have the consistency of social purpose to carry that out."

Mary Nichols, whose topic was reshaping California's cities, echoed the notion of public willingness. "The issues that I'm talking about here are certainly not new. We are perhaps at the end of a long cycle, but I don't think we're raising any new questions or concerns, and the policy choices aren't really all that different from what they have been in the past. It's a question of whether we now have the political opportunities or the political will to do something about them," she said. She decried the decision-making process in multiple levels of government: "We're making decisions in a way that isn't coordinated and doesn't respond to any particular set of policies that make any internal or integrated sense."

"The tax structure that we've created for ourselves makes it nearly impossible for the people who have control over land-use decisions to do the right thing," Nichols continued. "We try to preserve the notion that land-use decisions should be made at the level of government closest to the people. Revenues from land-use development are the principal source of income for local governments to do the job of planning and governance and provide police protection and court systems and all the other things that people want from government. So we have created a tax system that penalizes local governments for allowing for greater residential development and instead rewards those that can attract the greatest amount of commercial development. But figuring out how to change that in a way that takes the incentive for bad land-use decisions away and replaces it with positive incentives to do the right thing is extraordinarily difficult to agree to." On one side are the citizen organizations, homeowners, and environmentalists, and on the other are business and landowner groups. All want the maximum amount of flexibility.

The key to good land-use decisions, and the one that environmentalists are most concerned about, is mobility—"a lifestyle that will allow people to move about in their communities"—Nichols said, and this leads to a focus on transportation. Not only is transportation responsible for 75 percent of our smog problem, but "we're beginning to develop the data to show that we're underpricing our transportation system in a serious way. We have a road system that is being used at above its capacity. At the same time, we have no mechanism for pricing access to that system that would lead people to invest in other, better alternatives. The transportation sector is one of the few areas in which the public has been willing to vote additional taxes at the state and local level."

Even though the public has seemed willing to pay for transportation improvements, Nichols maintained that "we need to look at the way we invest in transportation projects. We should try to make those investments on a basis that in the electric-utility sector is known as least-cost energy planning, in which you make investments based on *all* of the costs of achieving a particular level of energy performance, including the environmental externalities." Although government regulation and investment have been proceeding along separate tracks for several decades, Nichols thought that the "revolutionary" idea that transportation planners and air-quality planners should talk to each other had finally dawned on government officials.

John Holdren also saw energy policy as the link that would enable California "to deal with the intersection of land use, transportation patterns, and regional air pollution." But in his talk, he sought to put California "in context as it exists for the United States and for the larger world in which California has to try to fit and to prosper."

In looking at the energy problems that we have in the nineties, Holdren claimed "we are certainly not running out of energy in any global or absolute sense. There are tremendous quantities of energy resources." But he listed a number of important things that we *are* running out of: the cheapest and most accessible supplies of petroleum and natural gas and hydroelectric sites;

the regenerative capacity of biomass; the environment's capacity for effluents; public tolerance for the perceived risks of nuclear energy; and public tolerance for inequity in the distribution of energy's costs and benefits. We're also running out of money for alternatives, as well as time to adjust and steer the "very ponderous energy system" onto a new course, Holdren continued, and we're running out of the capacity to deal with the enormous complexity of the special interests. "And we're running out of, or perhaps never had, the resolve to act," he said.

Of all the environmental problems, Holdren considered that "the most intractable, the most difficult in the long run, and perhaps the most serious constraint on our energy choices for the next hundred years is the threat of climate change through accumulating greenhouse gases in the atmosphere," for which energy is about 60 percent responsible. The rich countries (about 1.2 billion people versus 4.1 billion in poor countries) use 75 percent of the industrial energy forms and two-thirds of all the energy forms and produce most of the carbon dioxide. "Of course, the poor don't plan to stay that way," said Holdren. "They plan to get rich, and most of them plan to get rich the same way we did—on a subsidy of cheap fossil fuels. And there are still enough of those around, particularly the coal, for them to make a very good try at it."

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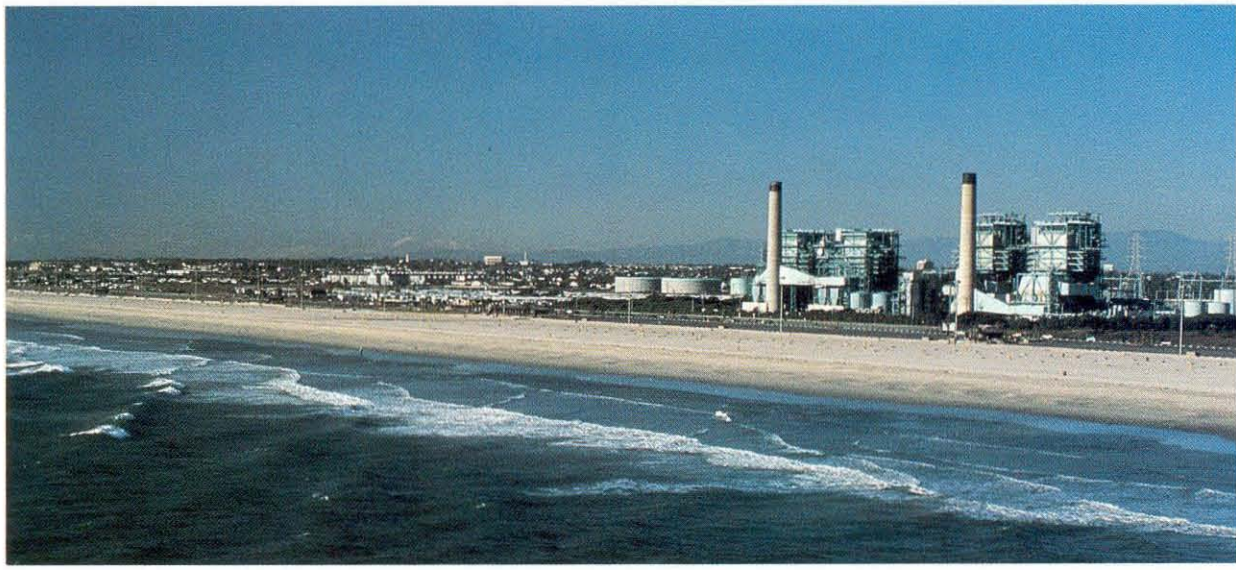
Narrowing down to California, Holdren pointed out that on the basis of GNP per unit of energy, the state "does much better than the world as a whole or than the United States as a whole, in part because of our service industries and other relatively low-energy activities." But California still needs to increase further the efficiency of energy use, an approach Holdren called "the cleanest, cheapest, fastest, safest, most reliable way" to address energy problems. He stressed the importance of finding cleaner and safer ways of using the energy sources we have now, since we can't simply abandon those overnight. But at the same time, "we need to begin a transition to forms of energy supply that are more sustainable in the environmental sense."

Among the kinds of technologies he saw emerging in California between the year 2000 and 2050, Holdren topped his list with fuel cells for dispersed as well as central-station electricity-generation applications and biofueled cogeneration of process heat and electricity. Further down the list come hydropower ("although there's not a great deal more of that in California that can be developed without running into very strong public opposition, which would include me, against damming the last remaining free-flowing rivers in the state"), wind, and geothermal power ("not inexhaustible and not an enormous potential for California"). Among the "sleepers—things of low probability but which could fool us all," Holdren listed advanced fission reactors, solar thermal electricity generation, and fusion, a field in which he himself works. ("None of us expect to see something you could describe as a commercial fusion reactor until 2025 or 2030; that means there's really no chance of a large impact before 2050.")

Although the federal government hasn't been doing enough to move us closer to these kinds of energy sources, Holdren said, "California is very well positioned to do a lot." Among the state's assets he included "the most progressive and informed electric utilities in the U.S." and the ones most willing to take action, the best universities, the best public-interest organizations, and the high-tech companies "that will know an opportunity when they see it. We have more good energy R&D than anyone outside of the federal government, and we have a less developed neighbor to remind us of why their situation matters, too. And we have a tradition of leading, rather than following, on energy and environment issues."

John Bryson, in opening the panel discussion, focused on regulation of those same electric utilities that Holdren had called the most progressive and informed in the country. "The question is whether or not regulated electric utilities as they traditionally exist can continue to exist in the future." Traditionally, regulation in the public interest has enabled utilities to make long-term investments with a reliable recovery of the cost. And reducing environmental impact, in particular reducing carbon dioxide emissions to minimize the potential for global warming, involves costs and choices that a utility company needs to plan for over the long term. The current climate of economic deregulation, however, said Bryson, in which customers may be able to choose where to go for their electric supply, puts the now regulated utilities in a dilemma. "The problem is," he said, "that there is simply no agreement at the current time about the steps that might reasonably be taken now to protect the environment." He emphasized that "we have an enormous social consensus that the environment is worth giving more attention to, paying more for than we have traditionally paid."

But Bryson did not approve of regulation for regulation's sake, describing command-and-control environmental regulation for improving air quality as "blunt, crude, and cost ineffective," with no discretion left to utilities or others in the



Right: At SCE's Huntington Beach electricity-generating plant, which burns oil and gas, emissions control may be managed by tradable permits in the future. Below: This view under the hood of an electric car may be a common sight by the year 2020.

private sector "to use their best engineering ingenuity and their understanding of costs in their own areas to come to desired solutions. With regulatory micromanagement we would end up paying vastly more per unit, for example, of nitrogen oxide reduction in the Los Angeles basin than under a market-based system of regulation that provided incentives."

Bryson also addressed the role of technology. "At Southern California Edison we are seeking to direct our research dollars into technology advances that can contribute significantly to solving energy and air-quality problems. As a utility with customers across the commercial base in greater Los Angeles, we have some direct connection to the problems businesses face with respect to meeting air-quality standards. And one of the things that we're initially encouraged by is the extent to which our work in the development of or identification of advanced electric technologies can contribute to the solution of some of these problems, while enhancing productivity at the same time."

Most of the question session veered back to the automobile, as one symposium participant observed that he was usually alone on the shuttle bus between the hotel and Caltech and hoped, probably in vain, that the others had all walked. "How can we possibly hope to change others' behavior if we can't change our own?" Panel moderator Roger Noll owned up to driving his own "gas-guzzling dinosaur" but tactfully did not press the question on the rest of the panel. But if we're not going to get out of our personal vehicles, how can we make them more efficient and environmentally sound? What will the automobile of the year 2020 be like?

Cass suggested that a large number of potentially successful technologies—"from a very tight, well-built, durable gasoline-powered vehicle to vehicles powered by alternate fuels to electric vehicles"—could compete to satisfy a requirement that the car of 2020 have virtually zero emissions and degrade gracefully. But we can't wait till 2020. He pointed out that the 20-year-old car of 2020 would be designed in the very near future. "We can't waste any time in requiring that more durable emission-control systems be built into the automobiles that are being designed now." Nichols believed that transition would involve various fuels, such as reformulated gasoline, natural gas, and methanol, but by 2020 "we'll be well on our way to a viable electric car as a result of breakthroughs in battery technology."

Bryson concurred that although "the battery technology is not there today, we see signs that it will move very rapidly." He said that even considering the power plants that would charge those batteries, electric cars would represent about a 97 percent reduction in pollutants over new gasoline-powered vehicles. He and Nichols also agreed that there would be some shift to more mass transportation. The Los Angeles County Transportation Commission is planning $150 billion, Bryson said, in investments in various forms of mass transportation, including electrified buses and commuter rail. These solutions would not, however, deal with the nitrogen oxide problem in the LA basin. "We

Although in the future the Los Angeles basin will see more electric rail, such as the new Blue Line shown here, this will not solve the nitrogen oxide problems.

need to think all these things through in a more integrated fashion," said Bryson.

What all the panelists seemed to agree on was the need for some sort of national energy policy and a government role in R&D, beyond what the market alone can do. Holdren made the point that part of the strategy needed to consist of internalizing more of the environmental costs. "We have to find ways to bring the environmental costs into the balance sheets, into the decision makers' field of vision," he said, "and when we do that, a whole new array of opportunities for cost-effective and efficient energy sources will become attractive. Today at the national level we are spending less than $2 billion a year on all energy-supply R&D," said Holdren. "That's equivalent to a tax of $0.02 a gallon on gasoline in the United States. I'm not suggesting that a tax on gasoline alone is necessarily the right way to raise this money, but the notion that the United States government cannot afford more than $2 billion on all energy R&D is preposterous. The assumption behind it is that the R&D will get done somehow if the government doesn't do it."

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The others were less circumspect about proposing a tax that would force the producers and users of energy to bear the true cost of the externalities of environmental degradation. "I've never talked to anybody in the oil industry, the utility industry, or at any level of local or state government who believes that the current emphasis on the market as a solution to all of our problems is the right answer for the United States," said Nichols. "Almost everybody who thinks about these issues believes that some form of tax—whether it's a carbon tax or a gasoline tax or whatever is needed—has to be put into research and development." And Noll pointed out, "An absolutely necessary condition to rely upon private R&D to invent new, less polluting energy sources would be that the old energy sources that are polluting would bear their full costs. So it's a complete nonsequitur to refuse to tax the carbon but then to simultaneously refuse to subsidize the R&D that might make up for the fact that we're subsidizing the carbon." Bryson agreed: "I've come increasingly to the view that some form of energy or carbon tax is the right approach to a national energy policy. What we need is an overall tax that gets effectively at the undisputable externalities that are associated with our current energy system."

But R&D won't do it alone. Nichols brought the problem back to land use and the fact that the number of miles people drive has risen twice as fast as the rate of population increase. "Unless we can get a handle on that through attacking the land-use patterns that are forcing people to drive all those extra miles, the technology won't save us." Cass was also skeptical: "New technology is going to be a very necessary and important part of any actual solution to the problem, because the new technology is going to make it that much easier to formulate the solution in a mode that people will accept. But it's not completely clear to me that new technology alone is going to get us where we want to go. We're going to have to have a lot of cooperation from people in their use of that new technology to reduce emissions by 97 percent relative to the completely uncontrolled situation. It takes only a few uncooperative individuals in the population to double the net emissions. I think we are going to have to educate people more clearly about their responsibility to cooperate in this joint venture." □