The Demographic Transition and the Technological Transition

The session was chaired by Maurice Van Arsdol, professor of sociology and director of the Population Research Laboratory at USC. Panelists included Carl Djerassi; Robert Gillespie, head of Population Communications; James Bonner, professor of biology, emeritus, Caltech; J. Gustave Speth, president, World Resources Institute; Lance Davis, Harkness Professor of Social Science, Caltech; J. Michael Davis, Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy; Robert White, president, National Academy of Engineering; and Robert Williams, senior research scientist, Center for Energy and Environmental Studies, Princeton University.

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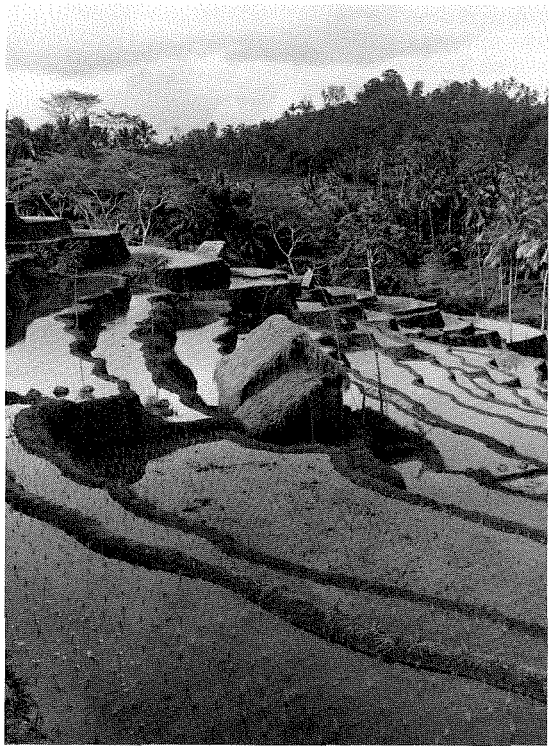
This session covered a lot of ground, starting with population control, proceeding to agriculture, technology, and energy, and finally running up against the brick wall of economics. Robert Gillespie called the population problem "monumental," saying, "the world had one billion people in 1850. The second came in 1930, the third in 1963, the fourth in 1975, the fifth in 1988, and the sixth will be in the year 2000. In the lifetime of many people in this room, the population will triple. When the last flood hit Bangladesh and took 139,000 lives, they were replaced in three weeks. Half the people in the world haven't even started having children—they *are* children. Forty-eight percent of the population in Africa is below 15, so for Africa to achieve population stabilization, they'd all have to have one-child families for the next 30 years. Latin America and Asia, with 37 percent of the population below 15, would have to have one-child families for 25 years. Taiwan is constantly used as a model for family planning, with one of the most successful programs in the world, yet its population has doubled since the early 1960s, and will double again because of the momentum factor."

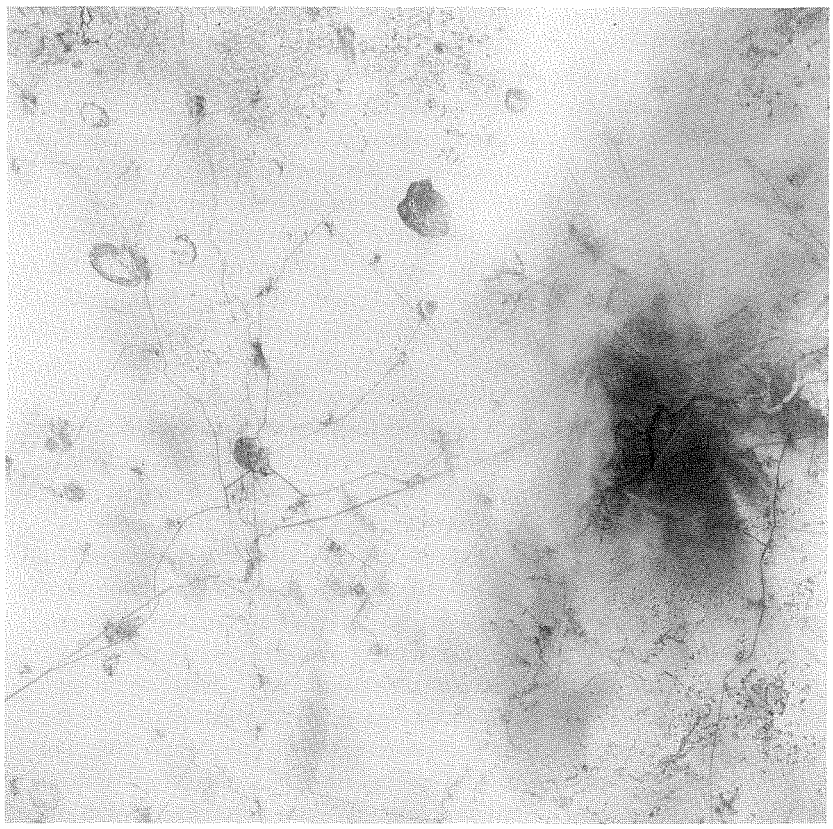
Gillespie explained that "there are a lot of ways that you can change people's value systems to achieve the small-family goal." These ways include improving the status of women, increasing the age of marriage, and lengthening the intervals between pregnancies. "In India I've mobilized vasectomy carnivals. In Bangladesh we hired 18,000 family-planning field workers. In Thailand we held condom blowing-up contests in the grade schools." Successful programs, Gillespie said, establish a set of tangible rewards for people who participate in the program, and establish visible, recognizable symbols of that participation. A pin, for example, worn by Indonesian youth who commit themselves to not marry before a certain age, and to ultimately have small families. Coupon books designed to lengthen the interval between pregnancies—a stamp goes in the book each month, and when the next child is born, the book can be redeemed for goods and services, like Green Stamps. The more stamps in the book, the greater its redemption value. Vasectomy Club cards for discounts at participating restaurants, bowling alleys, department stores, and so on—increasing the merchant's business as well. But the card must have tangible value, or it won't work.

Even if we can stabilize the population at, say, 10 billion, the achievement will be irrelevant if we can't feed them. James Bonner asserted that "we can operate sustainable, eco-friendly agriculture in perpetuity on the human time scale." Bonner stated that we know everything necessary to keep our food production stable, including how to breed plants to survive different climates, resist diseases, and bear more fruit, seeds, or whatever we eat; what the soil, nutritional, and water needs are; how to irrigate without poisoning the soil with salts; how to control erosion; and how to rotate crops to control pests and return nutrients to the soil. These techniques were all used together for the first time in the "green revolution" of the 1960s and 70s. The growing use of beneficial insects that eat crop-eating bugs; the potential development of more



Right: Rice paddies—an example of sustainable agriculture in the tropics.

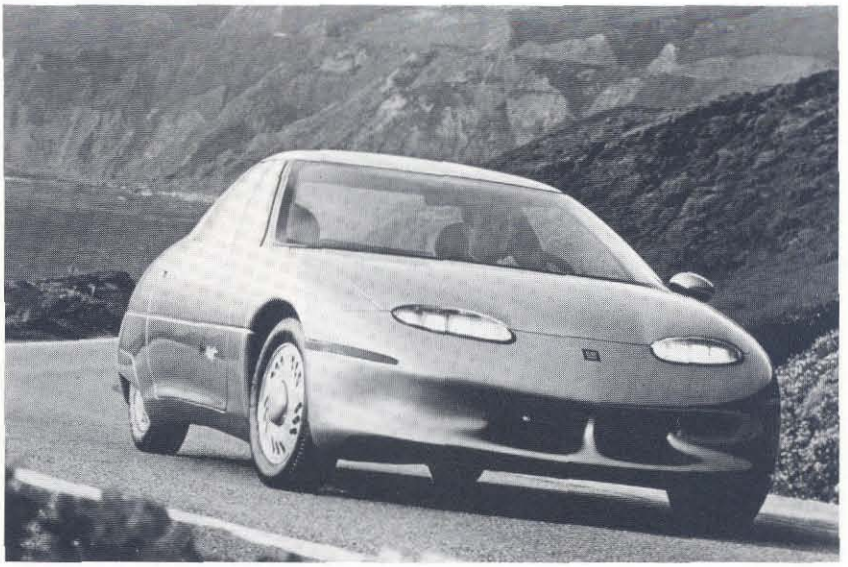
Below: This space shuttle shot shows sooty snow surrounding the Siberian steel city of Troitsk.



efficient, slow-release fertilizers embedded in ceramic pellets; and advances in biotechnology—incorporating disease-resistance and other genes into plants—hold the promise that food production can keep pace with population growth, but only for a limited increase in human numbers. Said Bonner, "I calculate that if we educate farmers worldwide to use optimal practices, and we don't grow on marginal land or chop down tropical forests, we can support, as vegetarians, about 15 billion people. If we want to support them on the American diet, in which of the 12,000 calories per person per day we produce, we eat 2,000 calories as plant products—bread, Rice Krispies, pie, and hamburger buns—and feed the remaining 10,000 calories to cows and chickens, getting a 10-percent return (1,000 calories) in animal products, we can support about 3 billion people, a figure less than the present world population. Those calories that are lost to us are supporting cows and chickens in idleness—a gigantic animal-welfare program. How many people the world can grow food for depends in large part on how many cows we want for company."

Maurice Van Arsdol pointed out that Europe had achieved prosperity, and the low birth and death rates that go with it, by colonizing much of the rest of the world. The inflow of resources to Europe as it industrialized led some scholars to assume that technological advances would always be able to support growth. "Sociologist William Catton, in *Overshoot, The Ecological Basis of Revolutionary Change*, makes the telling point that advanced societies are again hunters and gatherers—not of plants and animals, but of fossil fuels and minerals. Are we using the fossil fuels and minerals that might be our grandchildren's birthright? Technology has not until recently turned to dealing with maintaining a sustainable world."

Gustave Speth predicted that if current trends continue, the world economy in 2050 could easily be five times larger than today's. He called for a worldwide revolution in technology—the rapid, wholesale abandonment of materials-intensive, high-volume manufacturing processes for ones that use fuels and raw materials efficiently, generate little or no waste, and recycle most of that. Such technology must reduce environmental damage per unit of output fast enough to outpace production increases. "There's simply no hope of this planet accommodating the expected economic growth unless there's a thoroughgoing ecological modernization of industry and agriculture—a new industrial revolution focused as much on saving natural capital as on generating



Right: The Impact, built by General Motors, is a prototype of what the electric car of the mid-1990s might look like.

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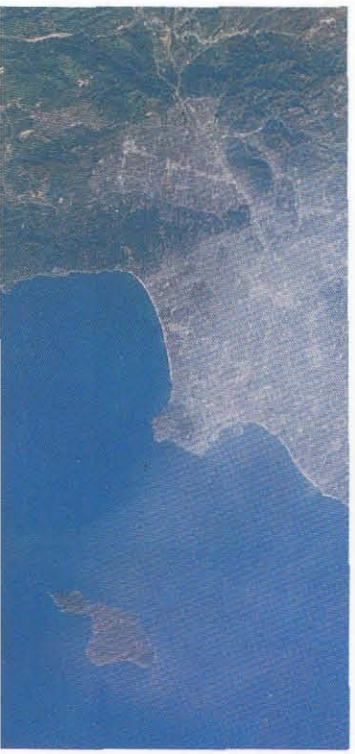
man-made wealth. And that means siting and building new plants. We're becoming a nation proficient at retrofitting, at keeping dirty plants alive."

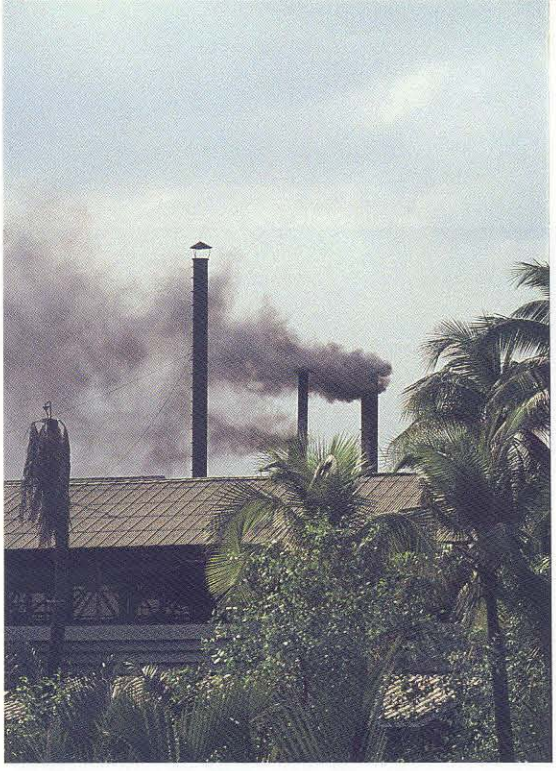
Speth's technological revolution will require revolutions in private attitudes and public policy. "Environmentalists are instinctively antitechnology, or have deep concerns about technology as a source of solutions, because it has been the source of so many problems. I recently wrote an article, saying much the same things I'm saying here, for a magazine published by a prominent environmental organization. The editors rejected it, saying the message would be anathema to the members." Speth called on environmentalists and industry to let go of one another's throats and work together, with government, to integrate sustainability into new technologies and products, by design, from their inception. Our national R&D, technology, and competitiveness policies must identify critical environmental technologies, and stimulate the private sector to develop them. "We need to mobilize the resources of the private sector as never before." Furthermore, we should "reevaluate our approaches to environmental regulation. Current regulations may actually inhibit innovation—they certainly provide no incentive for going beyond standards." He recommended rethinking the Environmental Protection Agency's problem-oriented approach—programs for water pollution, air pollution, pesticides, solid waste, and so forth—and reorganizing the EPA in part by economic sectors such as energy, agriculture, manufacturing, housing, and transportation. This would place environmental concerns at the beginning of the planning process, through better coordination with other government departments and with the economy itself.

Below: When the wind is right, Los Angeles's smog layer extends all the way out to Santa Catalina Island, 24 miles offshore, as seen in this view from the shuttle *Columbia*.



The panel agreed that much of the necessary technology exists in nascent form today. Various panelists cited biotechnology to treat effluents, reclaim soils, sequester or recycle carbon dioxide, and put more octane in biofuels such as alcohol from sugar cane; computer-aided design and manufacturing to use raw materials efficiently and reduce waste; the use of satellites and computers for environmental management; and such mundane, readily achievable things as making motors, power plants, buildings, and appliances more energy efficient. Robert White predicted that "a global market for environmental technologies will develop. Japan, sensing the opportunity, has already begun massive investment in such technologies." Observed Speth, "most important, perhaps, is producing and marketing the green automobile. There's probably no other product that causes so much environmental damage. The day is fast approaching when we'll have to move beyond vehicles that operate on fossil fuels. Hydrogen- and electric-powered vehicles are possible, and hydrogen and electricity can be made from renewable sources of energy such as photovoltaic cells [that convert sunlight into electricity] and wind power."

Robert Williams looked at the energy future. He acknowledged that we may have to reduce greenhouse-gas emissions by 60 to 80 percent over the next several decades, but said this may not be as painful as it sounds. "Energy demand



The smoke cloud issuing from this steel plant might not be so black if tropical nations had ready access to the newest technologies for producing basic materials.

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in the industrialized countries could actually decline for decades to come. The U.S. and other industrialized countries appear to be approaching saturation in the demand for the energy-intensive basic materials like steel, cement, glass, and fertilizers, whose production has dominated much of our energy use." And energy consumption in developing countries, where demand for these materials is far from saturated, might not grow as rapidly as ours did. As these countries build, "they're not going to retrace our paths of development, but rather they're going to take advantage of modern materials and methods. We should think about technological leap-frogging, introducing new technologies for producing steel, cement, fertilizer, and the like in developing countries first." Furthermore, as energy efficiency in *all* economic sectors increases—just doing things we already know how to do would have a dramatic effect—energy demand declines. And again, developing countries can install energy-efficient systems to begin with. White agreed that the developing countries need to be in the forefront of technological development. It's therefore critical, he said, to build an indigenous scientific and technological base in developing countries.

But even with declining energy demand, said Williams, we won't be able to meet greenhouse-gas reduction targets unless electricity and hydrogen become our energy currency by the late 2000s. "Hydrogen could emerge much more quickly than most people think, due to the confluence of concerns about global warming, air pollution, and oil imports. Southern California's mandate to have some 10 percent of the motor vehicles in the year 2003 be zero-emission vehicles provides a fine incentive. The hydrogen-fuel-cell car is going to be even more interesting than the electric car. Hydrogen can be derived from many sources, and hydrogen-fuel-cell technologies that convert chemical fuel directly into electricity are improving rapidly." The fuel-cell car will offer zero emissions without the prolonged recharging time and limited cruising range of the electric car. Several demonstration automobiles are being planned for the 1990s, and Williams speculated that fuel-cell cars could be competitive with gasoline-powered cars by 2010.

Williams recommended developing the embryonic industries that market, not energy, but the services that energy provides—space conditioning, lighting, motive power, and whatnot—a field with enormous growth potential. "By the middle of the next century, I think utilities will be primarily marketing energy services. They're going to go back to Thomas Edison's original concept of a utility as a purveyor of lighting, instead of a purveyor of electrons. Electricity generating will cease being a monopoly activity, because of the growing number of options for generating electricity competitively at a modest scale." Williams predicted that today's large, centralized 500–1000 megawatt power plants will be rare, replaced by 50–200 megawatt plants. There'll also be a welter of local generating systems, ranging from 5–200 megawatts—typical of today's industrial cogeneration systems, which derive heat and electricity from one fuel source—down to photovoltaic systems that

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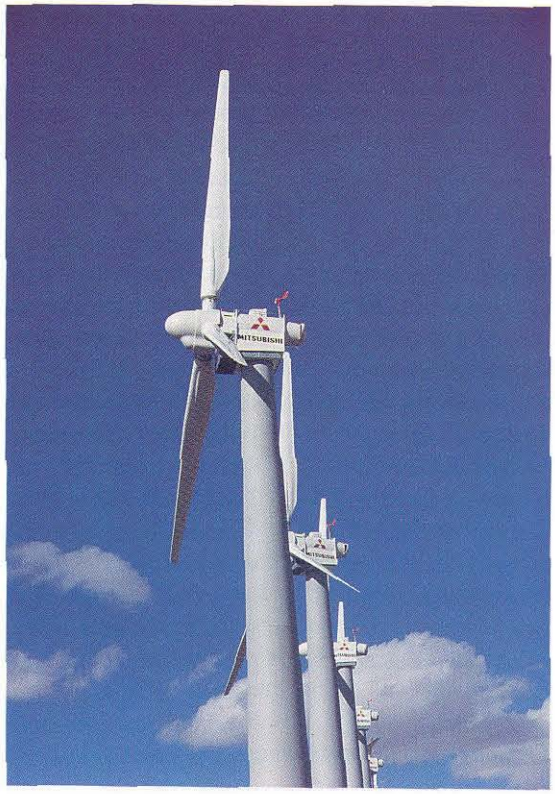
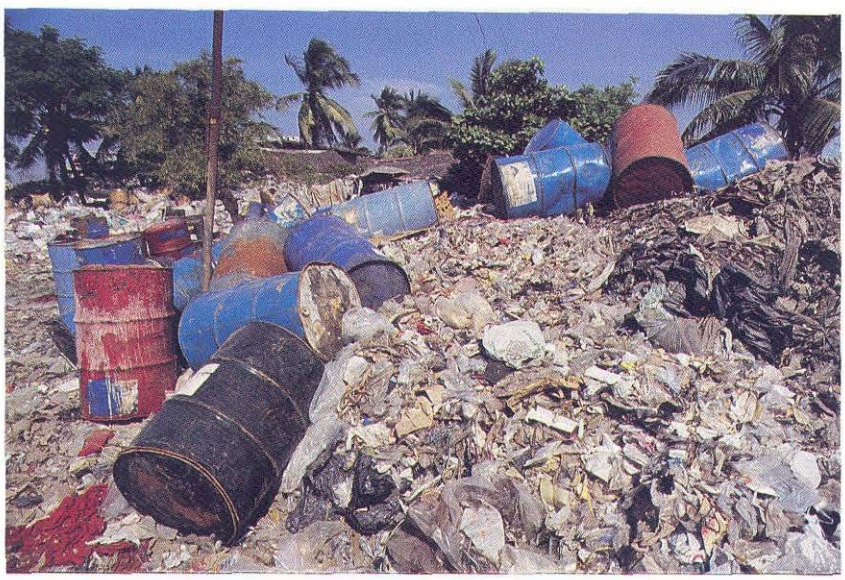


Right: Doing the right thing environmentally. Each one of these windmills—part of a farm of 300 in California's Tehachapi Mountains—can meet the energy needs of 62 average households.



Below: Doing the cheap thing. Drums of toxic waste mingle with household trash in this third-world dump.

generate just a few kilowatts, in rooftops and south-facing windows. Buildings of all sorts will have cogenerating fuel cells powered by hydrogen, natural gas, methanol, or biomass. The ubiquitous steam turbine will be displaced by cleaner, less costly, more efficient gas turbines, powered by the same sources. And windmill farms and other intermittent renewable energy sources will be more prominent.

In the transition to a hydrogen economy, Williams expects the first hydrogen suppliers to be small: off-peak hydroelectric power, or the reforming of natural gas. Then, on a larger scale, the cheapest sources of hydrogen are likely to come from the thermochemical gasification of biomass and coal. Coal gasification could include a step to separate out and store carbon dioxide—perhaps in depleted natural-gas reservoirs—which could reduce CO_2 emissions from coal use by up to 90 percent. "Greenhouse-friendly coal is not necessarily an oxymoron." Eventually, once the electrical market is saturated, wind farms and solar farms could produce hydrogen electrolytically—for export, as it were—in regions such as the windy Great Plains and the sunny Southwest.

"In order to bring about these new technologies," Williams remarked, "we must find out what it takes to launch new industries. In particular, we have to find ways to promote the demonstration of a wide range of technologies. What are the best ways of sharing the risks, without depending on the federal government? We're already seeing considerable activity in these areas in Japan and Germany. We need to catalyze creativity in the U.S. as well. Innovation in the energy sector could be much greater than it is. I'm not talking about innovations like cold fusion or even hot fusion, but rather about many technologies that have reached an advanced state of development but haven't yet attracted the backing to make it into the marketplace."

Speth spoke for most panelists when he said, "If we're going to achieve this technological transition, we'll need an economic transition in which prices really reflect long-term environmental costs. Doing the right thing environmentally should be the cheap thing, not the expensive thing as it almost always is today. It's been said that the planned economies failed, in part, because their prices didn't reflect economic realities. The market economies—our economies—will one day fail unless our prices reflect ecological realities." Gillespie suggested issuing a "sustainability card" that would accrue value as people turn off lights, use less water, and so on, saying, "we have to give value to sustainability as we give value to currency when we shop, and

"Pricing reform can go hand-in-hand with tax reform, shifting at least some of the burden from things we want to encourage, like labor and savings, to things we want to discourage, like pollution and waste."

value to sustainability's symbols as we give value to military insignia." Several panelists called for pollution taxes (or "environmental user fees") in various guises—on carbon dioxide or fluorocarbon emissions, or on the cost of replacing nonrenewable energy or revegetating land. Speth hoped such measures could finance the revolution. "Pricing reform can go hand-in-hand with tax reform, shifting at least some of the burden from things we want to encourage, like labor and savings, to things we want to discourage, like pollution and waste."

Lance Davis was less sanguine. "Technical progress may well be a necessary condition for economic growth, but it's not a sufficient one. An invention like Ford's assembly line may hold the promise of a revolution in production technology, but it can't have any effect unless it's been embodied in physical or human capital." New capital—resources provided but not consumed—is in very short supply. Davis noted that the personal savings rate—the amount of money the average American puts in the bank, which the bank can then loan to industry—has declined from about 14 percent in the late 1950s to about 3 to 4 percent today. This decline, coupled with massive government deficits, which he called "dis-savings," have led to high interest rates that discourage investment in general and steer what investments *are* made into ones with rapid payoffs and away from long-term ones such as new manufacturing plants and machines that embody the new technologies. Things won't get better soon: demographer Richard Easterlin has found that, in contrast to the youth of the 1950s, almost all of today's teenagers work part time. However, they save no money and "probably have the highest level of discretionary income that they're ever going to achieve in their whole lives. They don't pay for housing; they don't pay for food; they don't pay for health care. What's going to happen to the savings rate 10 years from now, when these people try to support a spouse and children while maintaining that pattern of discretionary spending?"

Michael Davis agreed that "our ability to make decisions to allocate our limited capital is, at best, poor. Our oil industry can't possibly produce its market, so what do we do? We subsidize it. Our agricultural industry can *over*produce its market in a New York second. What do we do? We subsidize it." He bemoaned the time wasted in irrelevant debates, such as about CAFE (the Corporate Average Fuel Economy act), whose stated objectives are to produce cleaner air and more efficient vehicles, but which doesn't address oil dependence because it never mentions alternative technologies such as biofuels. "CAFE is an unfortunate discussion, but what doesn't get discussed is even more unfortunate."

He was optimistic that the rural economy can be rebuilt around biofuels, without subsidies, pollution taxes, or increased personal savings. "Almost everybody looks to the peace dividend. I don't. We have better examples closer to home. We're willing to spend 120 to 150 billion dollars under a highway bill in debate right now. We'll have the best roads and bridges in the world on which to drive imported vehicles running on imported fuels. What would happen if we spent a couple of billions of those dollars actually working on those fuels and vehicles instead of simply creating a stationary platform that doesn't do anything for our future?"

White pointed out that some economic incentives already exist. For example, electric utilities have found that promoting conservation is more cost-effective than building new power plants. But "incentives generally imply taxation or systems of trading pollution rights, and taxation is divisive because of the potential effects on national economies, and agreeing on incentives will be difficult because each nation will weigh economic costs and environmental benefits differently."

All agreed that summoning the political will to make the changes happen was going to be the hardest part. Gillespie observed, "It's going to be very difficult to bribe people to want less." Speth commented, "I'm a technological optimist. Not optimistic that it *will* happen, but optimistic that it *can* happen." □